VOL. 1

Azadi Ka Amrit Mahotsav

Agriculture and Allied Sciences

Restructured and Revised Syllabi of Post-graduate Programmes

- Plant Sciences
- Forestry
- Plant Protection
- Sericulture
- Horticultural Sciences

भाकृअनुप
ICAR

Education Division
Indian Council of Agricultural Research
New Delhi

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त्रिलोचन महापात्र, पीएच.डी.
एफ एन ए, एफ एन ए एस सी, एफ एन ए ए एस
सचिव एवं महानिदेशक

TRILOCHAN MOHAPATRA, Ph.D.
FNA, FNASc, FNAAS
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001

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Foreword

THE ICAR has been continuously striving to bring necessary reforms for quality assurance in agricultural education. The Council has appointed National Core Group and BSMA Committees for revision and restructuring of Post-graduate and Doctoral syllabi in consultation with all the stakeholders to meet the challenges and harness opportunities in various disciplines of agriculture and allied sciences. It has been observed that a paradigm shift is necessary in academic regulations to comply with various provisions of National Education Policy-2020. It is heartening to note that the respective Committees have taken due care by following flexible, multi-disciplinary and holistic approach while developing the syllabus and academic regulations. The students are given opportunities to select the courses to support their planned research activities, to register for online courses and to pursue internship for development of entrepreneurship during Masters' programme. Further, the Teaching Assistantship has been introduced to provide experience to the Ph.D. scholars on teaching, evaluation and other related academic matters. This is an important part of doctoral training all over the world and it is expected to address the shortage of faculty in many institutions/universities. By intensive discussion with the subject experts and based on the feedback from the faculty and students, the syllabus of Masters' and Doctoral programmes in 79 disciplines was restructured and new courses were introduced. The syllabus has been revised suitably with the view to equip the students to gain knowledge, enhance their employability and skill sets to mould towards entrepreneurship and build themselves to prepare for global competitiveness. The opinions and suggestions invited from the concerned institutions, eminent scientists and other stakeholders were also reviewed by the Committees.

The Council sincerely thanks Dr Arvind Kumar, Chairman of the National Core Group and its members for the guidance to develop the syllabus in line with contemporary and projected national and global agricultural trends. The Council acknowledges the dedicated efforts and contribution of all the Chairpersons and members of 19 BSMA Committees for preparation of the syllabus. It gives me immense pleasure to express profuse thanks to the Agricultural Education Division for accomplishing this mammoth task under the guidance of Dr N.S. Rathore, former DDG and Dr R.C. Agrawal, DDG. I compliment Dr G. Venkateshwarlu, former ADG (EQR) for his sincere efforts and overall coordination of the meetings. Special thanks to DKMA for bringing out the entire syllabus in six volumes.

(T. Mohapatra)

Date: 13th August 2021
Place: New Delhi-110 001

Contents

Common Academic Regulations for PG and Ph.D. Programmes

1. Academic Year and Registration

- An academic year shall be normally from July to June of the following calendar year otherwise required under special situations. It shall be divided into two academic terms known as semesters. Dates of registration, commencement of instructions, semester end examination, end of semester and academic year, etc. The Academic Calendar shall be developed by the concerned University from time to time and notified accordingly by the Registrar in advance.
- An orientation programme shall be organized by the Director (Education)/ Dean PGS for the benefit of the newly admitted students immediately after commencement of the semester.
- On successful completion of a semester, the continuing students shall register for subsequent semester on the date specified in the Academic/ Semester Calendar or specifically notified separately. Every enrolled student shall be required to register at the beginning of each semester till the completion of his/ her degree programmes.

2. Credit requirements

Framework of the courses

The following nomenclature and Credit Hrs need to be followed while providing the syllabus for all the disciplines:

	Masters' Programme	Doctoral Programme
(i) Course work		
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	–
Seminar	01	02
(ii) Thesis Research	30	75
Total	70	100

Major courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken may be given *mark

Minor courses: From the subjects closely related to a student's major subject

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overallcompetence.

Common Courses: The following courses (one credit each) will be offered to all students undergoing Master's degree programme:

1. Library and Information Services
2. Technical Writing and Communications Skills
3. Intellectual Property and its management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approval of the Head of Department (HoD)/ Board of Studies (BoS).

Supporting Courses

The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. If required, the contents may be modified to suit the individual discipline with approval of the concerned BoS:

Code	Course Title	Credit Hours
STAT 501	Mathematics for Applied Sciences	2+0
STAT 502	Statistical Methods for Applied Sciences	3+1 2+1
STAT 511	Experimental Designs	2+1
STAT 512	Basic Sampling Techniques	2+1

Course Code	Course Title	Credit Hours
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
MCA 501	Computers Fundamentals and Programming	2+1
MCA 502	Computer Organization and Architecture	2+0
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques in Biochemistry	2+2

Syllabus of Common Courses for PG programmes

LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

To equip the students/ scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
- Writing of abstracts, summaries, précis, citations, etc.;
- Commonly used abbreviations in the theses and research communications;
- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;

- Editing and proof-reading;
- Writing of a review article;
- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- Accentual pattern: Weak forms in connected speech;
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

Suggested Readings

1. Barnes and Noble. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language.*
2. *Chicago Manual of Style*. 14th Ed. 1996. Prentice Hall of India.
3. *Collins' Cobuild English Dictionary*. 1995.
4. Harper Collins. Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed.
5. Holt, Rinehart and Winston. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.
6. James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
7. Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
8. Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
9. Richard WS. 1969. *Technical Writing.*
10. Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
11. Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, LicenseAgreement.

Suggested Readings

1. Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

2. Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
3. *Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC and Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
6. Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralisation of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

1. Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
2. Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS and Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.
2. Punia MS. *Manual on International Research and Research Ethics*. CCS Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.
4. Singh K. 1998. *Rural Development - Principles, Policies and Management*. Sage Publ.

Mandatory requirement of seminars

- It has been agreed to have mandatory seminars one in Masters (One Credit) and two in Doctoral programmes (two Credits).
- The students should be encouraged to make presentations on the latestdevelopments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills.

3. Residential requirements

- The minimum and maximum duration of residential requirement for Masters' Degree and Ph.D. Programmes shall be as follows : on

P.G. Degree Programmes	Duration of Residential Requirement	
	Minimum	Maximum
Masters' Degree	2 Academic Years (4 Semesters)	5 Academic Years (10 Semesters)
Ph.D.*	3 Academic Years (6 Semesters)	7 Academic Years (14 Semesters)

*Student may be allowed to discontinue temporarily only after completion of course work

In case a student fails to complete the degree programme within the maximum duration of residential requirement, his/ her admission shall stand cancelled. The requirement shall be treated as satisfactory in the cases in which a student submits

his/ her thesis any time during the 4th and 6th semester of his/ her residentship at the University for Masters' and Ph.D. programme, respectively.

4. Evaluation of course work and comprehensive examination

- For M.Sc., multiple levels of evaluation (First Test, Midterm and Final semester) is desirable. However, it has been felt that the comprehensive examination is redundant for M.Sc. students.
- For Ph.D., the approach should be research oriented rather than exam oriented. In order to provide the student adequate time to concentrate on the research work and complete the degree in stipulated time, the examination may have to be only semester final. However, the course teacher may be given freedom to evaluate in terms of assignment/ seminar/ first test.
- For Ph.D., the comprehensive examination (Pre-qualifying examination) is required. As the students are already tested in course examinations, the comprehensive examinationshould be based onoral examinationby an external expert and the evaluation should cover both the research problem and theoretical background to execute the project. This shall assess the aptitude of the student and suitability of the student for the given research topic. The successful completion of comprehensive examination is to obtain the "Satisfactory" remark by the external expert.

5. Advisory System

Advisory Committee

- There shall be an Advisory Committee for every student consisting of not fewer than three members in the case of a candidate for Masters' degree and four in the case of Ph.D. degree with the Advisor as Chairperson. The Advisory Committee should have representatives from the major and minor fields amongst the members of the Post-graduate faculty accredited for appropriate P.G. level research. However, in those departments where qualified staff exists but due to unavoidable reasons Post-graduate degree programmes are not existing, the staff having Post-graduate teaching experience of two years or more may be included in the Advisory Committee as member representing the minor.
- At any given time, a P.G. teacher shall not be a Chairperson, Advisory Committee (including Master's and Ph.D. programmes) for more than five students.
- The Advisor should convene a meeting of the Advisory Committee at least once in a Semester. The summary record should be communicated to the Head of Department, Dean of the College of concerned, Director (Education)/ Dean PGS and Registrar for information.

Advisor/ Co-guide/ Member, Advisory Committee from other collaborating University/ Institute/ Organization

- In order to promote quality Post-graduate research and training in cutting edge areas, the University may enter into Memorandum of Understanding (MOU) with other Universities/ Institutions for conducting research. While constituting an Advisory Committee of a student, if the Chairperson, Advisory Committee feels the requirement of involving of a faculty member/ scientist of such partnering university/ Institute/ Organization, he/ she may send a proposal to this effect to Director (Education)/ Dean PGS along with the proposal for consideration of Student's Advisory Committee (SAC).
- The proposed faculty member from the partnering institution can be allowed to act as Chairperson/ Co-guide/ Member, SAC, by mutual consent, primarily on the basis of intellectual input and time devoted for carrying out the research work at the particular institution. The faculty member/ scientist of partnering institutions

in the SAC shall become a temporary faculty member of the University by following the procedure approved by the Academic Council.

Allotment of students to the retiring persons

Normally, retiring person may not be allotted M. Sc. Student if he/ she is left with less than 2 years of service and Ph.D. student if left with less than 3 years of service. However, in special circumstances, permission may be obtained from the Director (Education)/ Dean PGS, after due recommendation by the concerned Head of the Department.

Changes in the Advisory Committee:

(i) Change of the Chairperson or any member of the Advisory Committee is not ordinarily permissible. However, in exceptional cases, the change may be effected with due approval of the Director of Education/ Dean PGS.

(ii) Normally, staff members of the university on extra ordinary leave or on study leave or who leave the University service will cease to continue to serve as advisors of the Post-graduate students of the University. However, the Director (Education)/ Dean PGS may permit them to continue to serve as advisor subject to the following conditions:
   (a) The concerned staff member must be resident in India and if he/ she agrees to guide research and must be available for occasional consultations;
   (b) An application is made by the student concerned duly supported by the Advisory Committee;
   (c) In case of a Ph.D. student, he/ she must have completed his/ her comprehensive examinations and the research work must be well in progress and it is expected that the student will submit the thesis within a year;
   (d) The Head of the Department and the Dean of the College concerned agree to the proposal;
   (e) The staff member, after leaving the University service is granted the status of honorary faculty's membership by the Vice-Chancellor on the recommendation of the Director (Education)/ Dean PGS for guiding as Chairperson or Member, Advisory Committee the thesis/ theses of the student(s) concerned only.

(iii) In case the Chairperson/ member of a Student's Advisory Committee retires, he/ she shall be allowed to continue provided that the student has completed his course work and minimum of 10 research credits and the retiring Chairperson/ member stays at the Headquarters of the College, till the thesis is submitted.

(iv) If the Chairperson/ member proceeds on deputation to another organization, he/ she may be permitted to guide the student provided his/ her new organization is at the Headquarters of the College and his/ her organization is willing for the same.

(v) The change shall be communicated to all concerned by the Head of Department.

6. Evaluation of research work

- It is highly desirablefor Ph.D. programme and this should be done annually as an essential part of research evaluation. The Student Advisory Committee shallreview the progress of research and scrutinize annual progress reports submitted by the student.
- Midterm evaluation of Ph.D. (to move from JRF to SRF) is a mandatory requirement for all the funding agencies. Hence, the second review of annual progress report need to be done after completion of two years. The successful completion enables the students to become eligible for SRF.

Prevention of plagiarism

- An institutional mechanism should be in place to check the plagiarism. The students must be made aware that manipulation of the data/ plagiarism is punishable with serious consequences.

7. Learning through online courses

- In line with the suggestion in new education policy and the initiatives taken by ICAR and MHRD in the form of e-courses, MOOCs, SWAYAM, etc. and also changes taking place globally in respect of learning through online resources it has been agreed to permit the students to enrol for online courses. It is expected that the provision of integrating available online courses with the traditional system of education would provide the students opportunities to improve their employability by imbibing the additional skills and competitive edge.

The Committee recommends the following points while integrating the online courses:

1. Board of Studies (BoS) of each Faculty shall identify available online courses and a student may select from the listed courses. The interested students may provide the details of the on-line courses to the BoS for its consideration.
2. A Postgraduate student may take up to a maximum of 20% credits in a semester through online learning resources.
3. The host institute offering the course does the evaluation and provide marks/ grades. The BoS shall develop the conversion formula for calculation of GPA and it may do appropriate checks on delivery methods and do additional evaluations, if needed.

Internship for Development of Entrepreneurship in Agriculture (IDEA)

Currently, a provision of 30 credits for dissertation work in M.Sc./ M.Tech/ M.F.Sc./ M.V.Sc. programmes helps practically only those students who aspire to pursue their career in academic/ research. There is hardly any opportunity/ provision under this system to enhance the entrepreneurship skills of those students who could start their own enterprise or have adequate skills to join the industry. Therefore, in order to overcome this gap, an optional internship/ in-plant training (called as IDEA) in lieu of thesis/ research work is recommended which will give the students an opportunity to have a real-time hands-on experience in the industry.

It is envisaged that the internship/ in-plant training would enhance the interactions between academic organizations and the relevant industry. It would not only enable the development of highly learned and skilled manpower to start their-own enterprises but also the industry would also be benefitted through this process. This pragmatic approach would definitely result in enhancedpartnerships between academia and industry.

The main objectives of the programme:

1. To promote the linkages between academia and industry
2. To establish newer University – Cooperative R&D together with industry for knowledge creation, research and commercialization
3. Collaboration between Universities and industries through pilot projects
4. To develop methods for knowledge transfer, innovation and networking potential
5. To enhance skill, career development and employability

Following criteria for IDEA will be taken into consideration:

- At any point of time there will not be more than 50% of students who can opt under IDEA
- Major Advisor will be from Academia and Co-advisor (or Advisory Committee member) from industry

- Total credits (30) will be divided into 20 for internship/ in-plant training and10 for writing the report followed by viva-voce similar to dissertation
- Work place will be industry; however, academic/ research support would be provided by the University or both. MoU may be developed accordingly
- The IPR, if any, would be as per the University policy

9. Teaching assistantship

- Teaching assistantship shall be encouraged. This will give the required experience to the students on how to conduct courses, practical classes, evaluation and other related academic matters. This is an important part of Ph.D. training all over the world and it is expected to address the shortage of faculty in many institutions/ universities.
- The fulltime doctoral students of the University with or without fellowship may be considered for award of Teaching Assistantships in their respective Departments. The Teaching Assistantship shall be offered only to those doctoral students who have successfully finished their course work. Any consideration for award of Teaching Assistantships must have the consent ofthe supervisor concerned.
- Teaching Assistantships shall be awarded on semester to semester basis on the recommendation of a screening/ selection committee to be constituted by the ViceChancellor. All classes and assignments given to the Teaching Assistants, including tutorials, practicals and evaluation work shall be under the supervisionof a faculty member who would have otherwise handled the course/ assignment.
- Each Ph.D. student may be allowed to take a maximum of 16 classes in a month to UG/ Masters students.
- No additional remuneration shall be paid to the students who are awarded ICAR JRF/ SRF. The amount of fellowship to be paid as remuneration to other students (who are receiving any other fellowship or without any fellowships) may be decided by the concerned universities as per the rules in force.However, the total amount of remuneration/ and fellowship shall not exceed the amount being paid as JRF/ SRF of ICAR.
- At the end of each term, Teaching Assistants shall be given a certificate by the concerned Head of the Department, countersigned by the School Dean, specifying the nature and load of assignments completed.

10. Registration of project personnel (SRF/ RA) for Ph.D.

- A provision may be made to enable the project personnel (SRF/ RA) to register for Ph.D. However, this can be done only if they are selected based on some selection process such as walk-in-interview. The prior approval of PI of the project is mandatory to consider the application of project personnel (SRF/ RA) for Ph.D. admission
- The candidates need to submit the declaration stating that the project work shall not be compromised because of Ph.D. programme. Further, in order to justify the project work and Ph.D. programme, the number of course credits should not be more than 8 in a semester for the project personnel (SRF/ RA) who intend to register for Ph.D.

11. Compliance with the National Education Policy-2020

- While implementing the course structure and contents recommended by the BSMA Committees, the Higher Education Institutions (HEIs) are required to comply with the provisions of National Education Policy-2020, especially the following aspects:
- Given the 21st century requirements, quality higher education must aim to develop good, thoughtful, well-rounded, and creative individuals. It must enable an individual to study one or more specialized areas of interest at a deep level, and also develop character, ethical and Constitutional values, intellectual curiosity,

scientific temper, creativity, spirit of service, and 21st century capabilities across a range of disciplines including sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects. A quality higher education must enable personal accomplishment and enlightenment, constructive public engagement, and productive contribution to the society. It must prepare students for more meaningful and satisfying lives and work roles and enable economic independence (9.1.1. of NEP-2020).

- At the societal level, higher education must enable the development of an enlightened, socially conscious, knowledgeable, and skilled nation that can find and implement robust solutions to its own problems. Higher education must form the basis for knowledge creation and innovation thereby contributing to a growing national economy. The purpose of quality higher education is, therefore, more than the creation of greater opportunities for individual employment. It represents the key to more vibrant, socially engaged, cooperative communities and a happier, cohesive, cultured, productive, innovative, progressive, and prosperous nation (9.1.3. of NEP-2020).
- Flexibility in curriculum and novel and engaging course options will be on offer to students, in addition to rigorous specialization in a subject or subjects. This will be encouraged by increased faculty and institutional autonomy in setting curricula. Pedagogy will have an increased emphasis on communication, discussion, debate, research, and opportunities for cross-disciplinary and interdisciplinary thinking (11.6 of NEP-2020).
- As part of a holistic education, students at all HEIs will be provided with opportunities for internships with local industry, businesses, artists, crafts persons, etc., as well as research internships with faculty and researchers at their own or other HEIs/ research institutions, so that students may actively engage with the practical side of their learning and, as a by-product, further improve their employability (11.8 of NEP-2020).
- HEIs will focus on research and innovation by setting up start-up incubation centres; technology development centres; centres in frontier areas of research; greater industry-academic linkages; and interdisciplinary research including humanities and social sciences research (11.12. of NEP-2020).
- Effective learning requires a comprehensive approach that involves appropriate curriculum, engaging pedagogy, continuous formative assessment, and adequate student support. The curriculum must be interesting and relevant, and updated regularly to align with the latest knowledge requirements and to meet specified learning outcomes. High-quality pedagogy is then necessary to successfully impart the curricular material to students; pedagogical practices determine the learning experiences that are provided to students, thus directly influencing learning outcomes. The assessment methods must be scientific, designed to continuously improve learning and test the application of knowledge. Last but not least, the development of capacities that promote student wellness such as fitness, good health, psycho-social well-being, and sound ethical grounding are also critical for high-quality learning (12.1. of NEP-2020).

Definitions of Academic Terms

Chairperson means a teacher of the major discipline proposed by the Head of Department through the Dean of the College and duly approved by the Director of Education/ Dean Post Graduate Studies (or as per the procedure laid down in the concerned University regulations) to act as the Chairperson of the Advisory Committee and also to guide the student on academic issues.

Course means a unit of instruction in a discipline carrying a specific number and credits to be covered in a semester as laid down in detail in the syllabus of a degree programme.

Credit means the unit of work load per week for a particular course in theory and/ or practical. One credit of theory means one class of one clock hour duration and one credit practical means one class of minimum two clock hoursof laboratory work per week.

Credit load of a student refers to the total number of credits of all the courses he/ she registers during a particular semester.

Grade Point (GP) of a course is a measure of performance. It is obtained by dividing the per cent mark secured by a student in a particular course by 10, expressed and rounded off to second decimal place.

Credit Point (CP) refers to the Grade point multiplied by the number of credits of the course, expressed and rounded off to second decimal place.

Grade Point Average (GPA) means the total credit point earned by a student divided by total number of credits of all the courses registered in a semester, expressed and rounded off to second decimal place.

Cumulative Grade Point Average (CGPA) means the total credit points earned by a student divided by the total number of credits registered by the student until the end of a semester (all completed semesters), expressed and rounded off to second decimal place.

Overall Grade Point Average (OGPA) means the total credit points earned by a student in the entire degree programme divided by the total number of credits required for the P.G. degree, expressed and rounded off to econd decimal place

Restructured and Revised
Syllabi of Post-graduate Programmes
Vol. 1

Plant Sciences

– Genetics and Plant Breeding
– Seed Sciences and Technology
– Plant Genetic Resources

Contents

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 1

Plant Sciences

– Genetics and Plant Breeding

Course Title with Credit Load
M.Sc. (Ag) in Genetics and Plant Breeding (GPB)

Course Code	Course Title	Credit Hours	Semester
GPB 501*	Principles of Genetics	3 (2+1)	I
GPB 502*	Principles of Plant Breeding	3 (2+1)	I
GPB 503*	Fundamentals of Quantitative Genetics	3 (2+1)	II
GPB 504	Varietal Development and Maintenance Breeding	2 (1+1)	I
GPB 505	Principles of Cytogenetics	3 (2+1)	II
GPB 506*	Molecular Breeding and Bioinformatics	3 (2+1)	II
GPB 507	Breeding for Quality and Special Traits	3 (2+1)	II
GPB 508	Mutagenesis and Mutation Breeding	3 (2+1)	II
GPB 509	Hybrid Breeding	3 (2+1)	I
GPB 510	Seed Production and Certification	2 (1+1)	I
GPB 511	Crop Breeding-I *(Kharif* Crops)	3 (2+1)	I
GPB 512	Crop Breeding-II *(Rabi* Crops)	3 (2+1)	II
GPB 513	Breeding Vegetable Crops	3 (2+1)	I
GPB 514	Breeding Fruit Crops	3 (2+1)	II
GPB 515	Breeding Ornamental Crops	3 (2+1)	II
GPB 516	Breeding for Stress Resistance and Climate Change	3 (2+1)	I
GPB 517	Germplasm Characterization and Evaluation	2 (1+1)	I
GPB 518	Genetic enhancement for PGR Utilization	2 (1+1)	II
GPB 591	Seminar	01	
GPB 599	Thesis/ Research	30	
	Total Credits	70	

*Compulsory Major Courses

Course Contents
M.Sc. (Ag) in Genetics and Plant Breeding (GPB)

I. Course Title : Principles of Genetics*
II. Course Code : GPB 501
III. Credit Hours : 3 (2+1)

Theory

Unit I
Beginning of genetics, early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance; Multiple alleles, Gene interactions, Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

Unit II
Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.

Unit III
Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis, Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters; Regulation of gene activity in prokaryotes and eukaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression, RNA editing.

Unit IV
Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).

Unit V
Genomics and proteomics; metagenomics; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders.

VII. Practical

Laboratory exercises in probability and chi-square;Demonstration of genetic principles using laboratory organisms;Chromosome mapping using three-point test cross;Tetrad analysis; Induction and detection of mutations through genetic tests;DNA extraction and PCR amplification;Electrophoresis: basic principles and running of amplified DNA;Extraction of proteins and isozymes;Use of *Agrobacterium* mediated method and Biolistic gun;Detection of transgenes in the exposed plant material;Visit to transgenic glasshouse and learning the practical considerations.

VIII. Suggested reading

Daniel LH and Maryellen R. 2011. *Genetics: "Analysis of Genes and Genomes"*.

Gardner EJ and Snustad DP. 1991. *Principles of Genetics*. John Wiley and Sons. 8th ed. 2006

Klug WS and Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu. Pearson Education India; Tenth edition

Lewin B. 2008. *Genes XII*. Jones and Bartlett Publ. (International Edition) Paperback, 2018

Russell PJ. 1998. *Genetics*. The Benzamin/ Cummings Publ. Co

Singh BD. 2009. *Genetics*. Kalyani Publishers (2nd Revised Edition)

Snustad DP and Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley and Sons. 6th Edition International Student Version edition

Stansfield WD.1991. *Genetics*.Schaum Outline Series Mc Graw Hill

Strickberger MW. 2005. *Genetics* (*III Ed*). Prentice Hall, New Delhi, India; 3rd ed., 2015

Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs., McGraw Hill Education; 7 edition

Uppal S, Yadav R, Singh S and Saharan RP. 2005. *Practical Manual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

I. Course Title : Principles of Plant Breeding*

II. Course Code : GPB 502

III. Credit Hours : 3(2+1)

Unit I

Early Plant Breeding; Accomplishments through plant breeding; Objectives of plant breeding; Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity and its significance. Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.

Unit II

Genetic basis of breeding: self and cross pollinated crops including mating systems and response to selection; Nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding.

Unit III

Pure line theory, pure line and mass selection methods; pedigree, bulk, backcross, single seed descent and multiline breeding; Population breeding in self-pollinated crops with special reference to diallel selective mating; Transgressive breeding.

Unit IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S_1 and S_2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreeds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

Unit V

Breeding methods in asexually/ clonally propagated crops, clonal selection.

Unit VI

Special breeding techniques: Mutation breeding, Breeding for abiotic and biotic stresses; Concept of plant ideotype and its role in crop improvement, concept of MAS, concept of polyploidy and wide hybridization, doubled haploidy.

Unit VII

Cultivar development: testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

VI. Practical

Floral biology in self and cross pollinated species;Selfing and crossing techniques;Selection methods in segregating populations and evaluation of breeding material;Analysis of variance (ANOVA);Estimation of heritability and genetic advance;Maintenance of experimental records;

- Learning techniques in hybrid seed production using male-sterility in field crops;
- Prediction of performance of double cross hybrid.

VII. Suggested Reading

Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.

Chahal GS and Gossal, SS. 2002. *Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches*. Narosa Publishing House.

Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.

George A. 2012. *Principles of Plant Genetics and Breeding*. John Wiley & Sons.

Gupta SK. 2005. *Practical Plant Breeding*. Agribios.

Jain HK and Kharakwal MC. 2004. *Plant Breeding and–Mendelian to Molecular Approach*, Narosa Publications, New Delhi

Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publ. House.

Sharma JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.

Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi.

Simmonds NW.1990. *Principles of Crop Improvement*. English Language Book Society.

Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.

Singh S and Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.

I. Course Title : Fundamentals of Quantitative Genetics*

II. Course Code : GPB 503

III. Credit Hours : 3 (2+1)

Theory

Unit I

Introduction and historical background of quantitative genetics, Multiple factor hypothesis, Qualitative and quantitative characters, Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic, Nature of gene action- additive, dominance and epistatic, linkage effect. Principles of analysis of variance and linear model, Expected variance components, Random and fixed effect model, Comparison of means and variances for significance.

Unit II

Designs for plant breeding experiments- principles and applications; Variability parameters, concept of selection, simultaneous selection modes and selection of parents, MANOVA.

Unit III

Association analysis- Genotypic and phenotypic correlation, Path analysis Discriminate function and principal component analysis, Genetic divergence analysis- Metroglyph and D^2, Generation mean analysis, Parent progeny regression analysis

Unit IV

Mating designs- classification, Diallel, partial diallel, L × T, NCDs, and TTC; Concept of combining ability and gene action, G × E interaction-Adaptability and stability; Methods and models for stability analysis; Basic models- principles and interpretation, Bi-plot analysis.

Unit V

QTL mapping, Strategies for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis; Markers, Marker assisted selection and factors influencing the MAS, Simultaneous selection based on marker and phenotype.

IV. Practical

- Analysis and interpretation of variability parameters;Analysis and interpretation of Index score and Metroglyph;Clustering and interpretation of D^2 analysis;Genotypic and phenotypic correlation analysis and interpretation;path coefficient analysis and interpretation, Estimation of different types ofheterosis, inbreeding depression and interpretation;A, B and C Scaling test;L × T analysis and interpretation, QTL analysis;Use of computer packages;Diallel analysis;G × E interaction and stability analysis.

V. Suggested Reading

Bos I and Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.

Falconer DS and Mackay J. 1998. *Introduction to Quantitative Genetics* (3rd Ed.).ELBS/ Longman, London.

Mather K and Jinks JL.1985. *Biometrical Genetics* (3rd Ed.). Chapman and Hall, London.

Nandarajan N and Gunasekaran M. 2008. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.

Naryanan SS and Singh P. 2007. *Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.

Roy D. 2000. *Plant Breeding: Analysis and Exploitation of Variation*. Narosa Publishing House, New Delhi.

Sharma JR. 2006. *Statistical and Biometrical Techniques in Plant Breeding*. New Age International Pvt. Ltd.

Singh P and Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.
Singh RK and Chaudhary BD. 1987. *Biometrical Methods in Quantitative Genetic* analysis. Kalyani Publishers, New Delhi.
Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
Wricke G and Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

e-Suggested Reading

www.iasri.icar.gov.in
www.hau.ac.in/OPstat

I. Course Title : Varietal Development and Maintenance Breeding

II. Course Code : GPB 504

III. Credit Hours : 2(1+1)

Theory

Unit I

Variety Development systemsand Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, landraces, hybrid, and population; Variety testing, release and notification systems and norms in India and abroad.

Unit II

DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties - safeguards during seed production.

Unit III

Maintenance of varieties in self and cross pollinated crops, isolation distance; Principles of seed production; Methods of nucleus and breeder seed production; Generation system of seed multiplication -nucleus, breeders, foundation, certified.

Unit IV

Quality seed production technology of self and cross-pollinated crop varieties, viz., cereals and millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi, etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton/ jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).

Unit V

Seed certification procedures; Seed laws and acts, plant variety protection regulations in India and international systems.

IV. Practical

- Identification of suitable areas/ locations for seed production;Ear-to-row method and nucleus seed production;Main characteristics of released and notified varieties, hybrids and parental lines;PGMS and TGMS;Identification of important weeds/ objectionable weeds;Determination of isolation distance and planting ratios in different crops; Seedproduction techniques of varieties in different crops;Hybrid seed production technology of important crops;DUS testing and descriptors in major crops;Variety release proposal formats in different crops.

V. Suggested Reading

Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.

Kelly AF. 1988. *Seed Production of Agricultural Crops*. Longman.

McDonald MB Jr and Copeland LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.

Poehlman JM and Borthakur D. 1969. *Breeding Asian Field Crops*. Oxford & IBH.

Singh BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani. 2015

Thompson JR. 1979. *An Introduction to Seed Technology*. Leonard Hill

I. Course Title : **Principles of Cytogenetics**

II. Course Code : **GPB 505**

III. Credit Hours : **3 (2+1)**

Theory

Unit I

Cell cycle and architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; artificial chromosome construction and its uses; Special types of chromosomes.Variation in chromosome structure: Evolutionary significance; Introduction to techniques for karyotyping; Chromosome banding and painting -*In situ* hybridization and various applications.

Unit II

Structural and numerical variations of chromosomes and their implications; Symbols and terminologies for chromosome numbers, euploidy, haploids, diploids and polyploids; Utilization of aneuploids in gene location; Variation in chromosome behaviour, somatic segregation and chimeras, endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations, balanced lethal and chromosome complexes; Inter-varietal chromosome substitutions.

Unit III

Fertilization barriers in crop plants at pre-and postfertilization levels; *In-vitro* techniques to overcome the fertilization barriers in crops; Polyploidy. Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid *vs* allopolyploids; Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer; Alien addition and substitution lines, creation and utilization; Apomixis, evolutionary and genetic problems in crops with apomixes.

Unit IV

Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, *Triticale*, *Brassica***,** and cotton); Hybrids between species with same chromosome number, alien translocations; Hybrids between species with different chromosome number; Gene transfer using amphidiploids, bridge species.

Unit V

Chromosome manipulations in wide hybridization; case studies; Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

I. Course Title : **Principles of Cytogenetics**

II. Course Code : **GPB 505**

III. Credit Hours : **3 (2+1)**

Theory

Unit I

Cell cycle and architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; artificial chromosome construction and its uses; Special types of chromosomes.Variation in chromosome structure: Evolutionary significance; Introduction to techniques for karyotyping; Chromosome banding and painting -*In situ* hybridization and various applications.

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Unit V

Chromosome manipulations in wide hybridization; case studies; Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

IV.Practical

a. Learning the cytogenetical laboratory techniques, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning, etc.;
b. Microscopy: various types of microscopes;
c. Preparing specimen for observation;
d. Fixative preparation and fixing specimen for light microscopy studies in cereals;
e. Studies on mitosis and meiosis in crop plants;
f. Using micrometres and studying the pollen grain size in various crops. Pollen germination *in vivo* and *in-vitro*;
g. Demonstration of polyploidy.

V.Suggested Reading

Becker K and Hardin J. 2004. *World of the Cell.* 5th Ed. Pearson Edu. 9th edition.

Carroll M. 1989. *Organelles*. The Guilford Press.

Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications.

Darlington CD and La Cour LF. 1969. *The Handling of Chromosomes*. George Allen & Unwin Ltd.

Elgin SCR. 1995. *Chromatin Structure and Gene Expression*. IRLPress,Oxford.

Gupta PK and Tsuchiya T. 1991. *Chromosome Engineering in Plants: Genetics, Breeding and Evolution*. Part A.

Gupta PK. 2010. *Cytogenetics*. Rastogi Pubishers.

Johannson DA. 1975. *Plant Micro technique*. McGraw Hill.

Karp G. 1996. *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons.

Khush GS. 1973. *Cytogenetics of aneuploids*. Elsevier. 1 edition.

Roy D.2009. *Cytogenetics*. Alpha Science Intl Ltd.

Schulz SJ.1980. *Cytogenetics- Plant, animals and Humans*. Springer.

Sharma AK and Sharma A. 1988. *Chromosome Techniques: Theory and Practice*. Butterworth-Heinemann publisher 2014.3rd edition

Singh RJ. 2016. Plant *Cytogenetics* 3rd Edition. CRC Press.

Sumner AT. 1982. *Chromosome Banding*. Unwin Hyman Publ. 1 edition, Springer pub.

Swanson CP. 1960. *Cytology and Cytogenetics*. Macmillan & Co.

I. Course Title : Molecular Breeding and Bioinformatics*

II. Course Code : GPB 506

III. Credit Hours : 3(2+1)

Theory

Unit I

Genotyping; Biochemical and Molecular markers; Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs, etc.), Functional markers; Mapping populations (F_2s, back crosses, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits; Statistical tools in marker analysis.

Unit II

Allele mining; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants; Marker-assisted backcross breeding for rapid introgression; Genomics- assisted breeding; Generation of EDVs; Gene pyramiding.

Unit III

Introduction to Comparative Genomics; Large scale genome sequencing strategies; Human genome project; Arabidopsis genome project; Rice genome project; Comparative genomics tools; Introduction to proteomics; 2D gel electrophoresis; chromatography and sequencing by Edman degradation and mass spectrometry; Endopeptidases; Nanotechnology and its applications in crop improvement.

Unit IV

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer; Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc. and commercial releases; Biotechnology applications in male sterility/ hybrid breeding, molecular farming; Application of Tissue culture in molecular breeding; MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights; Introduction to bioinformatics: bioinformatics tools, biological data bases (primary and secondary), implications in crop improvement.

IV. Practical

Requirements for plant tissue culture laboratory;Techniques in plant tissue culture;Media components and media preparation;Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations;Inoculation of explants, callus induction and plant regeneration; Standardizing the protocols for regeneration;Hardening of regenerated plants; Establishing a greenhouse and hardeningprocedures

- Visit to commercial micropropagation unit;Transformation using Agrobacterium strains;
- GUS assay in transformed cells/ tissues;DNA isolation, DNA purity and quantification tests;Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship;Construction of genetic linkage maps using computer software;NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p, Gene PredictionTool, Expasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder;Comparative Genomic Resources: - Map Viewer (UCSC Browser and Ensembl);Primer designing- Primer 3/ Primer BLAST.

V. Suggested Reading

Azuaje F and Dopazo J. 2005. *Data Analysis and Visualization in Genomics and Proteomics*. John Wiley and Sons.

Brown TA. 1991. *Essential Molecular Biology: a practical Approach*. Oxford university press, 2002, 2nd edition

Chawala HS. 2000. *Introduction to Plant Biotechnology*. Oxford & IBH Publishing Co. Pvt. Ltd.

Chopra VL and Nasim A. 1990. *Genetic Engineering and Biotechnology: Concepts, Methods and Applications*. Oxford & IBH.

Gupta PK. 1997. *Elements of Biotechnology*. Rastogi Publ.

Hackett PB, Fuchs JA and Messing JW. 1988. *An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation*. 2nd Ed. Benjamin Publ. Co.

Jollès P and Jörnvall H. 2000. *Proteomics in Functional Genomics: Protein Structure Analysis*. Birkhäuser.

Lewin B. 2017. *Genes XII*. Jones & Bartlett learning, 2017.

Robert NT and Dennis JG. 2010. *Plant Tissue Culture, Development, and Biotechnology*. CRC Press.

Sambrook J and Russel D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Lab. Press.

Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani Publishers, New Delhi.

Watson J. 2006. *Recombinant DNA*. Cold Spring harbor laboratory press.

I. Course Title : Breeding for Quality and Special Traits

II. Course Code : GPB 507

III. Credit Hours : 3(2+1)

Theory

Unit I

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors; Nutritional improvement - A human perspective.

Unit II

Breeding for grain quality parameters in rice and its analysis; Golden rice and aromatic rice: Breeding strategies, achievements and application in Indian context; Molecular basis of quality traits and their manipulation in rice; Post harvest manipulation for quality improvement; Breeding for baking qualities in wheat, characters to be considered and breeding strategies, molecular and cytogenetic manipulation for quality improvement in wheat.

Unit III

Breeding for quality improvement in Sorghum, pearl millet, barley and oats; Quality protein maize, specialty corns, concept and breeding strategies; Breeding for quality improvement in important forage crops for stay green traits; Genetic resource management for sustaining nutritive quality in crops.

Unit IV

Breeding for quality improvement in pulses – Chickpea, pigeonpea, green gram and black gram cooking quality; Breeding for quality in oilseeds -groundnut**,** mustard, soybean, sesame, sunflower and minor oilseeds; Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality improvement in cotton. Breeding for quality improvement in Sugarcane, potato.

Unit V

Genetic engineering protocols for quality improvement: Achievements made; Biofortification in crops; Classification and importance, Nutritional genomics and Second generation transgenics.

IV. Practical

- Grain quality evaluation in rice; Correlating ageing and quality improvement in rice;Quality analysis in millets;Estimation of anti-nutritional factors like tannins in different varieties/ hybrids:A comparison;Quality parameters evaluation in wheat, pulses and oilseeds;Evaluation of quality parameters in cotton, sugarcane and potato;Value addition in crop plants;

- Post-harvest processing of major field crops;Quality improvement in crops through tissue culture techniques;Evaluating the available populations like RIL, NIL, etc. for quality improvementusing MAS procedures;Successful example of application of MAS for quality trait in rice, mustard, maize,etc.

V. Suggested Reading

Chahal GS and SS Ghosal. 2002. *Principles and procedures of plant breeding - Biotechnological and Conventional approaches***,** Narosa Publications Chopra VL. 1997. *Plant Breeding*. Oxford & IBH. 2018.

FAO 2001. *SpecialityRices of the World - Breeding, Production and Marketing*. Oxford & IBH,1

Nov 2001.
Ghosh P. 2004. *Fibre Science and Technology*. Tata McGraw Hill.
Gupta SK. 2007. *Advances in Botanical Research* Vol. 45 Academic Press USA.
Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.
Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.
Singh BD. 1997. *Plant Breeding*. Kalyani Publishers, New Delhi.
Singh RK, Singh UK and Khush GS. 2000. *Aromatic Rices*. Oxford & IBH.

I. Course Title : Mutagenesis and Mutation Breeding

II. Course Code : GPB 508

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Mutation and its history, nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations; Detection of mutations. Paramutations in crops plants.

Unit II

Mutagenic agents: physical – radiation types and sources: Ionizing and non-ionizing radiations. Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects – RBE and LET relationships; Effect of mutations on DNA – repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects; Dosimetry -Objects and methods of treatment; Factors influencing mutation: dose rate, acute vs chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects; Radiation sensitivity and modifying factors: External and internal sources – Oxygen, water content, temperature and nuclear volume.

Unit III

Chemical mutagens: Classification – base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action; Dose determination and factors influencing chemical mutagenesis; Treatment methods using physical and chemical mutagens, Combination treatments; other causes of mutation – direct and indirect action, comparative evaluation of physical and chemical mutagens.

Unit IV

Observing mutagen effects in M_1 generation: plant injury, lethality, sterility, chimeras, etc.; Observing mutagen effects in M_2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, etc.; Individual plant based mutation analysis and working out effectiveness and efficiency in M_3 generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies.

Unit V

Use of mutagens in creating oligogenic and polygenic variations – Case studies; *In-vitro* mutagenesis – Callus and pollen irradiation; Handling of segregating M_2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for micromutations breeding/ polygenic mutations; Achievements of mutation breeding- varieties released across the world, problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING.

V. Practical

- Precautions on handling of mutagens; Dosimetry-Studies of different mutagenic agents:Physical mutagens and Chemical mutagens;Learning on Radioactivity-Production source and isotopes at BRIT, Trombay, Learning about gamma chamber;Radiation hazards: Monitoring – safety regulations and safe transportation of radioisotopes, visit to radio isotope laboratory; learning on safe disposal of

radioisotopes;Hazards due to chemical mutagens – Treating the plant propagules at different doses of physical and chemical mutagens;Procedures in combined mutagenic treatments;Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature;

- Study of M_1 generation – Parameters;Study of M_2 generation – Parameters;Mutation breeding in cereals and pulses-achievements made and an analysis;Mutation breeding in oilseeds and cotton- achievements and opportunities;Mutation breeding in forage crops and vegetatively propagated crops;Procedure for detection of mutations for polygenic traits in M_2 and M_3 generations.

VI. Suggested Reading

Alper T. 1979. *Cellular Radiobiology*. Cambridge Univ. Press, London.

Chadwick KH and Leenhouts HP. 1981. *The Molecular Theory of Radiation Biology*. Springer-Verlag.

Cotton R, Edkin E and Forrest S. 2000. *Mutation Detection: A Practical Approach*. Oxford Univ. Press.

International Atomic Energy Agency. 1970. *Manual on Mutation Breeding*. International Atomic Energey Agency, Vienna, Italy.

Shu QY, Forster BP and Nakagawa N. 2012. *Plant Mutation Breeding and Biotechnology*. Gutecnberg Press Ltd. Rome Italy ISBN:978-925107-022-2 (FAO).

Singh BD. 2003. *Genetics*. Kalyani Publishers, New Delhi.

Strickberger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall.

www.barc.gov.in

I. Course Title : Hybrid Breeding

II. Course Code : GPB 509

III. Credit Hours : 3(2+1)

IV. Theory

Unit I

Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Evolutionary aspects – Genetic consequences of selfing, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; Pre-Mendelian and Post-Mendelian ideas – Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis.

Unit II

Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F_2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.; Relationship between genetic distance and expression of heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/ genetic stocks and inbreeds, their improvement for increasing heterosis.

Unit IV

Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreeds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis, maintenance breeding of parental lines in hybrids; Fixation of heterosis in self, cross and often cross pollinated crops, asexually/ clonally propagated crops, problems and prospects; Apomixis in fixing heterosis-concept ofsingle line hybrid; Organellar heterosis and complementation

Unit V

Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed-mustard, sunflower, safflower and castor oilseed crops and pigeonpea.

V. Practical

- Characterization of male sterile lines using morphological descriptors;Restorer line identification and diversification of male sterile sources;Male sterile line creation in crop plants, problems in creation of CGMS system,ways of overcoming them;Diversification and restoration;Success stories of hybrid breeding in Maize, Rice, Pearl millet, Sorghum and Pigeonpea;Understanding the difficulties in breeding apomicts;Estimation of heterotic parameters in self, cross and asexually propagated crops;Estimation from the various models for heterosis parameters;Hybrid seed production in field crops—an account on the released hybrids, theirpotential, problems and ways of overcoming it;Hybrid breeding at National and International level,opportunities ahead.

VI. Suggested Reading

Agarwal RL. 1998. *Fundamental of Plant Breeding and hybrid Seed Production*. Science Publisher London.

Akin E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.

Ben HL. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.

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De JG. 1988. *Population Genetics and Evolution*. Springer-Verlag. 30 January 2012

Hartl DL. 2000. *A Primer of Population Genetics*. 3rd Ed. Sinauer Assoc.

Mettler LE and Gregg TG. 1969. *Population Genetics and Evolution*. Prentice-Hall. 25 April 1988

Montgomery DC. 2001. *Design and Analysis of Experiments*. 5th Ed., Wiley & Sons. 2013

Mukherjee BK. 1995.*The Heterosis Phenomenon*. Kalyani Publishers, New Delhi.

Proceedings of *Genetics and Exploitation of Heterosis in Crops* – An International Symposium CIMMYT, 1998.

Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin. 30 May 1997

Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.

Srivastava S and Tyagi R. 1997. *Selected Problems in Genetics*. Vols. I, II. Anmol Publ.

Virmani SS. 1994. *Heterosis and Hybrid Rice Breeding. Monographs of "Theoretical and Applied Genetics*", Springer-Verlag.

I. Course Title : Seed Production and Certification

II. Course Code : GPB 510

III. Credit Hours : 2(1+1)

IV. Theory

Unit I

Importance of seed as basic input in agriculture; Seed quality concept and importance; Generation system of seed multiplication -Varietal replacement rate, Seed multiplication ratios, Seed replacement rate, Seed renewal period and seed demand and supply; Various factors influencing seed production –Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration.

Unit II

Nucleus seed production and its maintenance - Maintenance of parental lines of hybrids, Production of breeder, foundation and certified seed and their quality maintenance; Principles of seed production in self- and cross-pollinated crops; Hybrid seed production - system and techniques involved in Seed village concept; Organic seed production and certification.

Unit III

Principles of seed production in field crops; Floral structure, pollination mechanism and seed production techniques in self- and cross-pollinated cereals and millets.

Unit IV

Floral structure, pollination mechanism and methods and techniques of seed production in major pulses and oilseed crops; Varietal and hybrid seed production techniques in Pigeon pea, Mustard, Castor and Sunflower.

Unit V

Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibres. Hybrid-seed production techniques in major vegetatively propagated crops.

Unit VI

Seed certification - history, concept, objectives;Central seed certification board Seed certification agency/ organization and staff requirement; Legal status - Phases of seed certification, formulation, revision and publication of seed certification standards; Minimum Seed Certification Standards (MSCS) for different crops - General and specific crop standards, Field and seed standards; Planning and management of seed certification programs; Eligibility of a variety for certification, area assessment, cropping history of the seed field.

V. Practical

- Planting design for variety- hybrid seed production techniques, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony;Identification of rogues and pollen shedders, supplementary pollination, detasseling, hand emasculation and pollination;Pollen collection and storage methods, pollen viability and stigma receptivity;Pre-harvest sanitation, maturity symptoms, harvesting techniques;Visits to seed production plots - visit to seed industries;Planning for seed production: cost benefit ratio, seed multiplication ratio and seedreplacement rate; General procedure of seed certification, identification of weed and other crop seeds as per specific crops, field inspection at different stages of a crop and observations recorded on contaminants and reporting of results, inspection and sampling, harvesting/ threshing, processing and after processing for seed law enforcement;Specifications for tags and labels to be used for certification purpose.

VI. Suggested Reading

Agrawal PK and Dadlani M. 1987. *Techniques in Seed Science and Technology*, South Asian Publishers, Delhi.

Agrawal RL. 1997. *Seed Technology,* Oxford & IBH Publishing.

Anon, 1965. *Field Inspection Manual and Minimum Seed Certification Standards*, NSC Publication, New Delhi.

Anon. 1999. *Manual of Seed Certification procedures.* Directorate of Seed Certification, Coimbatore, Tamil Nadu.

Joshi AK and Singh BD. 2004. *Seed Science and Technology*, Kalyani Publishers, New Delhi.

Kelly AF. 1988. *Seed Production of Agricultural Crops*. John Wiley, New York.

Mc Donald MB and Copeland LO. 1997. *Seed Science and Technology*, Scientific Publisher, Jodhpur.

Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. *Seed Legislation in India*. Agrobios (India), Jodhpur, Rajasthan.

Singhal NC. 2003. *Hybrid Seed Production in Field Crops*, Kalyani Publications, New Delhi

Tunwar NS and Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

e-Resources

www.gov.mb.ca
www.agricoop.nic.in
www.agri.nic.in
www.fao.org
www.seednet.gov.in

I. Course Title : Crop Breeding I (*Kharif* Crops)

II. Course Code : GPB 511

III. Credit Hours : 3(2+1)

IV. Theory

Unit I

Rice: Origin, evolution, mode of reproduction, chromosome number; Genetics – biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Aerobic rice, its implications and drought resistance breeding.

Maize: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, releasedvarieties, examples of MAS used for improvement- QPM and Bt maize – strategies and implications.

Small millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - breeding objectives yield, quality characters, biotic and abiotic stress resistance, etc.

Unit II

Pigeon pea: evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at National and International institutes.

Groundnut: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Other pulses: Urdbean, mungbean, cowpea,: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III

Soybean: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Castor and Sesame: Origin, evolution mode of reproduction, chromosome number; Genetics –cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS

used for improvement; Hybrid breeding in castor – opportunities, constraints and achievements.

Unit IV

Cotton: Origin, evolution, mode of reproduction, chromosome number; Genetics – biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton.

Jute: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Unit V

Sugarcane: Evolution and distribution of species and forms, wild relatives and germplasm; Cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance, etc.

Forage crops: Evolution and distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance, etc.

Seed spices: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement; Achievements of important spice crops.

V. Practical

- Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea, soybean, sesame, cotton;Study of range of variation for yield and yield components;Study of segregating populations in cereal, pulses and oilseed crops; Learning on the crosses between different species; attempting crosses between black gram and green gram;Evaluating the germplasm of cotton for yield, quality and resistance parameters,learning the procedures on development of Bt cotton;Visit to Cotton Technology Laboratory and Spinning Mills;Learning on the Standard Evaluation System (SES) and descriptors; Use of softwarefor database management and retrieval;Practical learning on the cultivation of fodder crop species on sewage water,analysing them for yield components and palatability;Laboratory analysis of forage crops for crude protein, digestibility percent andother quality attributes;Visit to animal feed producing factories;Learning the practice of value addition; Visiting the animal husbandry unit andlearning the animal experiments related with palatability and digestibility of fodder.

VI. Suggested Reading

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Bahl PN and Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.

Chandraratna MF. 1964. *Genetics and Breeding of Rice*. Longmans.

Chopra VL and Prakash S. 2002. *Evolution and Adaptation of Cereal Crops*. Oxford & IBH.

Gill KS. 1991. *Pearl Millet and its Improvement*. ICAR.

IRRI. 1964. *Rice Genetics and Cytogenetics*. Elsevier.

IRRI. 1986. *Rice Genetics*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.

IRRI. 1991. *Rice Genetics II*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.

IRRI. 1996. *Rice Genetics III*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.

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Jennings PR, Coffman WR and Kauffman HE. 1979. *Rice Improvement*. IRRI, Los Banos, Manila, Philippines.

Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*. Directorate of Extension Education, TNAU, Coimbatore.

Murty DS, Tabo R and Ajayi O. 1994. *Sorghum Hybrid Seed Production and Management*. ICRISAT, Patancheru, India.

Nanda JS. 1997. *Manual on Rice Breeding*. Kalyani Publishers.

Parthasarathy VA. 2017. *Spices and Plantation Crops Vol.1* (*Part A*) *Breeding of Horticultural Crops* Vol.1 (Part-B), Today and Tomorrow Printers and Publishers

Poehlman, JM. 1987. *Breeding of Field Crops*. AVI Publishing Co. Inc. East Post Connecticut, USA.

Ram HH and Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.

Sharma, AK. 2005. *Breeding Technology of Crop Plant*. Yesh Publishing House, Bikaner

Slafer GA. (Ed.). 1994. *Genetic Improvement of Field Crops*. Marcel Dekker.

Singh HG, Mishra SN, Singh TB, Ram HH and Singh DP. (Eds.). 1994. *Crop Breeding in India*. International Book Distributing Co.

Walden DB. 1978. *Maize Breeding and Genetics*. John Wiley & Sons.

I. Course Title : **Crop Breeding-II (*Rabi* Crops)**

II. Course Code : **GPB 512**

III. Credit Hours : **3(2+1)**

IV. Theory

Unit I

Wheat: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Oats: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Barley: Origin, evolution, center of origin, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Unit II

Chickpea: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Other pulses: Lentil, field pea, Rajma, Horse gram: Origin, evolution, mode of reproduction, chromosome number; Genetics. cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III

Rapeseed and Mustard: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives; yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Oil quality, Improvement for oil quality.

Sunflower, Safflower: Origin, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Unit IV

Mesta and minor fibre crops: Origin, mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality

characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Forage crops: Origin, evolution mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

Unit V

Seed spices: Origin, evolution, mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, scope of heterosis breeding, released varieties, examples of MAS used for crop improvement.

V. Practical

- Floral biology, emasculation and pollination techniques in wheat, oats, barley, chickpea, rajma, rapeseed mustard, sunflower;Study of range of variation for yield and yield components;Study of segregating populations in cereal, pulses and oilseed crops;Use of descriptors for cataloguing; Learning on the crosses between different species;Trait based screening for stress resistance;Learning on the Standard Evaluation System (SES) and descriptors;Use of software for database management and retrieval.

VI. Suggested Reading

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Bahl PN and Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.

Gupta SK. 2012. *Technological Innovations in Major World Oil crops*. Vol. I. Springer, USA.

Gupta SK. 2012. *Technological Innovations in Major World Oil crops*. Vol. II. Springer, USA.

Gupta SK. 2016. *Breeding of Oilseed Crops for Sustainable Production*. Academic Press, USA.

Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*. Directorate of Extension Education, TNAU, Coimbatore.

Parthasarathy VA. 2017. *Spices and Plantation Crops* Vol.1 (Part A) *Breeding of Breeding and Genetics*. John Wiley & Sons.

I. Course Title : Breeding Vegetable Crops

II. Course Code : GPB 513

III. Credit Hours : 3(2+1)

IV. Theory

Unit I

Breeding for Leafy vegetables: Amaranth, chenopods and lettuce.

Unit II

Breeding for Cucurbits: Gourds, melons, pumpkins and squashes.

Unit III

Breeding for Solanaceae: Potato and tomato, eggplant, hot pepper, sweet pepper

Unit IV

Breeding for Cole crops: Cabbage, cauliflower, broccoli and knolkhol.
Breeding for Root vegetables: Carrot, beetroot, radish, sweet potato and tapioca.

Unit V

Breeding for other vegetable crops: Peas, beans, onion, garlic and okra.

V. Practical

- Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm;Hybridization and handling segregating generations;Induction of flowering, palanological studies, selfing and crossing techniques invegetable crops;Hybrid seed production of vegetable crops in bulk;Screening techniques for insect-pests, disease and environmental stress resistance in vegetable crops;Demonstration of sib-mating and mixed population;Molecular marker techniques to identify useful traits in the vegetable crops andspecial breeding techniques;Visit to breeding blocks, MAS for incorporating traits governed by major andpolygenes.

Suggested Reading

Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons.

Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable Crops: Breeding and Seed Production*. Vol. I. Kalyani Publishers, New Delhi.

Kalloo G. 1988. *Vegetable Breeding*. Vols. I-III. CRC Press.

Kalloo G. 1998. *Vegetable Breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.

Peter KV and Pradeep KT. 2008. *Genetics and Breeding of Vegetables*. ICAR.

Rai N and Rai M. 2006. *Heterosis Breeding in Vegetable Crops*. New India Publication Agency.

Ram HH. 2005. *Vegetable Breeding-Principles and Practices*. Kalyani Publishers

Sharma JP. 2010. *Principles of Vegetable Breeding*. Kalyani Publishers, New Delhi.

Singh BD. 1983. *Plant Breeding*. Kalyani Publishers

I. Course Title : Breeding Fruit Crops

II. Course Code : GPB 514

III. Credit Hours : 3(2+1)

IV. Theory

Unit I

Fruit crop breeding: History, importance of fruit breeding, centers of diversity, distribution, domestication and adaptation of commercially important fruits.

Unit II

Issues in fruit crop breeding – heterozygosity, polyploidy, polyembryony, parthenocarpy and seed lessness, incompatibility and sterility systems.

Unit III

Apomixis - merits and demerits, types, variability for economic traits, role of genetic engineering and biotechnology in improvement of fruit crops.

Unit IV

Crop improvement in Mango, Banana, Citrus, Grapes, Papaya, Sapota and Pomegranate, Pineapple and Guava, Apple and other Rosaceous crops andregion specific fruit crops.

V. Practical

- Germplasm documentation;Floral biology of mango, guava, citrus, grape, pomegranate, pollen viability in major fruit crops;Pollen germination to study time of anthesis and stigma receptivity;Hybridization technique in important fruit crops, hybrid seed collection and raising;Colchicine treatment for induction of polyploidy;Exposure to resistance breeding and screening techniques;
- Mutation breeding practices raising and evaluation of segregating populations;Use of mutagens to induce mutations and polyploidy;Visit to Biotechnology Lab and study of *in-vitro* breeding techniques.

VI. Suggested Reading

Bhojwani SS and Razdan MK. 2006. *Plant Tissue Culture -Theory and Practice*. Elsevier Publication, Amesterdam.

Chadha KL and Pareek, OP. 1996. (Eds.). *Advances in Horticulture.* Vol. I to IV. Malhotra Publ. House, New Delhi.

Chadha KL and Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House, New Delhi.

Janick and Moore JN. 1996. *Advances in Fruit Breeding*, AVI Pub., USA.

Janick J and Moore JN. 1996. *Fruit Breeding*. Vols. I to III. John Wiley & Sons.

Kumar N. 2006. *Breeding of Horticultural Crops - Principles and Practices*. New India Publishing Agency, New Delhi.

Moore JN and Janick Jules. 1996. *Methods in Fruit Breeding*. Purdue University Press, South Campus Court D., USA.

Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK. and Mohanadas S. 2001. *Biotechnology of Horticultural Crops.* Vols. I-III. Naya Prokash, Kolkata.

Ray PK. 2002. *Breeding of Tropical and Sub-tropical Fruits*. Narosa Publishing House, New Delhi.

Simmonds NW. 1976. *Evolution of Crop Plants*, Orient Longman, London.

I. Course Title : Breeding Ornamental Crops

II. Course Code : GPB 515

III. Credit Hours : 3(2+1)

IV. Theory

Unit I

History of improvement of ornamental plants; Centre of origin of ornamental crop; Objectives and techniques in ornamental plant breeding.

Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops, viz., Rose, Jasmine, *Chrysanthemum*, Tuberose, *Gerbera*, *Gladiolus*, *Dahlia*, *Lilium*, *Gaillardia*, *Petunia*, *Bouganvillea*, Pansy, Marigold, *Geranium*, *Antirrhinum*, China aster, Orchids, *Carnation*, *Hibiscus*, etc.

Unit III

Development of promising cultivars of important ornamental and flower crops; Role of Heterosis and its exploitation, production of F_1 hybrids and utilization of male sterility.

Unit IV

Production of open pollinated seeds, harvesting, processing and storage of seeds; Seed certification.

V. Practical

- Study of floral biology and pollination in important species and cultivars of ornamental crops;
- Techniques of inducing polyploidy and mutation;
- Production of pure and hybrid seed;
- Methods of breeding suited to seed propagated plants;
- Polyploidy and mutations to evolve new varieties;
- Breeding methods for biotic and abiotic stresses;
- Visit to research institutes involved in ornamental crop breeding.

VI. Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

VII. Learning outcome

After completion of this course the students will be able to do the breeding of ornamental crops by conventional breeding and biotechnological methods and to know the genetics of major ornamental crops.

VIII. Suggested Reading

Alexander V. 2002. *Breeding for ornamentals: Classical and Molecular Approaches*. Kluwer Academic Publishers, London.

Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons. INC. New York.

Bhattacharjee SK and De LC. 2003. *Advanced Commercial Floriculture* Vol. 1. Aavishkar Publishers & Distributors, Jaipur.

Bose TK and Yadav LP. 2003. *Commercial Flowers*. Naya Prokash Publishers, Kolkata.

Chadha KL and Bhattacharjee SK. *Advances in Horticulture* Vol. 12, Malhotra Publishing House, New Delhi.

Mc Donald MB and Kwong FY. 2005. *Flower Seeds Biology and Technology*, CABI Publishing, Oxfordshire, UK.

Watts L.1980. *Flower and Vegetable Plant Breeding*. Grower Books

I. Course Title : Breeding for Stress Resistance and Climate Change

II. Course Code : GPB 516

III. Credit Hours : 3(2+1)

IV. Theory

Unit I

Concept and impact of climatic change; Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses – major pests and diseases of economically important crops.

Unit II

Concepts of resistance to insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defence mechanisms against viruses and bacteria.

Unit III

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants; Quantitative resistance/ adult plant resistance and slow rusting resistance; Classical and molecular breeding methods - Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications.

Classification of abiotic stresses - Stress inducing factors, moisture stress/ drought and water logging and submergence; Acidity, salinity/ alkalinity/ sodicity; High/ low temperature, wind, etc.; Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

Unit IV

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging and submergence, high and low/ freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton, etc.; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/ contaminants in soil, water and environment.

Unit V

Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

V. Practical

- Understanding the climatological parameters and predisposal of biotic and abiotic stress factors- ways of combating them for diseases caused by fungi and bacteria;Symptoms and data recording; use of MAS procedures;Phenotypic screening techniques for sucking pests and chewing pests – Traits tobe observed at plant and insect level;Phenotypic screening techniques for nematodes and borers; Ways of combatingthem;Evaluating the available populations like RIL, NIL, etc. for pest resistance;Use of standard MAS procedures. Breeding

strategies - Weeds – ecological,environmental impacts on the crops;Breeding for herbicide resistance;Screening crops for drought and flood resistance; factors to be considered and breeding strategies;Screening varieties of major crops for acidity and alkalinity- their effects andbreeding strategies;Screening forage crops for resistance to sewage water and tannery effluents; Qualityparameters evaluation.

VI. Suggested Reading

Blum A. 1988. *Plant Breeding for Stress Environments*. CRC Press.

Christiansen MN and Lewis CF. 1982. *Breeding Plants for Less Favourable Environments*. Wiley International.

Fritz RS and Simms EL. (Eds.). 1992. *Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics*. The University of Chicago Press.

Li PH and Sakai A. 1987. *Plant Cold Hardiness*. Liss, New York Springer

Luginpill P. 1969. *Developing Resistant Plants - The Ideal Method of Controlling Insects*. USDA, ARS, Washington DC.

Maxwell FG and Jennings PR. (Eds.). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons. Wiley-Blackwell.

Roberto F. 2018. *Plant Breeding for Biotic and Abiotic Stress Tolerance*. Springer.

Russel GE. 1978. *Plant Breeding for Pest and Disease Resistance*. Butterworths.

Sakai A and Larcher W. 1987. *Frost Survival in Plants*. Springer-Verlag.

I. Course Title : Germplasm Characterization and Evaluation

II. Course Code : GPB 517

III. Credit Hours : 2(1+1)

IV. Theory

Unit I

Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits; Measuring diversity using agro-morphological data, statistical procedures to measure population genetic variation, markers and their use in PGR, evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

Unit II

Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces, evaluation and maintenance of wild relatives of crop plants. Genetic enhancement, Use of CWRs genetic resources for crop improvement.

Unit III

High throughput phenotyping systems- imaging and image processing concepts for automated germplasm characterization (phenotyping) – evaluation for nutritional traits, resistance traits -Biochemical and molecular markers for characterization.

V. Practical

- Field layout and experimental designs;Recording field data on germplasm evaluation in different agri-horticultural crops,ost harvest handling;Evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm, data processing;Documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing, biochemical analyses of samples.

VIII. Teaching methods

- Lectures
- Power point presentations
- assignments, quiz
- Group tasks, student's presentations

IX. Suggested Reading

Brown AHD, Clegg MT, Kahler AL, Weir BS (eds.) 1990. *Plant Population Genetics, Breeding, and Genetic Resources*, Sinauer Associates, USA.

Frankel R and Galun E 1977. *Pollination Mechanisms, Reproduction and Plant Breeding. Monographs on Theoretical and Applied Genetics*, Springer-Verlag, Berlin, Heidelberg.

Hayward MD, Bosemak NO and Romagosa I. 1993. *Plant Breeding: Principles and Practices*, Chapman & Hall.

Holden JHN and Williams JT 1984. *Crop genetic resources: conservation and evaluation*, IBPGR.

Puzone, L and Th. Hazekamp 1996. *Characterization and Documentation of Genetic Resources Utilizing Multimedia Database*. NBPGR, New Delhi.

Rana RS, Sapra RL, Agrawal RC and Gambhir R 1991. Plant Genetic Resources, *Documentation and Information Management*. NBPGR, New Delhi.

Stoskopf NC 1993. *Plant Breeding: Theory and Practice*, Westview Press.

Sundeep Kumar, *et al.* 2016. *Evaluation of 19,460 wheat accessions conserved in the Indian national genebank to identify new sources of resistance to rust and spot blotch diseases.* PloS One Vol 11, pages 0167702.

Tripathi K, Bhardwaj R, Bhalla S, Kaur V, Bansal R, Yadav R, Gangopadhyay KK, Kumar A and Chaudhury R. 2018. *Plant Genetic Resources Evaluation: Principles and Procedures*, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi. vi+50 p.

I. Course Title : Genetic enhancement for PGR Utilization

II. Course Code : GPB 518

III. Credit Hours : 2(1+1)

IV. Theory

Unit I

Concepts of gene pools; Introduction, potential of pre-breeding. Role of crop wild relatives, semi exotics, creating and managing variation, basic concepts to set up a successful pre-breeding programme.

Unit II

Understanding crop adaptation, handling and maintenance of CWRs, synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments, role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm, identifying desirable traits in natural populations, screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits, genetic analysis to understand the inheritance of novel traits.

Unit III

Parental selection for prebreeding, search for superior genotypes, breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization, Incongruity and its management, modern tools for incongruity management, cytogenetical approaches for gene transfer such as alien addition and substitution, segregating populations and their management in wide crosses, purging the undesirable traits, testing and improving the adaptability of wide cross derivatives, cytological studies, florescence microscopy, embryo rescue methods, pollen physiology and storage, pollen storage methods to facilitate wide hybridization, pre- and post-zygotic barriers.

V. Practical

- Characterization of CWRs by visiting the fields;Screening methods for special traits-biotic and abiotic resistance;Screening for nutritional traits;Crossability studies in CWRs of cereals, legumes, oilseeds, vegetables. Assessmentof pre and post-zygotic barriers in wide hybridization crosses;Pollen storage studies;
- Special requirements for growing CWRs, inducing flowering by manipulating day length, temperature, chemical spraying, etc.

VI. Suggested Reading

Andey Pereira. 2006. *Plant Reverse Genetics*, Methods and Protocols, Humana Press

Bisht *et al*. 2004. Broadening the genetic base of sesame (*Sesamum indicum* L.) through genetic enhancement. *Plant Genetic Resources* **2**(3): 143–151.

Dale JW and von Schantz M. 2007. *From genes to genomes. Concepts and applications of DNA technology*. John Wiley & Sons Ltd., Chichester, England.

Duvick DN. 1990. Genetic enhancement and plant breeding. p. 90–96. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland.

Goodman, RM. 2004. *Encyclopedia of plant and crop science*. Marcel Dekker Inc., Switzerland.

Kimber, G and Feldman, M. 1987. *Wild Wheat: An introduction*. Special report 353, College of Agriculture, University of Missouri-Columbia.

Lynch M. and Walsh B. 1998. *Genetics and analysis of quantitative traits*. Sinauer Associates Inc., MA, USA.

Murphy D. 2007. *Plant breeding and biotechnology: Societal context and the future of agriculture*. Cambridge University Press, Cambridge, UK.

Ram JS. 2010. *Plant Cytogenetics*. CRC Press.

Ramanatha Rao V, Brown AHD, Jackson M. 2001. *Managing Plant Genetic Diversity*. CABI publication.

Sharma S, Upadhyaya HD, Varshney RK, *et al*. 2013. Pre-breeding for diversification of primary gene pool and genetic enhancement of grain legumes. *Front. Plant Sci*. **4**: 309.

Yunbi Xu. 2010. Molecular plant breeding, CABI publishers

Course Title with Credit Load
Ph.D. in Genetics and Plant Breeding (GPB)

Course Code	Course Title	Credit Hours	Semester
GPB 601*	Advances in Plant Breeding Systems	3(3+0)	I
GPB 602	Advances in Biometrical Genetics	3(2+1)	II
GPB 603	Molecular Cytogenetics for Crop Improvement	2(2+0)	II
GPB 604	Plant Genetics Resources, Conservation and Utilization	2(2+0)	I
GPB 605*	Genomics in Plant Breeding	3(3+0)	I
GPB 606	Population Genetics	2(2+0)	II
GPB 607	Crop Evolution	3(3+0)	I
GPB 608	Breeding Designer Crops	2(1+1)	I
GPB 609*	IPR and Regulatory Mechanism (e-course)	1(1+0)	II
	Major courses (Minimum 12 credits from above courses including *marked Courses)	12	
	Minor courses	06	
	Supporting courses	05	
GPB 691	Seminar I	01	
GPB 692	Seminar II	01	
GPB 699	Thesis/ Research	75	
	Total Credits	100	

Comprehensive (Pre-qualifying) Examination (Non-credit of 100 marks) Satisfactory/ Not satisfactory

*Compulsory Major Courses

Course Contents
Ph.D. in Genetics and Plant Breeding (GPB)

I. Course Title : Advances in Plant Breeding Systems*
II. Course Code : GPB 601
III. Credit Hours : 3(3+0)
IV. Theory

Unit I

Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed; Pollen pistil interaction: biochemical and molecular basis, environmental factors governing anthesis and bottlenecks for gene transfer.

Unit II

Plant Breeding methodologies: Classic versus modern; Over view of Pre and Post Mendelian breeding methods in self and cross pollinated crops; Molecular and transgenic breeding approaches; doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed breeding, participatory plant breeding, breeding for organic situations.

Unit III

Principles and procedures in the formation of a complex population; Genetic basis of population improvement in crop plants; Recurrent selection methods in self and cross pollinated crops and their modifications; Convergent selection, divergent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selection in clonally propagated crops – Assumptions and realities.

Unit IV

Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment, application of MAS for selection of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotic germplasm, introgression libraries.

Unit V

Genetic resources: primary, secondary, tertiary and alien trans gene pool; Molecular and biochemical basis of self-incompatibility and male sterility, nucleocytoplasmic interactions with special reference to male sterility – genetic, biochemical and molecular bases.

Unit VI

Genetic engineering technologies to create male sterility, prospects and problems, use of self-incompatibility and sterility in plant breeding – case studies; Fertility restoration in male sterile lines and restorer diversification programs; Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies; Case studies - Generating new cyto-nuclear interaction system for diversification of male sterile; Stability of male sterile lines – Environmental influence on sterility, Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding; Temperature sensitive genetic male sterility and its use heterosis breeding; Apomixis and its use in heterosis breeding; Incongruity: Factors influencing incongruity Methods to overcome incongruity mechanisms.

Unit VII

Breeding for climate change -Improving root systems, abiotic stress tolerance, water use efficiency, flooding and sub-mergence tolerance; Biotic stress tolerance; Nutrient use efficiency, nitrogen fiXation and assimilation, greenhouse gases and carbon sequestration; Breeding for bio-fortification.

V. Suggested Reading

Agarwal RL. 1996. *Fundamentals of Plant Breeding and Hybrid Seed Production*. Oxford & IBH.

Allard RW. 1966. *Principles of Plant Breeding*. John Wiley & Sons.

Briggs FN and Knowles PF. 1967. *Introduction to Plant Breeding*. Reinhold.

Fehr WR. 1987. *Principles of Cultivar Development: Theory and Technique*. Vol I. Macmillan.

Hayes HK, Immer FR and Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.

Kang MS and Priyadarshan PM (Edit.). 2007. *Breeding Major Food Staples*. Blackwell Publishing.

Kole C. 2013. *Genomics and Breeding for Climate-Resilient Crops*. Springer. Volume 2-Target Traits.

Mandal AK, Ganguli PK and Banerji SP. 1995. *Advances in Plant Breeding*. Vol. I, II. CBS.

Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.

Sharma JR. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.

Simmonds NW. 1979. *Principles of Crop Improvement*. Longman.

Singh BD. 1997. *Plant Breeding: Principles and Methods*. 5th Ed., Kalyani Publishers, New Delhi.

Singh P. 1996. *Essentials of Plant Breeding*. Kalyani Publishers, New Delhi.

Welsh JR. 1981. *Fundamentals of Plant Genetic and Breeding*. John Wiley.

I. Course Title : Advances in Biometrical Genetics

II. Course Code : GPB 602

III. Credit Hours : 3(2+1)

IV. Theory

Unit I

Continuous variation-evolutionary studies; Genetic principles of continuous variation, Qualitative and quantitative techniques-differences, population types, approaches; various types of metrics, F_2, $F\alpha$ and mixed; Selection of parents Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes.

Unit II

Components of mean- Additive effect, breeding value, coefficient of gene dispersion, dominance; Simple scaling test, expectation of mean of character in various types of families in coupling and dispersed phase; Epistasis- Specification, weighted and un-weighted joint scaling test; Effect of linkage to generation mean, specification of mean to G × E interaction.

Unit III

Component of variances-advantages, variances of different generations, balance sheet of variance; estimation of parameters-weighted and unweighted, least square analysis; random mating population; experimental population-BIPs, NCD-I, II, III, Triple test cross for random mating population and inbreds; Estimates of linkage and non-allelic interactions; Combining ability analysis, Hayman's Approach.

Unit IV

G × E Interaction, stability and adaptability; Advanced models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Merits and limitation of different stability analysis methods; Analysis and selection of genotypes; Methods and steps to select the best model - Biplots and mapping genotypes.

Unit V

Construction of saturated linkage maps, concept of framework map development; QTLs-different types of markers and mapping populations, linkage maps, mapping- Strategies for QTL mapping - desired populations, statistical methods; MAGIC populations, Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on markers - simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods; Use of advanced software packages for biometrical analysis, interpretationof analysed data.

VII. Practical

- Generation mean analysis: ABC scaling test and Joint scaling test- Analysis and interpretation;Estimation of variance of different filial generations and interpretations;Diallel analysis: Numerical, graphical and combining ability analysis; Triallel analysis;NC Designs: Triple test cross analysis;Stability analysis: Eberhart and Russel model;AMMI model - Principal Component Analysis model - Additive and multiplicativemodel - Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes;Construction of linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping;Phenotype and Marker linkage studies;Use of advanced software in biometrical analysis.

VIII. Suggested Reading

Bos I and Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.

Dabholkar AR.1993. *Elements of Biometrical Genetics*. Concept Publishing Co. New Delhi.

Falconer DS and Mackay J. 1996. *Introduction to Quantitative Genetics* (4 Ed.). ELBS/ Longman, London.

Mather K and Jinks JL. 1985. *Biometrical Genetics* (3rd Ed.). Chapman and Hall, London.

Nandarajan N and Gunasekaran M. 2008. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.

Roy D. 2000. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publishing House, New Delhi.

Singh P and Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.

Singh RK and Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani Publishers, New Delhi.

Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Dat*a. Sinauer Associates.

Wricke G and Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

I. **Course Title : Molecular Cytogenetics for Crop Improvement**

II. **Course Code : GPB 603**

III. **Credit Hours : 2(2+0)**

IV. **Theory**

Unit I

Organization and structure of genome, Genome size, Organization of organellar genomes, Nuclear DNA organization, Nuclear and Cytoplasmic genome interactions and signal transduction; Inheritance and expression of organellar DNA; Variation in DNA content - C value paradox; Sequence complexity – Introns and Exons, Repetitive sequences, Role of repetitive sequence.

Unit II

Karyotyping – Chromosome banding and chromosome painting; Tracking introgressions using FISH, GISH, localization and mapping of genes/ genomic segments.

Unit III

Pre-breeding and applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchange genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges-use in producing inbreds, transfer of genes- linked marker methods; Duplication - production and use; Inversions and location of genes; B/ A chromosome translocations and gene location.

Unit IV

Trisomics- types, production, breeding behavior and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomics methods of production, breeding behavior and location of genes; Intervarietal substitutions-allelic and non-allelic interactions; Telocentric method of mapping.

Unit V

Cytogenomics: Concept, tools and techniques for crop improvement; Chromosome sorting: Isolation of specific chromosome for development of molecular maps and gene location.

Unit VI

Role of polyploidy in crop evolution and breeding. Auto- and allopolyploids; Distant hybridization, barriers to interspecific and intergeneric hybridization; Behaviour of interspecific and intergeneric crosses.

V. **Suggested Reading**

Clark MS and Wall WJ. 1996. *Chromosomes: The Complex Code*. Chapman & Hall. 30 June 1996

Conger BV. (Ed.). 1981. *Cloning Agricultural Plants via in-vitro Techniques*. CRC Press. 31 January 2018

Constabel F and Vasil IK. (Eds.). 1988. *Cell Culture and Somatic Cell Genetics of Plants*. Vol. V. Cell Culture and Phytochemicals in Plant Cell Cultures. Academic Press.

Gupta P K. 2006. *Cytogenetics*. Rastogi Publisher

Lal R and Lal S. (Eds.). 1990. *Crop Improvement Utilizing Biotechnology*. CRC Press.

Mantel SH and Smith H. 1983. *Plant Biotechnology*. Cambridge University Press.

Sen SK and Giles KL. (Eds.). 1983. *Plant Cell Culture in Crop Improvement*. Plenum Press. 13 July 2013

Yao-Shan F. 2002. *Molecular Cytogenetics: Protocols and Application*. Human Press

I. Course Title : Plant Genetic Resources, Conservation and Utilization

II. Course Code : GPB 604

III. Credit Hours : 2(2+0)

IV. Theory

Unit I

Concept of natural reserves and natural gene banks; *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ* conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

Unit II

Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, perma-frost conservation, guidelines for seed multiplication and exchange to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling, clonal repositories, genetic stability under long term storage condition.

Unit III

In-vitro storage, maintenance of *in-vitro* culture under different conditions, *in-vitro* bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/ suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of *in-vitro* gene bank.

Unit IV

Cryopreservation- procedure for handling seeds of orthodox and recalcitrant-cryo-protectants, desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation/ dehydration techniques, national facilities, achievements, application of cryopreservation in agricultural, horticultural and forestry crops. Problems and prospects; challenges ahead.

Unit V

Concept and procedure for PGR management, germplasm characterization, evaluation and utilization; Concept of core and mini core; collections and registration of plant germplasm.

V. Suggested Reading

Ellis RH, Roberts EH and White Head J. 1980. *A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks*. FAO/ IBPGR Pl. Genet. Resources News 41-3-18.

Frankel OH and Hawkes JG. 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press, Cambridge.

Paroda RS and Arora RK.1991. *Plant Genetic resource Conservation and management*, NBPGR, New-Delhi.

Simmonds NW. 1979. *Principles of Crop Improvement*, Longman.

Westwood MN. 1986. *Operation Manual for National Clonal Germplasm Repository*. Processed Report. USDA-ARS and Oregon State Univ. Oregon, USA.

Withers LA. 1980. *Tissue Culture Storage for Genetic Conservation*. IBPGR Tech. Rep. IBPGR, Rome, Italy.

I. Course Title : Genomics in Plant Breeding*

II. Course Code : GPB 605

III. Credit Hours : 3(3+0)

IV. Theory

Unit I

Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes; Concept of genome size and complexity: C-value paradox, repetitive and unique DNA.

Unit II

Genome sequencing: Principles and techniques of conventional approaches and next generation sequencing including sequencing-by-synthesis/ ligation and single molecule real time (SMRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing including shot gun and clone-by-clone method.

Unit III

Molecular maps: Use of molecular markers/ SNPs for development of genetic and physical maps; Linkage and LD-based gene mapping approaches including gene/ QTL mapping, genome wide association studies (GWAS) and association analysis; Integration of genetic and physical map for map-based cloning of economically important genes. Concept of allele mining; Diversity array technology: concepts and applications.

Unit IV

Functional genomics: concept of reverse and forward genetics; Use of activation tagging, transposon tagging, insertional mutagenesis, TILLING and ecoTILLING for crop improvement; Genome-wide and gene-specific transcriptomics approaches: serial analysis of gene expression, massively parallel signature sequencing, next generation sequencing, microarray, northern hybridization, RT-PCR, qRT-PCR and molecular beacon.

Unit V

Development and management of database; Applications of bioinformatics tools/ software in genomics for crop improvement. Basic concepts of high-throughput proteomics, metabolomics and phenomics.

Unit VI

Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENS and ZFNs for crop improvement. Cisgenesis and Intragenesis tools as twin sisters for Crop Improvement; Genomics-based plant breeding: Genome-Wide Genetic Diversity Studies, Identification of molecular markers linked to single Genes and QTL, Marker Assisted Selection (Marker Assisted Backcross Selection, Association mapping, Breeding by Design, Genome selection).

V. Suggested Reading

Alonso JM, Stepanova AN. 2015. *Plant Functional Genomics: Methods and Protocols*. Springer.

Chopra VL, Sharma RP, Bhat SR and Prasanna BM. 2007. *Search for New Genes*. Academic Foundation, New Delhi.

Hackett PB, Fuchs JA and Messing JW. 1988. *An Introduction to Recombinant DNA Technology—Basic Experiments in Gene and Manipulation*. 2nd Ed. Benjamin Publication Co.

Primose SB and Twyman RM. 2006. *Principles of Gene Manipulation and Genomics*. 7th Ed. Wiley-Blackwell Publishing.

Sambrook J and Russel D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Laboratory Press.

Singh BD. 2005. *Biotechnology: Expanding Horizons*. Kalyani Publishers, New Delhi.

Somers DJ, Langridge P, Gustafson JP. 2009. *Plant Genomics: Methods and Protocols*. Springer.

I. Course Title : Population Genetics

II. Course Code : GPB 606

III. Credit Hours : 2(2+0)

IV. Theory

Unit I

Population: Properties of population, Mendelian population; Genetic constitution of a population through time, space, age structure, etc.; Frequencies of genes and genotypes; Causes of change: population size, differences in fertility and viability, migration and mutation.

Unit II

Hardy-Weinberg equilibrium, Hardy-Weinberg law, Proof and applications of the Hardy-Weinberg law, Test of Hardy-Weinberg equilibrium; Mating frequencies: Non-dominance, Codominance, Snyder's ratio, importance and its effect over random mating in succeeding generations.

Unit III

Multiple alleles, More than one locus, Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations - Changes of gene frequency, Migration, Mutation, Recurrent and non-recurrent Selection; Balance between selection and mutation; Selection favoring heterozygotes; Overdominance for fitness.

Unit IV

Mating systems, Random mating population, Nonrandom mating: selfing –inbreeding coefficient, panmictic index, sibmating, Assortative mating and disassortative mating; Pedigree populations and close inbreeding, Estimation of linkage disequilibrium, Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops; Gene substitution and average effects; Breeding value- Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis- Adaptive organization of gene pools; Polymorphism- Balanced and Non-balanced polymorphism, heterozygous advantage- Survival of recessive and deleterious alleles in populations.

V. Suggested Reading

Chawla V and Yadava RK. 2006. *Principles of Population Genetics – A Practical Manual*. Dept. of Genetics, CCS HAU Hisar.

Falconer DS and Mackay J. 1996. *Introduction to Quantitative Genetics*. Longman.

Jain JP, Jain J and Parbhakaran VT. 1992. *Genetics of Populations*. South Asia Books.

Li CC. 1955. *Population Genetics*. The Univ. of Chicago Press.

Mather K and Jinks JL. 1982. *Biometrical Genetics*. Chapman & Hall.

Sorrens D and Doniel G. 2007. *Methods in Quantitative Genetics*. Series: *Statistics for Biology and Health*. Likelihood.

Tomar SS. 1992. *Text Book of Population Genetics*. Universal Publication.

I. Course Title : Crop Evolution

II. Course Code : GPB 607

III. Credit Hours : 3(3+0)

VI. Theory

Unit I

Origin and evolution of species; Centres of diversity/ origin, diffused centres; Time and place of domestication; Patterns of evolution and domestication-examples and Case studies; Domestication and uniformity – Characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift – Consequences.

Unit II

Speciation and domestication–The process of speciation, Reproductive isolation barriers; Genetic differentiation during speciation; Hybridization - speciation and extinction; Exploitation of natural variation: Early attempts to increase variation, Distant hybridization and introgression, Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques; Validation of transferred genes and their expression; Controlled introgressions.

Unit III

Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution, Multifactorial genome, Intragenomic interaction, Intergenomic interaction, Genome introgression; Methods to study crop evolution - Contemporary Methods, Based on morphological features, Cytogenetic analysis, Allozyme variations and crop evolution, DNA markers, genome analysis and comparative genomics.

Unit IV

Evolutionary significance of polyploidy, evolution of crop plants through ploidy manipulations; Polyploids: methods, use of autopolyploids; haploidy and DH-method of production and use, allopolyploids; synthesis of new crops; Case studies – Cereals, Pulses, Oilseeds, vegetables, Fibre crops, Plantation crops, Forage crops, Tuber crops, Medicinal Plants.

VII. Suggested Reading

Hancock JF. 2004. *Plant Evolution and the Origin of Crop Species*. 2nd Ed. CABI.
Ladizinsky G. 1999. *Evolution and Domestication*. Springer.
Miller AJ. 2007. *Crop Plants: Evolution*. John Wiley & Sons.
Smartt J and Simmonds NW. 1995. *Evolution of Crop Plants*. Blackwell.

I. Course Title : Breeding Designer Crops

II. Course Code : GPB 608

III. Credit Hours : 2(1+1)

Unit I

Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins, vaccines, gums, starch and fats.

Unit II

Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency,

water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement; Breeding for special traits, viz., oil, protein, vitamins, amino acids, etc.; Ecospecific ideotypes, Ideotypes for high and low moisture conditions, low and high input conditions, conversion mechanism of C_3 to C_4 plants; Determination of genetics of above mentioned traits.

Unit III

Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of suboptimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.

Unit IV

Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories in vaccines, modified sugars, gums and starch through biopharming.

Unit V

Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management.

IV. Practical

- Demonstration of plant responses to stresses through recent techniques;
- Water use efficiency, transpiration efficiency, screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation, heat/ drought/ salt shock proteins.

VIII. Teaching methods

Suggested Reading

IX.

Balint A. 1984. *Physiological Genetics of Agricultural Crops*. AK Ademiaikiado.
Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.
Pessarakli M. 1995. *Handbook of Plant and Crop Physiology*. Marcel Dekker.
Taiz L and Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

I. Course Title : IPR and Regulatory Mechanism (e-course)*

II. Course Code : GPB 609

III. Credit Hours : 1(1+0)

IV. Why this course?

Biodiversity conservation and its judicious utilization are important in sustainable plant breeding programs. Breeders' and farmers' rights are important in scenario of globalization of agriculture so knowledge of IPRs is essential for a plant breeder to protect his varieties.

V. Aim of the course

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR), related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

VI. Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement

VII. Suggested Reading

Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 1

Plant Sciences

– Seed Science and Technology

Course Title with Credit load
M.Sc. (Ag) in Seed Science and Technology (SST)

Course Code	Course Title	Credit Hours	Semester
SST 501*	Seed Developmental Biology	2 (1+1)	I
SST 502	Seed Dormancy and Germination	2 (1+1)	I
SST 503*	Seed Production Principles and Techniques in Field Crops	3 (2+1)	II
SST 504*	Seed Production Principles and Techniques in Vegetable Crops	3 (2+1)	I
SST 505	Seed Production Techniques in Fruits, Flowers, Spices, Plantation and Medicinal Crops	3 (2+1)	
SST 506	Seed Production Techniques in Forage, Pasture and Green Manure Crops	2 (1+1)	II
SST 507*	Seed Legislation and Certification	3 (2+1)	I
SST 508*	Post Harvest Handling and Storage of Seeds	3 (2+1)	II
SST 509*	Seed Quality Testing and Enhancement	2 (1+1)	II
SST 510	Seed Technology of Tree Species	2 (1+1)	
SST 511	Seed Industry and Marketing Management	2 (1+1)	
SST 512	Seed Health Testing and Management	2 (1+1)	
	Major Courses (minimum 20 credits from above courses including *marked Courses)	20	
	Minor Courses	08	
	Supporting Courses	06	
	Common Courses	05	
SST 591	Seminar	01	
SST 599	Research	30	
	Total Credits	**70**	

*Compulsory Major Courses

Course Contents
M.Sc. (Ag) in Seed Science and Technology (SST)

I. Course Title : Seed Developmental Biology*

II. Course Code : SST 501

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Floral biology – types of pollination, mechanisms; sporogenesis – micro and mega sporogenesis; gametogenesis – development of male and female gametes and their structures; pollination and fertilization – mode of pollination, double fertilization, factors affecting pollination, fertilization; self-incompatibility and male sterility.

Unit II

Embryogenesis – development of monocot and dicot embryos – embryo plane formation – development of endosperm, cotyledons and seed coat – hard seed; apomixis – identification, classification, significance and its utilization; poly-embryony – types and significance; haplontic and diplontic sterility system, causes of embryo abortion, embryo rescue technique; somatic embryogenesis.

Unit III

Seed development – source of assimilates – mechanism of translocation; chemical composition – synthesis and deposition of storage reserves – starch, protein, fat and secondary metabolites – hormonal regulation.

Unit IV

Maturation drying – orthodox and recalcitrant seeds – desiccation tolerance – mechanism – structural changes during desiccation – role of LEA protein.

Unit V

Seed maturity indices – physiological and harvestable maturity; biotic and abiotic factors influencing seed development – development of hard seeds.

V. Practical

- Study on floral biology of monocot;Study on floral biology of dicot plants;
- Study on pollen morphology of different crops;Pollen germination and viability test in major crops;Seed embryo and endosperm development in monocots;Seed embryo and cotyledon development in dicots;Anatomy and morphology of seed coat during development;Hard seed coat development;Study on external and internal structures;Seed development and maturation in agricultural crops – physical and physiological changes;Seed development and maturation in horticultural crops – physical andphysiological changes;Study of biochemical changes during seed development and maturation in agricultural crops;Study of biochemical changes during seed development and maturation in horticultural crops;Study on physiological and harvestable maturity and maturity indices in differentcrops;Study on acquisition of seed dormancy and germination at different stages ofmaturity;Preparation of seed album and identification of seeds.

VI. Suggested Reading

Adkins SW, Ashmore SE and Navi SC. 2007. *Seeds: Biology, Development and Ecology*. CAB International, Oxfordshire, UK.

Bewley JD and Black M. 1994. *Seeds: Physiology of Development and Germination*. Springer, New York.

Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. *Seeds: Physiology of Development, Germination and Dormancy*. Springer, New York.

Black M, Bewley JD and Halmer P. 2006. *The Encyclopedia of Seeds: Science, Technology and Uses*. CAB International publications, UK.

Chhabra AK. 2006. *Practical Manual of Floral Biology of Crop Plants*. Department of Plant Breeding, CCSHAU, Hisar.

Copeland, LO and McDonald MB. 2001. *Principles of Seed Science and Technology*. 4th Ed. Kluwer Academic publishers, USA.

Frankel R and Galun E. 1977. *Pollination Mechanisms, Reproduction and Plant Breeding*. Springer Verlag, New York.

Hesse MH, Haidemarie R, Zettler M, Webber R, Buchner AR, Radivo and Ulrich S. 2009. *Pollen Terminology. An illustrated hand book*. Springer Verlag, New York.

Kozlowski. TT. 2012. *Seed Biology: Importance, Development and Germination*. (Vol. I). Academic Press Inc., New York.

Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.

VII. Suggested e-books

https://www.springer.com/in/book/9783642810619
https://www.springer.com/in/book/9780792373223
https://www.springer.com/gp/book/9780792346456
https://www.cabi.org/bookshop/book/9780851997230
https://www.worldcat.org/title/seed-development-and-germination/oclc/44954614
https://books.google.co.in/books/about/Seeds.html?id=-Zbzr1F_z74C&redir_esc
https://books.google.co.in/books/about/Seeds.html?id=6S75BwAAQBAJ& printsec=frontcover& source=kp_read_button&redir_esc=y#v=onepage&q&f=false

VIII. Suggested websites

https://agriinfo.in/botany/18/
http://www.seedbiology.de/structure.asp
http://www.fao.org/3/ad232e/AD232E02.htm
sbc.ucdavis.edu/Research_pages/Seed_physiology_and_technology/
https://courses.lumenlearning.com/wm-biology2/chapter/development-seeds-fruit
www.iari.res.in/indeX.php?option=com_content&view=article&id=449& Itemid=137

I. Course Title : Seed Dormancy and Germination

II. Course Code : SST 502

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Seed dormancy – definition, concept and theories – significance – evolution; classification and mechanism of dormancy – ecological singnificance.

Unit II

Induction of dormancy during development – hormonal, physiological, molecular and genetic control of dormancy – maternal and paternal contribution; environmental factors influencing dormancy induction and release – seasonal influence – winter and summer annuals – secondary dormancy induction mechanism; artificial induction of dormancy and release; soil seed bank – natural release of dormancy and its mechanism; dormancy breaking – principles and methods.

Unit III

Seed germination – types and phases of germination; imbibition – pattern and water kinetics – events of germination – physical, physiological, biochemical changes -aerobic and anaerobic respiration quiescent.

Unit IV – Physiological and biochemical changes

Enzyme activation – mechanism – factors affecting enzyme activation – breakdown of stored materials – starch, protein and fat – energy generation – mobilization of storage reserves – changes in phenolic compounds.

Unit V – Molecular and genetic mechanisms

Molecular and genetic control of seed germination – auto tropism; factors affecting germination – media – temperature – light – gases; *in-situ* and viviparous germination – causes and mechanism – pattern of seed germination – tri-phasic curve.

V. Practical

- Seed dormancy – identification of dormancy;Estimation of ABA and GA in dormant and non-dormant seeds;Study on artificial induction of dormancy;Dormancy breaking methods – scarification and stratification;Dormancy breaking methods – hormonal and chemical treatments;Dormancy breaking methods – after ripening and leaching of inhibitors;Dormancy breaking methods – combined treatments;Assessing the period of natural release of seed dormancy;Seed germination – studying the pattern of imbibition;Studying the pattern of seed germination in different media;Study on influence of light and temperature on germination and seedling development;Estimation of hydrolytic enzyme – α amylase in different species;Estimation of hydrolytic enzyme – protease;Estimation of hydrolytic enzyme – lipase;Estimation of dehydrogenase enzyme and respiratory quotient in seeds;Estimation of food reserve composition during seed germination.

VI. Suggested Reading

Baskin C and Baskin JM. 2014. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Academic Press, Cambridge, UK.

Bewley J and Black M. 1994. *Physiology of Development and Germination*. Springer, New York.

Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. *Seeds: Physiology of Development, Germination and Dormancy*. Springer, New York.

Bewley JD and Black M. 1982. *Physiology and Biochemistry of Seeds in Relation to Germination*. Volume 2: Viability, Dormancy and Environmental Control.Springerlink, New York, USA

Benech-Arnold R and Rodolfo S. 2004. *Handbook of Seed Physiology: Applications to agriculture* CRC Press., Florida, USA.

Black M and Bewley JD. 2000. *Seed Technology and its Biological Basis*. CRC Press. Florida, USA.

Bradbeer JW. 1988. *Seed Dormancy and Germination*. Chapman and Hall, New York, USA.

David R. Murray. 1985. *Seed Physiology*. Volume 2: Germination and Reserve Mobilisation. Academic Press, London, UK.

Heydecker W. 1985. *Seed Ecology*. Pennsylvania State University Press, USA.

Khan AA. 1977. *The Physiology and Biochemistry of Seed Dormancy and Germination*. North – Holland Publishing Company, USA.

Kozlowski TT. 2012. *Seed Biology: Importance, Development and Germination*. (Vol. I). Academic Press Inc., New York.

Maiti RK, Sarkar NC and Singh VP. 2012. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur.

Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.

Mayer AM and Mayber AP. 1963. *Germination of Seeds*. Pergamon Press, Oxford, New York.

Prakash M. 2011. *Seed Physiology of Crops*. Satish Serial Publishing house. Azadpur. New Delhi.

Roberts EH. 1972. *Viability of seeds*. Springerlink, New York, USA.

VII. Suggested e-books

https://www.springer.com/in/book/9780792373223
https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1756-1051.2000.tb01610.x
https://www.elsevier.com/books/seeds/baskin/978-0-12-416677-6
https://books.google.co.in/books/about/Physiology_and_Biochemistry_of_ Seeds_in.html?id= 91nsCAAAQBAJ&printsec=frontcover&source=kp_read_ button&redir_esc=y#v= onepage&q&f=false
https://books.google.co.in/books/about/The_Germination_of_Seeds.html? id=aV62AgAAQBAJ& printsec=frontcover&source=kp_ read_button&redir_ esc=y#v=onepage&q&f=false
https://books.google.co.in/books/about/Seed_Dormancy_and_Germination. html?id=18HeBw AAQBAJ&printsec=frontcover&source=kp_read_button&redir_esc=y#v=onepage&q&f=false

VIII. Suggested websites

https://agriinfo.in/botany/18/
https:/sproutnet.com/seed-dormancy/
https://www.britannica.com/science/germination
http://www.biologyreference.com/Re-Se/Seed-Germination-and-Dormancy.html
https://www.intechopen.com/books/advances-in-seed-biology/seed-dormancy

I. Course Title : Seed Production Principles and Techniques in FieldCrops*

II. Course Code : SST 503

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Importance of seed – seed quality concept – factors influencing seed production; generation system of seed multiplication – classes of seed, stages of seed multiplication in varieties and hybrids – seed multiplication ratio (SMR) – seed replacement rate (SRR) – seed renewal period (SRP) – varietal replacement rate (VRR).

Unit II

Genetic and agronomic principles of variety and hybrid seed production; methods and techniques of seed production in varieties and hybrids of important cereals and millets – wheat, oat, rice, maize, sorghum and pearl millet; varietal seed production in small millets – finger millet, foX tail millet, little millet, kodo millet, proso millet and barnyard millet.

Unit III

Methods and techniques of varietal seed production in major pulses – black gram, green gram, cowpea, chickpea, horse gram, soybean and lentil – varietal and hybrid seed production in red gram.

Unit IV

Methods and techniques of seed production in major oil seed crops – groundnut, sesame – varietal and hybrid seed production in sunflower, castor and mustard; varietal seed production in minor oilseed crops (safflower, linseed, niger) – varietal and hybrid seed production in cotton – varietal seed production in jute.

Unit V

Seed production planning for varieties and hybrids of major crops; participatory seed production – seed hubs, seed village concept and community seed bank.

V. Practical

- Seed selection – quality of seed on field establishment;Sowing and nursery management techniques;Planting – age of seedling on crop establishment – rice and pearl millet;Isolation distance and border rows in hybrid seed production field – space andbarrier isolation; modifying isolation based on border rows in maize;Planting design for hybrid seed production – rice, maize, pearl millet, cotton, redgram, sunflower;Practicing breeding tools for hybrid seed production – detasseling – emasculationand dusting;Study on methods of achieving synchronization – rice, bajra, sunflower;Practicing supplementary pollination – rice and sunflower;Study on foliar nutrition and influence on seed yield;Practicing roguing operation – identification of off-types, pollen shedders, shedding tassels, partials, selfed bolls;Pre and post harvest sanitation operations – cereals, millets and pulses;Estimation of shattering and shattering loss; study on insitu germination andloss;Visit to seed production fields;Visit to seed industry;Seed production planning and economics of seed production – varieties;Seed production planning and economics of seed production – hybrids.

VIII. Teaching methods

IX. Suggested Reading

Agrawal RL. 2019. *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.

Hebblethwaite PD. 1980. *Seed Production*. Butterworth Heinemann Ltd., London, UK.

Joshi AK and Singh BD. 2004. *Seed Science and Technology*. Kalyani Publishers, New Delhi.

Kulkarni GN. 2011. *Principles of Seed Technology*. Kalyani Publishers, New Delhi.

Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.

McDonald MB and Copeland L. 1998. *Seed Production Principles and Practices*. CBS Publishers, New Delhi.

Mondal SS, Saha M and Sengupta K. 2009. *Seed Production of Field Crops*. New India Publishing Agency, New Delhi.

Singhal NC. 2003. *Hybrid Seed Production in Field Crops*. Kalyani Publications, New Delhi.Sen S and Ghosh N. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.

Singhal NC. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.

X. Suggested e-books

https://www.springer.com/in/book/9780792373223

https://www.springer.com/in/book/9780412075513

https://www.nipabooks.com/info/9788190723763/seed-production-of-field-crops

https://www.amazon.in/Production-Field-Crops-Brajesh-Tiwari/dp/9380179405

https://www.cambridge.org/core/journals/journal-of-agricultural-science/article/seed-production-of-agricultural-crops-by-kelly-a-f-227-pages-harlow-longman-1988-price-2500-hard-covers-isbn-0-582-40410-x/8BE3C99DFDC0F02D48E CB53418504D10

XI. Suggested websites

https://agriinfo.in/botany/18/

http://www.fao.org/3/a-e8935e.pdf

http://www.agriquest.info/seed_production.php

http://agritech.tnau.ac.in/seed_certification/seedtech_index.html

http://coin.fao.org/coinstatic/cms/media/16/13666518481740/seed_enterprises_enhacement_and_development_project_in_sierra_leone_mission_1_report_.pdf

I. Course Title : Seed Production: Principles and Techniques inVegetable Crops*
II. Course Cod : SST 504
III. Credit Hours : 3 (2+1)

V. Theory

Unit I

Importance and present status of vegetable seed industry – factors influencing vegetable seed production; varietal and hybrid seed production techniques in major solanaceous vegetable crops – tomato, brinjal, chilli; malvaceous vegetable crop – seed production techniques of bhendi.

Unit II

Varietal and hybrid seed production techniques in important cucurbitaceous vegetables – gourds and melons, cole crops – cauliflower, cabbage, knol-khol, root vegetables – carrot, beetroot, turnip, radish and other temperate/ hilly vegetable crops.

Unit III

Varietal seed production techniques in major leguminous vegetables – peas and beans; seed production techniques in leafy vegetables – amaranthus, palak, spinach, and lettuce.

Unit IV

Seed production techniques in tuber crops – potato, sweet potato, colocasia, tapioca and yam, seed-plot technique in potato – true potato seed (TPS) production techniques – seed production techniques in bulb crops – onion, garlic.

Unit V

Vegetative and clonal multiplication – methods, merits and demerits; clonal multiplication – potato, sweet potato, colocasia, tapioca and yam.

VI. Practical

- Identification of vegetable seeds;Study on sowing and nursery management;Study on transplanting and age of seedling on crop establishment;Studying floral biology of solanceous, malvaceous and ucurbitaceous vegetablecrops;Studying floral biology of other vegetable crops;Practicing planting design for hybrid seed production;Modification of sex ratio in cucurbits;Practicing emasculation and pollination methods;Practicing roguing operations – identification of off-types – selfed fruits;Harvesting methods – single and multiple harvesting method;Practicing seed extraction methods – wet methods – tomato, brinjal, othercucurbitaceous fruits;Seed extraction – dry methods – chillies, bhendi, cucurbitaceous;Visit to seed production fields;Visit to private seed industry;Planning and economics of varietal seed production;Planning and economics of hybrid seed production.

IX. Suggested Reading

Agarwal RL. 2012. *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi. Chadha KL. 1995. *Advances in Horticulture*. Volume 1 to 13. Malhothra Publishing House,New Delhi.

George RAT. 1985. *Vegetable Seed Production*. Lonhman Inc., New York.

Hebblethwaite PD. 1980. *Seed Production*. Butterworth Heinemann Ltd, London, UK. Kulkarni GN. 2011. *Principles of Seed Technology*. Kalyani Publishers, New Delhi.

Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.

McDonald MB and Copeland L. 1998. *Seed Production: Principles and Practices*. CBS

Publishers, New Delhi.
Sen S and Ghosh N. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.
Singhal NC. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.
Vanangamudi K, Natarajan N, Srimathi P, Natarajan K, Saravanan T, Bhaskaran M, Bharathi A, Natesan P and Malarkodi K. 2006. *Advances in Seed Science and Technology*. Vol. 2. *Quality Seed Production in Vegetables*. Agro bios, Jodhpur.

X. Suggested e-books

https://www.springer.com/in/book/9780792373223
http://203.64.245.61/fulltext-pdf/EB/1900-2000/eb0021.pdf
http://www.worldseed.org/wp-content/uploads/2017/01/Seed-Production-Good-practice-10.01.17-final.pdf
https://trove.nla.gov.au/work/6862691?q&sort=holdings+desc&-=1541066209 257&versionId=45008917+251246346

XI. Suggested websites

https://agriinfo.in/botany/18/
http://agritech.tnau.ac.in/seed_certification/seedtech_index.html
http://www.yspuniversity.ac.in/vgc/caft/Compendium2017-18.pdf
https://www.hort.vt.edu/Welbaum/seedproduction/Principles5.html
http://www.agrimoon.com/wp-content/uploads/Seed-Production-of-Vegetable.pdf
http://www.ciks.org/downloads/seeds/4.%20Seed%20Production%20Techniques %20for%20Vegetables.pdf

I. Course Title : **Seed Production Techniques in Fruits, Flowers, Spices, Plantation and Medicinal Crops**

II. Course Code : **SST 505**

III. Credit Hours : **3 (2+1)**

IV. Theory

Unit I

Scope for seed production in fruits, flowers, spices, plantation and medicinal crops; factors influencing seed production and quality; propagation methods – seed and clonal propagation; seed and seedling standards; propagation and seed production techniques in major tropical, sub-tropical and temperate fruit crops; seed orchards – seed collection, extraction processing and storage techniques.

Unit II

Seed production techniques in commercially important flower crops – nursery management, clonal propagation, planting, seed crop management, post-harvest seed handling and storage techniques.

Unit III

Seed production techniques in commercially important seed spices and other spices – nursery management, sowing, seed crop management and post-harvest seed handling and storage techniques.

Unit IV

Seed production in commercially important plantation crops – mother tree selection – criteria – nursery management, elite seedling production, planting, plantation management, post-harvest handling and storage techniques.

Unit V

Methods of quality seed production in commercially important medicinal plants – nursery management, sowing, seed crop management, post-harvest handling and storage methods.

V. Practical

- Study on the floral biology and pollination mechanism;Identification of seeds of fruits, flowers, spices, plantation and medicinal crops;Selection of mother plants and trees – phenotypic characters and genotypic characters;Study on different types of clonal and vegetative propagules;Seed and clonal standards of vegetatively propagating crops;Germination improvement treatments for seeds and vegetative propagules;Study on selection of planting materials and sowing methods;Nursery management practices for elite seedling production;Seed extraction methods – wet method and dry method;Post harvest seed handling – seed grading, upgrading techniques;Study of seed storage techniques;Practicing seed germination enhancement techniques in fruits, spices andplantation crops;
- Practicing seed germination enhancement techniques in flowers and medicinal crops;Planning for seed production – economics of seed production in flower crops;Visit to mother tree orchard;Visit to plantation and orchard.

VI. Suggested Reading

Chadha KL. 1995. *Advances in Horticulture*. (Volume 1 to 13). Malhotra Publishing House, New Delhi.

Hartman HT and Kester DE. 2000. *Plant Propagation: Principles and Practices*. Prentice Hall,

New Jersey, USA.
Singh SP. 2001. *Seed Production of Commercial Vegetables*. Agrotech, New Delhi.
Vanangamudi K and Natarajan K. 2008. *Advances in Seed Science and Technology*. *Quality Seed Production in Spices, Plantation, Medicinal and Aromatic crops* (Vol. 5). Agrobios. Jodhpur.
Vanangamudi KM Prabu and Lakshmi S. 2012. *Advances in Seed Science and Technology Vol. 7. Flower Seed Production*. Agrobios, Jodhpur.

VII. Suggested e-books

http://www.worldseed.org/wpcontent/uploads/2017/01/Seed-Production-Good-practice-10.01.17-final.pdf
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4233836/
https://www.academia.edu/35629702/Hybrid_Seed_Production_and_Flowers
http://www.agrimoon.com/horticulture-icar-ecourse-pdf-books/
https://cbp.icar.gov.in/EBook.aspx

VIII. Suggested websites

www.cimap.res.in/english/index.php
www.dmapr.org.in/amprs.kau.in/basic-page/publications
http://ecoursesonline.iasri.res.in/course/view.php?id=153
http://ecoursesonline.iasri.res.in/course/view.php?id=612
http://www.celkau.in/Crops/Plantation%20Crops/Rubber/production.aspx
http://sbc.ucdavis.edu/Courses/Seed_Production/

I. Course Title : Seed Production Techniques in Forage, Pasture and Green Manure Crops

II. Course Code : SST 506

III. Credits Hours : 2 (1+1)

IV. Theory

Unit I

Scope and importance of seed production in forage, pasture and green manure crops – factors influencing seed production – seasonal influence; problems and constraints in seed production – seed set, shattering and seed dormancy; vegetative and clonal propagules and apomictic seed.

Unit II

Quality seed production techniques in major fodder crops – lucerne, hedge lucerne, leucaena, fodder sorghum, fodder maize and oats.

Unit III

Seed and planting material production techniques of major forage grasses – bajra -napier grass, guinea grass, deenanath grass and *Cenchrus* sp.; forage legumes *Stylosanthus*, cowpea and berseem.

Unit IV

Seed production techniques in major green manure crops – *Glyricidia*, *Sesbania* sp., sunnhemp, daincha, jute and *Tephrosia* sp.

Unit V

Post-harvest seed handling – processing, threshing, grading and upgrading; dormancy breaking and germination improvement – quality standards for seed and vegetative propagules.

V. Practical

- Seed collection and identification of seeds;Estimation of seed setting and shattering loss;Maturity indices – determination of physiological and harvestable maturity;Seed extraction and threshing methods;Separation of ill filled seeds – practicing different methods;Study of seed and clonal materials – standards;Quality of planting material and vegetative propagules on crop establishment;Seed quality analysis in forage and fodder crops – tiller wise quality analysis;Seed quality analysis in determinate and indeterminate crops;Study on effect of ratooning on seed quality;Practicing seed quality enhancement techniques;Practicing different seed extraction and dormancy breaking treatments;Preparation of vegetative propagules and planting;Planning for seed production in fodder and green manure crops;Economics of seed production in fodder, forage crops and green manure crops;Visit to forage and fodder seed production farms.

VIII. Teaching Methods

IX. Suggested Reading

FAO. 2007. *Quality Declared Seed System*. FAO Plant Production and Protection Publication, FAO, Rome.

Farity DT and Hampton JC. 1997. *Forage Seed Production*. Vol. I. *Temperate Species*. CAB International Publications. UK.

Froma J. 1997. *Temperate Forage Legumes*. CAB International Publications. UK.

Gutterridge RG. 1997. *Forage Tree Legumes in Tropical Agriculture*. CAB International Publications, UK.

Masilamani S and Sivasubramanian K. 2016. *Seed Production in Green Manures*. Kalyani Publications, New Delhi.

X. Suggested e-books

https://www.cabi.org/bookshop/book/9780851992143
https://cgspace.cgiar.org/handle/10568/49375
http://www.fao.org/docrep/009/a0503e/a0503e00.htm
http://www.igfri.res.in/pdf/old_bulletins/tropical_pasture.pdf
https://cgspace.cgiar.org/bitstream/handle/10568/4479/Seed.pdf?sequence= 1&isAllowed=y

XI. Suggested websites

www.igfri.res.in/
https://cgspace.cgiar.org/handle/10568/4479
https://www.euroseeds.eu/grasses-and-clovers
https://www.sare.org/learning-center/green-manures
www.ndri.res.in/ndri/Design/forageres_mag_cen.html
http://orgprints.org/30588/1/Sort%20Out%20Your%20Soil.pdf

I. Course Title : Seed Legislation and Certification*

II. Course Code : SST 507

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Genesis of seed Industry in India; seed quality control – concept and objectives; regulatory mechanisms – Seed Act (1966) – Seed Rules (1968) – statutory bodies – Central Seed Committee – Central Seed Certification Board.

Unit II

Seed Control Order (1983) – New Policy on Seed Development (1988) – Exim Policy – National Seed Policy (2002) – Plant Quarantine Act.

Unit III

Introduction to WTO and IPR – UPOV and its role – OECD seed certification schemes – PPV & FR Act (2001) and Rules (2003) – Seed Bill (2004 and 2011): Seed certification system in SAARC countries, Europe, Canada, Australia and USA.

Unit IV

Seed certification – history and objectives; general and specific crop standards, field and seed standards; seed certification agency – role of certification agency/ department and seed certification officers, phases of seed certification; field inspection – counting procedures – liable for rejection (LFR) – downgrading and partial rejection – reporting.

Unit V

Post-harvest inspection – construction of seed lot number; seed sampling – testing – labeling, sealing and grant of certificate – types and specifications for tags and labels; seed lot validity and revalidation; appellate authority, stop sale order, penalties records and registers to be maintained by seed processing units and seed dealers – verification procedures, role of seed analyst and seed inspector in quality regulation.

V. Practical

- Preparation of sowing report – varieties – transplanted and direct sown crops and hybrids;Verification of sowing report – seed certification procedures;Field inspection – estimation of area and isolation distance, stages of inspectionfor varieties and hybrids – procedures;Practicing field counting procedures – methods for row planting, broadcasted –varieties;Practicing field counting procedures – direct sown and transplanted crops –varieties;Study on field counting procedures – hybrids – planting design, planting ratio andblock method and double count;Identification of contaminants – genetic and physical contaminants, procedure toremove partials, pollen shedders and shedding tassels;Assessing and calculation of field standards for important crops;LFR, partial rejection and downgrading – reasons, procedures and preparation ofreports;Yield estimation – single and multiple harvest crops;Post harvest inspection – groundnut, cotton, pulses;Inspection and maintenance (licence and renewal) of records in processing unit –float test, preparation of processing report and seed lot number construction;
- Visit to seed certification agency/ department;Visit to grow-out test field;Visit to seed retail shop – procedures followed by Seed Inspector, verification ofrecords and reporting;Procedure to issue tag, specification, bagging, tagging, labelling and sealing.

VI. Suggested Reading

Agarwal RL. 2012. *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.

Anon. 2016. *Manual of Seed Certification Procedures*. Directorate of Seed Certification, Coimbatore, Tamil Nadu.

Chakrabarthi SK. 2010. *Seed Production and Quality Control*. Kalyani Publishers, New Delhi.

Mishra DK, Khare D, Bhale MS and Koutu GK. 2011. *Handbook of Seed Certification*. Agrobios, Jodhpur, Rajasthan.

Neema NP. 1986. *Principles of Seed Certification and Testing*. Allied Publishers, New Delhi

Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. *Seed Legislation in India*. Agrobios, Jodhpur, Rajasthan.

Renugadevi J, Srimathi P, Renganayaki PR and Manonmani V. 2012. *A Handbook of Seed Testing*. Agrobios, Jodhpur, Rajasthan.

Sharma P. 2008. *Seed Legislation*. Gene-tech Book Publishers, New Delhi.

Trivedi PC. 2011. *Seed Technology and Quality Control*. Pointer Publications, Jaipur, Rajasthan.

Tunwar NS and Singh SV. 2003. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, GOI, New Delhi.

VII. Suggested e-books

http://cms.tn.gov.in/sites/default/files/documents/seed-certification-0.pdf

http://odishaseedsportal.nic.in/SeedPortalData/Resource%20Material/INDIAN-MINIMUM-SEED-CERTIFICATION-STANDARDS.pdf

https://www.india.gov.in/my-government/documents/e-books

https://books.google.co.in/books/about/Principles_of_Seed_Certification_and_ Tes.html?id=SQWHAAAACAAJ&redir_esc=y

https://dl.sciencesocieties.org/publications/books/tocs/cssaspecialpubl/theroleofseedce

VIII. Suggested websites

www.fao.org

www.agri.nic.in

www.agricoop.nic.in

www.gov.mb.ca

http:/agritech.tnau.ac.in

www.betterseed.org

www.oecd.org/india/

http://www.tnagrisnet.tn.gov.in/

https://pir.sa.gov.au/_data/assets/pdf_file/0003/148134/SeedCertification Manual.pdf

I. Course Title : Post Harvest Handling and Storage of Seeds*

II. Course Code : SST 508

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Seed processing – objectives and principles; processing sequence – threshing, shelling, ginning, extraction methods; drying – principles and methods; seed cleaning, grading, upgrading – methods – machineries and equipment – scalper, pre-cleaner, cleaner cum grader, specific gravity separator, indented cylinder, disc separator, spiral separator, velvet separator, magnetic separator, electronic colour sorter – working principles and functions.

Unit II

Online seed processing – elevators and conveyers – processing plant – specifications, design and layout; mechanical injury – causes and detection – management.

Unit III

Seed treatment – methods – pre and mid storage seed treatments, seed treating formulations and equipments; packaging materials – types – bagging and labeling; seed blending – principle and methods.

Unit IV

Seed storage – purpose and importance – factors affecting storage, optimum condition for storage of different seeds; storage principles – Harrington's thumb rule – concepts and significance of moisture equilibrium – maintenance of safe seed moisture – physical, physiological, biochemical and molecular changes during seed storage – storage behaviour of orthodox and recalcitrant seeds – prediction of viability – viability nomograph.

Unit V

Methods of seed storage – modified atmospheric storage – ultra dry storage – vacuum storage – cryopreservation – germplasm storage – gene banks – NBPGR, IPGRI and National seed storage laboratory; seed storage godown – structure – maintenance – sanitation.

V. Practical

- Seed extraction – wet and dry methods;Seed processing sequence for different crops;Design of processing plant – equipments – estimation of processing efficiency;
- Seed drying methods – principle and methods;Practicing seed grading – upgrading techniques;Delinting methods – assessment of mechanical damage;Visit to seed processing unit;Seed packaging – effect of packaging materials on seed longevity;Prediction of viability during storage – viability nomograph and accelerated ageingtest;Assessing physical changes during seed storage;Assessing physiological changes during seed storage;Assessing biochemical changes during seed storage;Storage behaviour of recalcitrant seeds;Pre-storage seed treatments – protectants – antioxidants – halogens;Practicing seed blending methods;Seed storage godown – sanitation, fumigation – visit to seed storage godown andcold storage unit.

XI. Suggested Reading

Barton LV. 1961. *Seed Preservation and Longevity*, (Vol. 1). Leonard Hill, London.

Gregg BR, Law AG, Virdi SS and Balis JS. 1970. *Seed Processing*. Avion printers, New Delhi.
Gupta D. 2009. *Seeds: their conservation principles and practices*. Sathish serial publishing house. New Delhi.
Justice OL and Bass LN. 1978. *Principles and Practices of Seed Storage*. Agriculture Hand Book No. 506, Castle House Publication Ltd., Washington.
Kulkarni GN. 2011. *Principles of Seed Technology*. Kalyani Publishers, New Delhi.
Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
Padmavathi S, Prakash M, Ezhil Kumar S, Sathiyanarayanan G and Kamaraj A. 2012. *A Text book of Seed Science and Technology*, New India Publishing Agency, New Delhi.
Sen S and Ghosh N. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.
Singhal NC. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.

XI. Suggested e-books

http://dfsc.dk/pdf/Handbook/chapter8_internet.pdf
https://naldc.nal.usda.gov/download/CAT87208646/PDF
https://www.springer.com/in/book/9780792373223
http://203.64.245.61/fulltext-pdf/EB/1900-2000/eb0021.pdf
https://www.kopykitab.com/ebooks/2016/05/6997/sample/sample_6997.pdf
https://trove.nla.gov.au/work/6862691?q&sort=holdings+desc&-=1541066209257 &versionId=45008917+251246346

http://www.worldseed.org/wp-content/uploads/2017/01/Seed-Production-Good-practice-10.01.17-final.pdf

XII. Suggested websites

http://www.fao.org/3/a-ah803e.pdf
agritech.tnau.ac.in/seed_certification/seedtech_index.html
http://ecoursesonline.iasri.res.in/mod/page/view.php?id=17806
http://www.bcseeds.org/wp-content/uploads/2015/01/Seed-Processing-2015-update.pdf
https://www.carolinafarmstewards.org/wpcontent/uploads/2012/05/Seed Processingand StorageVer_1pt3.pdf

I. Course Title : Seed Quality Testing and Enhancement*

II. Course Code : SST 509

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Seed testing – history and development; seed testing in India; ISTA and its role in seed testing; seed lot and size, types of seed and size, samples – sampling – intensity and methods, sampling devices, receipt and registration of submitted samples in the laboratory and sub sampling; purity analysis – components and procedure – determination of other distinguishable varieties (ODV) and test weight determination – application of heterogeneity test – method of testing coated and pelleted seeds; seed moisture estimation – principles and methods, application of tolerances.

Unit II

Seed germination test – requirements, media and methods – seedling evaluation, tolerance and reporting results; viability test (TZ test) – principle, procedure and evaluation; vigour tests – concept of seed vigour and vigour test – types of vigour tests – direct and indirect tests – physical, physiological and biochemical tests – principles and methods; seed health test – principles and methods.

Unit III

Genetic purity assessment – laboratory methods – physical, chemical, biochemical and molecular tests – growth chamber and field testing (Grow Out Test) methods; testing of GM seeds; storage of guard sample – referral test; application of tolerance in seed testing; advanced non destructive techniques of seed quality analysis – soft X-ray imaging – hyper spectral imaging, thermal imaging – spectroscopy – e-nose and machine vision techniques.

Unit IV

Seed quality enhancement techniques – history and development; classification – physical, physiological and protective seed treatments – special seed treatments; physical seed treatment – liquid floatation, specific gravity separation, irradiation, electric and electro-magnetic seed treatments – principles and methods – seed pelleting and coating principles, purpose and methods.

Unit V

Physiological seed enhancement treatments – seed infusion, seed priming – principles and methods – physiological, biochemical and molecular mechanisms; pre-germination and fluid drilling techniques; biological seed treatments – microbial inoculation; organic seed treatment – integrated seed treatment – concept and methods of designer seed.

V. Practical

- Seed testing – sampling and dividing methods;Determination of seed test weight and heterogeneity test;Physical purity analysis – components, procedure, reporting results;Seed moisture estimation – methods and equipments;Conduct of seed germination test and seedling evaluation;Conduct of quick viability (tetrazolium) test and evaluation;Conduct of vigour tests – direct, indirect test and special tests;Genetic purity assessment – laboratory and conventional methods – image analysisfor seed quality;Conducting different seed health tests to identify bacteria, fungi and insects;Visit to seed testing laboratory;Seed enhancement techniques – practicing physical treatments and water floatationtechniques;Seed

coating and pelleting – uses of adhesives and filler materials;Performing seed priming – hydro, halo and bio-priming – solid matrix priming;Practicing seed infusion and microbial inoculation treatments;Practicing pre-germination technique;Studying integrated seed treatment/ designer seed treatment.

VI. Suggested Reading

Agrawal PK. 1993. *Hand book of Seed Testing*. Ministry of Agriculture, GOI, New Delhi

Agrawal RL. 1997. *Seed Technology*. Oxford & IBH.

Agrawal PK and Dadlani M. 1992. *Techniques in Seed Science and Technology*. 2nd Ed. South Asian Publications.

Chakrabarthi SK. 2010. *Seed Production and Quality Control*. Kalyani Publishers. New Delhi.

Chalam GV Singh A and Douglas JE. 1967. *Seed Testing Manual*. ICAR and United States Agency for International Development, New Delhi.

Copeland LO and McDonald MB. 2001. *Principles of Seed Science and Technology*. 4th Ed. Kluwer Academic publishers, USA.

International Seed Testing Association. 2018. *Handbook on Seedling Evaluation*, 4th Edition, Published by ISTA, Zurichstr, Switzerland.

International Seed Testing Association. 2019. *International Rules for Seed Testing* 2019. Published by ISTA, Zurichstr, Switzerland.

ISTA. 1999. *Seed Science and Technology*, 27th supplement.

Renugadevi J, Srimathi P, Renganayaki PR and Manonmani V. 2012. *A Hand book of Seed Testing*. Agrobios. Jodhpur, Rajasthan.

Tridevi PC. 2011. *Seed Technology and Quality Control*. Pointer Publication. Jaipur, Rajasthan.

Vasudevan SN, Doddagowder SR, Rakesh CM and Patil SB. 2013. *Seed Testing and Quality Control*. Agrotech Publications, Udaipur, Rajasthan.

VII. Suggested e-books

http://odishaseedsportal.nic.in/SeedPortalData/Resource%20Material/INDIAN MINIMUM SEED CERTIFICATION STANDARDS.pdf.

www.kopykitab.com/Seed-Testing-and-Quality-Control-by-Vasudevan-SN

https://www.jstor.org/stable/10.14321/j.ctt7zt51m

https://link.springer.com/chapter/10.1007/978-1-4615-1619-4_13

https://www.researchgate.net/publication/269694458_QUALITY_SEED_ PRODUCTION_ITS_ TESTING_AND_CERTIFICATION_STANDARD

https://www.seedtest.org/upload/cms/user/ISTAMethodValidationforSeed Testing-V1.01.pdf

https://www.intechopen.com/books/new-challenges-in-seed-biology-basic-and-translational-research-driving-seed-technology/recent-advances-in-seed-enhancements

VIII. Suggested websites

http://agritech.tnau.ac.in/seed/Seed_seedtesting.html

https://core.ac.uk/download/pdf/85210907.pdf

https://www.betterseed.org/resources/seed-testing-accreditation-schemes/

http://sbc.ucdavis.edu/About_US/Seed_Biotechnologies/Seed_Enhancement/

https://www.seedtest.org/en/international-rules-for-seed-testing-content-1-1083. html

I. Course Title : Seed Technology of Tree Species

II. Course Code : SST 510

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Importance of tree seeds – seed quality in plantation establishment – scope of seed production in tree species; seed structure and its significance in natural regeneration of forest species.

Unit II

Reproductive biology – angiosperms and gymnosperms – reproductive age – seasonal influence on flowering – reproductive efficiency; factors influencing seed set – pollination – pollinating agents – self incompatibility – seed dispersal – mode and mechanism of dispersal.

Unit III

Seed stand – selection and delineation – seed production area – seed zone – selection criteria for candidate, plus and elite tree; seed orchards – definition – types – seedling and clonal seed orchard – pollen dilution zone – seed orchard establishment and management; OECD certification programmes for forest reproductive materials and seeds – ISTA certification standards for tree species.

Unit IV

Physiological maturity – maturity indices – determining optimum harvestable maturity; seed collection – methods – factors influencing seed collection – precautions in collection of recalcitrant seeds; seed extraction – methods – wet, dry and cone extraction; drying – critical moisture content – seed processing; dormancy – types of dormancy in tropical, sub tropical and temperate tree seeds – dormancy breaking treatments; recalcitrant seeds – mechanism.

Unit V

Seed production and handling techniques in important tree borne oil seeds (*Madhuca, Pongamia, Azadirachta, Simaruba, Callophyllum*), timber (teak, sandal, pine, cedar, red sanders, shisham), fuel wood (*Acacias*), pulp wood (Bambusa, *Ailanthus, Casuarina, Melia, Eucalyptus*), fodder (*Leucaena, Albizzia*) and ornamental (*Cassia, Delonix*) tree species.

V. Practical

- Study of tree seed structure – internal and external structures;Study on phenology of different tree species;Selection procedure of candidate and plus trees;Assessment of seed set, physiological and harvestable maturity;Assessing natural regeneration in different tree species;Study on seed dispersal methods and dispersal distance in different species;Seed collection techniques in important tree species – seed collection – orthodoxand recalcitrant seeds – safety measures during collection;Seed extraction methods – wet and dry extractions – fruits, pods, cones, etc.;Study on different seed drying methods and precautions;Practicing seed grading and upgrading techniques;Practicing seed dormancy breaking methods;Germination improvement treatments for elite seedling production;Study on storage of recalcitrant seed;Estimation of critical moisture content for safe storage;Visit to seed production area and seed orchard;Visit to tree seed processing unit.

VI. Suggested Reading

Dennis AJ, Schepp EN, Green RJ and West cott DA. 2007. *Seed Dispersal*. Agrobios, Jodhpur.

Khanna LS. 1993. *Principles and Practices of Silviculture*. Khanna Bandhu, Dehradun, India.

Lars Schmidt 2000. *Guide to Handling of Tropical and Sub Tropical Forest Seed*. Danida Forest Seed Centre, Denmark.

Negi SS. 1998. *Forest Tree Seed*. International Book Distributors, Dehradun, India.

Ram Prasad and Khandya AK. 1992. *Handling of Forestry Seeds in India*. Associated Publishers, New Delhi.

Sivasubramaniam K, Raja K and Geetha R. 2012. *Recalcitrant Seeds – Causes and Effects*. Sathish Serial Publishing House. Azadpur, New Delhi.

Umarani R and Vanangamudi K. 2004. *An Introduction to Tree Seed Technology*. International Book Distributors, Dehradun.

Vanangamudi K, Natarajan K, Saravanan J, Natarajan N, Umarani R, Bharathi A and Srimathi P. 2007. *Advances in Seed Science and Technology: Forest Tree Seed Production* (Vol. 4). Agrobios, Jodhpur

Willan RL. 1985. *A guide to Forest Seed Handling*. FAO, Rome

Zoebel B and Talbert TT. 1984. *Applied forest tree improvement*. Joh willey and Sons, New Yark.

VII. Suggested e-books

http://www.fao.org/3/a-ah803e.pdf
http://www.fao.org/3/ad232e/AD232E01.htm
https://www.springer.com/gp/book/9783540490289
http://www.fao.org/docrep/006/ad232e/ad232e00.htm
http://envis.nic.in/ifgtb/pdfs/Tree%20Seed%20Management.pdf
https://www.forestry.gov.uk/PDF/FCBU054.pdf/$FILE/FCBU054.pdf
https://www.forestry.gov.uk/PDF/FCBU059.pdf/$FILE/FCBU059.pdf

VIII. Suggested websites

www.ista.org.in
ifgtb.icfre.org/indeX.php
http://www.kfri.res.in/research.asp
http://www.fao.org/3/ad232e/AD232E21.htm
https://www.srs.fs.usda.gov/pubs/gtr/gtr_so107.pdf
http://www.sfri.nic.in/pdf_files/Seed%20Technology.pdf

I. Course Title : Seed Industry and Marketing Management

II. Course Code : SST 511

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Introduction to seed industry – genesis, growth and structure of seed industry – mission and objectives – present status of Indian and global seed industry – role of seed industry in Indian agriculture; government initiatives – seed hubs, seed villages and community seed production system.

Unit II

Seed industry – organization set up and functions – public, private, MNC's, seed corporations; structure of small, medium and large seed industries, components of seed industry – public private partnership – custom seed production – risk management – human resource – infrastructure – processing unit – storage go down.

Unit III

Seed production and distribution systems in state and central government; seed supply chain systems – seed production and distribution – planning, organization and coordination, staffing, assembling of resources; cost of seed production – overhead charges.

Unit IV

Seed marketing – definition – importance – role of marketing; type of markets – domestic and global market – problems and perspectives; marketing policies – seed marketing schemes – marketing channels, responsibilities of dealers – marketing mix.

Unit V

Seed demand forecasting – purpose – methods and techniques; indenting and seed dispatch procedures and forms – seed store records – maintenance – missing link in seed supply chain; market intelligence – SWOT analysis; seed cost analysis; seed pricing – policy – components of seed pricing – factors – local market rate (LMR) – fixation of procurement and sale price of seed.

V. Practical

- Data collection on status of Indian and global seed industry;Assessing the factors influencing farmers preference and assessment of seed demand and supply;Planning for establishment of small, medium and large seed industry;Planning for establishment of seed production and processing unit;Economics of seed production – varieties and hybrids;Seed pricings and cost analysis;Exercise on fixing seed procurement and sale price;Study of marketing channels – domestic and international;Maintenance of carryover seeds – Assessing risk factors in seed industry and theirmanagement;
- Survey and interaction with seed dealers and distributors;
- Visit to state seed corporations;
- Visit to MNCs and expert discussion;
- Case studies and SWOT analysis;
- Visit to modern seed processing unit and advanced seed storage complex;
- Custom seed production, contract farming and procurement – procedures;

- Planning and preparation of project proposal for setup of a seed industry;
- Final practical examination.

VI. Suggested Reading

Acharya SS and Agarwal NL. 2004. *Agricultural Marketing in India*. 4th Ed. Oxford and IBH.
Broadway AC and Broadway A. 2003. *A Text Book of Agri-business Management*.
Kalyani Singh AK and Pandey S. 2005. *Rural Marketing*. New Age Publications.
Kugbei S. 2008. *Seed Economics*. Scientific Publishers, Jodhpur, Rajasthan.
Sharma P. 2008. *Marketing of Seeds*, Green-Tech Book Publishers, New Delhi.
Singh G and Asokan SR. 1991. *Seed Industry in India: A Management Perspective* Oxford & IBH Publishing Co Pvt. Ltd., New Delhi.
Singh S. 2004. *Rural Marketing – Focus on agricultural Inputs*. Vikas Publishing House.

VII. Suggested e-books

https://link.springer.com/chapter/10.1007/978-1-4615-1783-2-15
http://www.fao.org/3/V4450E/V4450E00.htm
https://books.google.co.in/books?id=vPVlBos4WkYC
http://download.nos.org/srsec319new/319EL19.pdf
https://isengewant.de/Marketing-of-Seeds-By-Premjit-Sharma.pdf
https://www.kopykitab.com/A-Handbook-of-Seed-Processing-and-Marketing-by- Gaur-SC

VIII. Suggested websites

www.gov.mb.ca
www.agricoop.nic.in
www.agri.nic.in
https://sathguru.com/seed/
http://www.fao.org/3/V4450E/V4450E03.htm
https://www.seednet.gov.in/smis/SMIS-User%20Manual.pdf
https://www.icrisat.org/seed-systems-models-lessons-learned/
https://www.bookdepository.com/Seed-Industry-India-Gurdev-Singh/

I. Course Title : Seed Health Testing and Management

II. Course Code : SST 512

III. Credit Hours : 2 (1+1)

V. Theory

Unit I

History and economic importance of seed health in seed industry and plant quarantine – important seed borne and seed transmitted pathogens – role of microorganisms in seed quality deterioration – storage and field fungi – effect of storage fungi on seeds – factors influencing storage fungi and management.

Unit II

Transmission of pathogens – mode and mechanism – seed certification standards; mycotoxins – types and its impact on plant, animal and human health; seed health testing methods – direct examination, incubation, serological and molecular methods.

Unit III

Production of disease free seeds in agricultural and horticultural crops; management of seed borne pathogens – plant quarantine – Indian system and networking, post-entry quarantine and international systems – Pest Risk Analysis (PRA); Sanitary and Phytosanitary System (SPS) – certificates; International Seed Health Initiative (ISHI) on seed health standards.

Unit IV

Storage pests – insects, mites, rodents and their development – economic importance; insect infestation – factors influencing, sources and kinds, biochemical changes in stored seeds due to insect infestation; detection methods and estimation of storage losses; types of seed storage structures – domestic and commercial.

Unit V

Fumigation – principles and techniques – type of fumigants; preservatives and seed protectants on seed quality – non-chemical methods for managing seed storage pests – controlled and modified atmospheric storage – trapping devices – IPM for seed storage.

VI. Practical

- Detection of seed borne pathogens – direct examination;Detection of seed borne pathogens – incubation methods;Detection of seed borne pathogens – serological methods;Detection of seed borne pathogens – molecular methods;Study on seed transmission of seed borne fungi, bacteria and viruses;Identification of storage fungi;Management of seed borne pathogens – seed treatment methods;Identification of storage insects – internal and external feeders influencing insects;
- Study on the effect of pre harvest spray on field carryover storage pests;Estimation of storage losses due to pests;Methods of detection of insect infestation;Management of storage pests – pesticides, dose determination, preparation ofsolution and application;Management of storage pests – non-chemical management methods;Demonstration of controlled atmospheric storage;Safe handling and use of fumigants and insecticides;Visit to seed storage godowns.

VII. Suggested Reading

Agarwal VK and Sinclair JB. 1996. *Principles of Seed Pathology*. Edition, CRC Press Inc. Boca Raton, FL.

Athanassiou CG and Arthur FH. 2018. *Recent advances in stored product protection*. Springer-Verlag, Germany

Cotton, RT. 2007. *Insect Pests of Stored grain and Grain products*. Burgess Publ. Co., Minneopolis, Minn., USA

Karuna V. 2007. *Seed Health Testing*. Kalyani Publishers, New Delhi.

Karuna V. 2009. *Fundamentals of Seed Pathology*. Kalyani Publishers, New Delhi.
Neergaard P. 1979. *Seed Pathology*. Vol. 1. The Macmillan Press Ltd.
Ranjeet K. 2017. *Insect Pests of Stored grain – Biology, Behaviour and Management Strategies*. Apple Academic Press, New York, USA.

VIII. Suggested e-books

https://link.springer.com/book/10.1007/978-1-349-02842-9
https://www.crcpress.com/Principles-of-Seed-Pathology/Agarwal-Sinclair/p/book/9780429152856
https://books.google.co.in/books/about/Seed_Pathology.html?id=lvVJAAAAYAAJ &redir_esc=y
https://www.taylorfrancis.com/books/9781315365695
https://www.ebooks.com/en-us/610606/insects-of-stored-products/david-rees/
https://www.elsevier.com/books/insects-and-seed-collection-storage-testing-and-certification/kozlowski/978-0-12-395605-7

IX. Suggested websites

www.tnagrisnet.tn.gov.in/
www.storedgrain.com.au/
https://openlibrary.org/subjects/seed_pathology
http://ciat-library.ciat.cgiar.org/articulos_ciat/2015/12620.pdf
www.grainscanada.gc.ca/en/
https://entomology.ca.uky.edu/ef145
http://www.fao.org/3/t1838e/T1838E00.htm#Contents
https://www.agric.wa.gov.au/pest-insects/insect-pests-stored-grain

Course Title with Credit Load
Ph.D. in Seed Science and Technology (SST)

Course Code	Course Title	Credit Hours
SST 601*	Hybrid Seed Production Technology	3 (2+1)
SST 602	Organic Seed Production	2 (1+1)
SST 603	Physiology and Biochemistry of Seeds	2 (1+1)
SST 604*	Genetic Purity and DUS Testing	3 (2+1)
SST 605	Seed Vigour and Crop Productivity	2 (1+1)
SST 606*	Advances in Seed Science	2 (2+0)
SST 607	Advances in Seed Quality Enhancement	2 (1+1)
SST 608	Germplasm Conservation Techniques	2 (1+1)
SST 609	Seed Ecology	2 (1+1)
SST 610	Seed Planning, Trade and Marketing	2 (1+1)
	courses including *marked Courses)	
SST 691	Seminar I	01
SST 692	Seminar II	01
SST 699	Research	75
	Total Credits	**100**

Comprehensive (Pre-qualifying) Examination (Non-credit of 100 marks) Satisfactory/ Not satisfactory

*Compulsory Major Courses

Course Contents
Ph.D. in Seed Science and Technology (SST)

I. Course Title : Hybrid Seed Production Technology*

II. Course Code : SST 601

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Introduction – history – scope – importance of hybrid development – national and international scenario of seed industry – popular public sector hybrids in various crops. Heterosis – definition – expression – types – utilization of heterosis in hybrid development, hybrid vigour and seed vigour.

Unit II

Types of hybrids – intra-specific, inter-specific hybrids, single, double, three way cross, top cross hybrids – apomixes; generation system of seed multiplication in different types of hybrids. Development and maintenance of inbred lines – male sterile – maintainer lines – fertility restoration – transgenic hybrids – principles and method of development.

Unit III

Breeding tools – genetic mechanism – male sterility – types: CMS, GMS, CGMS, TGMS, PGMS – barnase and barstar system – pistillateness – self incompatibility. Manual creation of male sterility – emasculation and pollination – gametocides – mode of action, mechanism. Synchronization of flowering – problems – methods to achieve synchrony – planting ratio and supplementary pollination methods.

Unit IV

Techniques of hybrid seed production in major agricultural crops – cereals (wheat, rice), millets (maize, sorghum, bajra), pulses (red gram), oilseeds (sunflower, castor, mustard), cotton and forage crops.

Unit V

Hybrid seed production techniques in horticultural crops – tomato, brinjal, chilli, bhendi, onion, bitter gourd, bottle gourd, ridge gourd, cucumber, melon, cabbage, cauliflower, potato, coconut and papaya.

V. Practical

- Characteristics features of parental lines and their hybrids;Floral biology of rice, maize, pearlmillet, sunflower, castor and cotton;Study on floral biology of vegetable crops – solanaceous and other vegetables;Study on floral biology of cucurbitaceous crops;Production and maintenance of A, B and R lines;Practicing planting design and border rows – rice, maize, pearlmillet, sunflowerand red gram; brinjal and chillies;Practicing planting design and border rows in tomato, cotton and cucurbitaceousvegetables;Manipulation for synchronization – rice, sunflower, pearlmillet and sorghum;Practicing supplementary pollination – rice and sunflower;Practicing field inspection in hybrid seed production plot – crops planted in ratio –sunflower, pearlmillet, sorghum, etc.;Practicing field inspection in hybrid seed production field – red gram, castor, cotton,cucurbits and tomato;Practicing roguing and identification of off-types – pollen shedders –

sheddingtassel – selfed fruits;Visit to hybrid seed production fields;Visit to potato seed production plots;Determination of cost benefit of hybrid seed production;Visit to seed Industry and assessing problems and perspectives in hybrid seedproduction.

VIII. Suggested Reading

Agarwal RL. 2012. *Seed Technology*. 3rd Ed. Oxford & IBH Publishers, New Delhi.

Basra A. 1999. *Heterosis and Hybrid Seed Production in Agronomic Crops*. CRC Press., Florida, United States.

Chhabra AK. 2006. *Practical Manual of Floral Biology of Crop Plants*. Department of Plant Breeding, CCSHAU, Hisar.

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Frankel R and Galun E. 1977. *Pollination Mechanisms*, Reproduction and Plant Breeding. Springer Verlag, New York.

Hebblethwaite PD. 1980. Seed Production. Butterworth Heinemann Ltd., London, UK.

Joshi AK and Singh BD. 2004. *Seed Science and Technology*. Kalyani Publishers, New Delhi.

Krishnan M. 2012. *Plant breeding and Hybrid Seed Production*. Domin and Publishers & Distributors, New Delhi, India.

Kulkarni GN. 2011. *Principles of Seed Technology*. Kalyani Publishers, New Delhi.

Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios., Jodhpur, India.

McDonald MF and Copeland LO. 2012. *Seed Production: Principles and Practices*. Springer Science and Business Media, Boston, United States.

Mondal SS, Saha M and Sengupta K. 2009. *Seed Production of Field Crops*. New India Publishing Agency, New Delhi.

Sen S and Ghosh N. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.

Singhal NC. 2003. *Hybrid Seed Production*. Kalyani Publishers., New Delhi, India.

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Singhal NC. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.

Vanangamudi K, Prabhu M, Kalaivani S, Bhaskaran M and Manonmani V. 2010. *Vegetable Hybrid seed Production and Management*. Agrobios., Jodhpur, India.

IX. Suggested e-books

https://www.springer.com/in/book/9780792373223
https://www.springer.com/in/book/9780412075513
https://www.nipabooks.com/info/9788190723763/seed-production-of-field-crops
https://www.kopykitab.com/Vegetable-Hybrid-Seed-Production-And-Management
https://www.researchgate.net/publication/229432295_Hybrid_Seed_Production_ and_Flowers
http://www.worldcat.org/title/seed-production-principles-andractices/oclc
https://libgen.is/search.php?req=Raymond+A++T+George&column=author
https://libgen.is/search.php?req=Raymond%20A%20%20T%20George&column[]= author
https://www.researchgate.net/profile/Gulzar_S_Sanghera/publication/236865752_ Advances_ in_Hybrid_Rice_Technology_through_Applications_ of_Novel_Technologies/links/ 0deec519b46087d815000000.pdf

X. Suggested websites

www.agriquest.info
www.agriinfo.in
www.seedquest.com
https://agriinfo.in/botany/18/
http://www.fao.org/3/a-e8935e.pdf
http://www.agriquest.info/seed_production.php
http://agritech.tnau.ac.in/seed_certification/seedtech_index.html

I. Course Title : Organic Seed Production

II. Course Code : SST 602

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Organic farming – definition, genesis, concepts and principles; importance of organic farming and organic seed; organic seed – strategies, problems and perspectives – organic seed vs conventional seed; organic seed production – factors influencing seed production – soil health – GMO elements of seed.

Unit II

Techniques of organic seed production – selection of land – pre requisite for seed production – conversion period – soil amendments – green manures; multi-varietal seed techniques – organic sources of manures – bulky, concentrated and liquid manures, biofertilizers and biocontrol agents – organic seed treatment.

Unit III

Organic weed management practices – manual and mechanical methods – mulching – thermal weed control; growth promoting substances – *panchakavya*, fish amino acid, etc.; organic plant protection measures – herbal insecticides – IPM strategies; post harvest techniques – drying, processing and grading; organic seed treatment and storage.

Unit IV

Organic certification application – registration – verification of records; organic seed certification – tagging; role of organizations in production and marketing of organic seed – national and international organizations involved – public, private – NGOs – International Federation of Organic Agriculture Movement (IFOAM) – basic standards and EU regulations – organic seed marketing.

Unit V

Crop specific organic seed production and post harvest seed management techniques for major food crops, vegetables and fruit crops – economics of organic seed production and demand for organic seed.

V. Practical

- Studying the field and seed standards for organic seed production;Collection and identification of organic manures and liquids;Preparation of organic products for soil application;Preparation of *panchakavya*, starter solutions and vermiwash;Organic priming of seeds with *panchakavya* and vermiwash;Preparation of leaf extracts and starter solutions and preparation of organic products for foliar application;Studying the effect of organic nutrients and foliar sprays on seed quality;Preparation of organic products for seed treatment and studying the effect on seedquality;Assessing the storage behaviour of organically treated seeds;Selection of suitable container and dry leaves or shrubs for enhanced storability;Organic treatment for management of seed health;Production and assessment of bio control agents for effective pest control;Economics of organic seed production and assessing demand;Visit to organic farm and seed production field;Visit to Department of organic certification;Visit to organic retail shops.

X. Suggested Reading

Bryan Connolly B, Langer J and Lawn CR. 2011. *Organic Seed Production and Saving: The Wisdom of Plant Heritage*. Chelsea Green Publishing, Vermont, USA.

Gehlot D. 2010. *Organic Farming: Components and Management*. Agrobios., Jodhpur, India.

Gehlot D. 2012. *Organic Farming: Standards, Accreditation, certification and Inspection*. Agrobios., Jodhpur, India.
Panda SC. 2012. *Soil Management and Organic farming*, Agrobios., Jodhpur, India.
Panda SC. 2013. *Principles and Practices of organic Farming*. Agrobios., Jodhpur, India.
Suresh N and Deshmukh. 2010. *Organic Farming: Principles, Prospects and Problems*. Agrobios., Jodhpur, India.
White JM. 1995. *Organic Vegetable Production*. UF/IFAS Coop. Ext. Serv., HS720., Florida, United States.

XI. Suggested e-books

https://ufdcimages.uflib.ufl.edu/IR/00/00/33/80/00001/HS22700.pdf
https://www.ifoam.bio/en/organic-landmarks/principles-organic-agriculture
www.apeda.gov.in/apedawebsite/organic/organic.../english_organic_sept05.pd
https://ncof.dacnet.nic.in/Training./Training...in/Cert_and_Inspection_ manual.pdf
https://www.ebooks.com/en-us/96381019/organic-seed-production-and-saving/ bryan-connolly-jocelyn-langer-c-r-lawn/

XII. Suggested website

www.tnocd.net
https://www.sare.org/
https://www.ifoam.bio/
http://www.ncof.dacnet.nic.in
http://edis.ifas.ufl.edu/CV118
www.harrismoran.com/technology/default.htm
https://attra.ncat.org/attra-pub-summaries/?pub=70
http://www.harrismoran.com/technology/default.htm
https://www.academia.edu/4601825/Organic_seed_production
http://www.cals.ncsu.edu/sustainable/peet/IPM/diseases/org_cert.html
https://www.sare.org/Learning-Center/Topic-Rooms/Organic-Production/Organic-Seeds

I. Course Title : Physiology and Biochemistry of Seeds

II. Course Code : SST 603

III. Credit Hours : 2 (1+1)

VI. Theory

Unit I

Seed development and maturation – role of cell organelles – embryogeny – translocation of assimilates – synthesis of starch, protein, lipid, secondary metabolites and toxic compounds – possible alteration in metabolic pathway.

Unit II

Development of embryo, endosperm and seed coat – translocation of assimilates and food reserves; desiccation tolerance – mechanism, hypothesis, role of LEA proteins; development of hard seeds – mechanisms and factors.

Unit III

Seed dormancy – types – physiology and biochemistry of seed dormancy induction and release – hormonal regulation of seed dormancy – environmental control – genetic inheritance and control of dormancy; physiology of orthodox, recalcitrant and intermediate seeds.

Unit IV

Seed germination – acquisition of viability and capacity of germination during development – genetics of germination acquisition; types of germination – phases of germination – requirements – imbibition – enzyme activation and hormonal regulation – respiration – mitochondrial activity and ATP synthesis – protein and nucleic acid synthesis – metabolism of starch, protein, lipid – physiology of embryo growth and development.

Unit V

Seed deterioration – theories, causes – ultra-structural, cell membrane and functional changes; biochemical changes – enzyme activity, storage reserves and genetic changes; lipid peroxidation – biological effects – free radicals and secondary products.

VII. Practical

- Study on the pattern of seed development and maturation;Study on the structural changes during seed maturation;Estimation of seed moisture content, fresh and dry weight and acquisition of germination and dormancy;Estimation of different hormones during seed development and maturation – GA and ABA;Estimation of phenolic compounds during seed maturity;Estimation of food reserves accumulation – starch, protein and oil at different stages of maturity;Study on the pattern of seed development in recalcitrant seeds;Studying the germination behaviour of different type of seeds;Study on imbibition pattern and soaking injury in seeds;Estimation of enzymes in dormant and non-dormant seeds;Estimation of hormones in dormant and non-dormant seeds;Studying the effect of light and temperature on dormancy;Study on deterioration pattern of orthodox and recalcitrant seeds;
- Estimation of lipid peroxidation product and free fatty acid;Studying the cytological and chromosomal changes in deteriorated seeds;Estimation of volatile aldehydes during seed storage and deterioration.

XI. Suggested Reading

Barton LV. 1961. *Seed Preservation and Longevity*, (Vol. 1). Leonard Hill, London.

Baskin C and Baskin JM. 2014. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Academic Press, Cambridge, UK.

Bewley JD and Black M. 1982. *Physiology and Biochemistry of Seeds in Relation to Germination*

(Vol. I & II). Springer Verlage, Berlin Heldelberg, New York, United States.
Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. *Seeds: Physiology of Development*, Germination and Dormancy. Springer, New York.
Bradbeer JW. 1988. *Seed Dormancy and Germination*. Chapman and Hall, New York, USA.
David R Murray. 1985. *Seed Physiology*. Volume 2: Germination and Reserve Mobilisation. Academic Press, London, UK.
Justice OL and Bass LN. 1978. *Principles and Practices of Seed Storage*. Agriculture Hand Book No. 506, Castle House Publication Ltd., Washington.
Khan AA. 1977. *Physiology and Biochemistry of Seed Dormancy and Germination*. North Holland Co, Amsterdam, New York, United States.
Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios., Jodhpur, India.
Mayer AM and Mayber AP. 1989. *Germination of Seeds*. Pergamon Press, Oxford, United kingdom.
Ovcharov KE. 1977. *Physiological Basis of Seed Germination*, Amerind Publishing Co,New Delhi and New York, United States.
Prakash M. 2011. *Seed Physiology of Crops*. Satish Serial Publishing house. Azadpur. New Delhi.
Roberts EH. 1972. *Viability of seeds*. Springerlink, New York, USA.
Vanangamudi K. 2006. *Seed Physiology*. Associated Publishing Company, New Delhi, India.

XI. Suggested e-books

http://agris.fao.org/agris-search/search.do?recordID=US201300553998
http://www.worldcat.org/title/physiological-basis-of-seed-germination-fiziologicheskie-osnovy-vskhozhesti-semyan/oclc/19369598
https://www.springer.com/in/book/9783642686450
https://link.springer.com/chapter/10.1007/978-1-4615-1747-4_2
https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/desiccation-tolerance
https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/embryogenesis
https://www.cell.com/current-biology/comments/S0960-9822(17)30562-6
https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-3040.2012.02542.x
https://dl.sciencesocieties.org/publications/books/pdfs/cssaspecialpubl/physiologyofsee/frontmatter

XII. Suggested websites

http://www.seedbiology.de/dormancy2.asp
http://www.seedbiology.de/dormancy.asp
https://www.ncbi.nlm.nih.gov/pubmed/22620982
https://www.britannica.com/science/germination
http://sbc.ucdavis.edu/Research_pages/Seed_physiology_and_technology/
http://www.biologyreference.com/Re-Se/Seed-Germination-and-Dormancy.html
https://www.intechopen.com/books/advances-in-seed-biology/seed-dormancy
https://courses.lumenlearning.com/wm-biology2/chapter/development-seeds-fruit
www.iari.res.in/index.php?option=com_content&view=article&id=449 &Itemid=137

I. Course Title : Genetic Purity and DUS Testing*

II. Course Code : SST 604

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Genetic purity – importance – factors influencing genetic purity; genetic/ cultivar purity test – objectives – principles – methods; laboratory tests – green house and field plot methods, grow – out test, seed and seedling growth tests; chemical and biochemical methods; anthocyanin pigmentation, secondary compounds, phenol, peroxidase and fluorescence tests – chromatography techniques.

Unit II

Electrophoretic analysis of proteins and isozymes; DNA finger printing methods – RAPD, AFLP, SSR, SNP and other markers; computer based machine vision technique and image analysis for varietal identification.

Unit III

Genesis of Plant Variety Protection (PVP); International Union for Protection of New Varieties of Plants (UPOV) and its functions – GATT agreement in relation to plant variety protection; Protection of Plant Varieties and Farmer's Rights (PPV and FR) Act 2001 – objectives, salient features, farmer's rights, breeder's rights, researcher's rights – PPV and FRA Rules 2003.

Unit IV

Criteria for protection of new varieties of plants; Distinctness, Uniformity and Stability (DUS) testing – principles and procedures, guidelines, sample size, test duration, testing option; varieties of common knowledge – extant variety – essentially derived variety – collection of reference samples – grouping of varieties – example varieties; types and categories of characters – recording observations on characteristics – colour characteristics.

Unit V

Assessment of DUS characters of major crops based on morphological, biochemical and molecular markers – rice, maize, wheat, barley, black gram, green gram, red gram, cowpea, rajma, sunflower, groundnut, castor, mustard, tomato, brinjal, onion, potato, chilli, bhendi, cucurbits, cole crops, sugarcane, cotton, flower, fruit and tree species; statistical procedure – computer software for DUS testing; guidelines for registration of germplasm – impact of plant variety protection on seed industry growth.

V. Practical

- Genetic purity assessment based on seed characters;Genetic purity assessment based on seedling growth tests, anthocyaninpigmentation;Genetic purity assessment based on secondary compounds, phenol, peroxidase andfluorescence tests;Chromatography analysis of secondary compounds;Electrophoretic analysis of seed protein and isozymes;DNA fingerprinting using PCR techniques;DUS testing based on morphological descriptors of plant – rice and millets;DUS testing based on morphological descriptors of plant – pulses and oil seeds;DUS testing based on morphological descriptors of plant – vegetable crops;DUS testing based on morphological descriptors of plant – flower, fruit and tree species;Recording observations and interpretation of data;Tree method of classification of varieties/ cultivars;Chemical and biochemical test applicable for DUS testing;Practical exercise on recording DUS characteristics, statistical analysis and interpretation in major agricultural crops;Practical exercise on recording DUS characteristics, statistical analysis and interpretation in major

horticultural crops;Visit to DUS test centers.

VI. Suggested Reading

Anon. 2016. *Manual of Seed Certification Procedures*. Directorate of Seed Certification, Coimbatore, Tamil Nadu.

Chakrabarthi SK. 2010. *Seed Production and Quality Control*. Kalyani Publishers, New Delhi.

Choudhary DR. 2009. *Guidelines for Storage and Maintenance of Registered Plant Varieties in the National Gene Bank*. Published by Protection of Plant Varieties and Farmer's Rights Authority. Ministry of Agriculture, GoI, New Delhi, India.

ISTA. 2010. *Handbook of Variety Testing*. International Seed Testing Association, Switzerland.

Joshi AK and Singh BD. 2004. *Seed Science and Technology*, Kalyani Publishers, New Delhi, India.

Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios., Jodhpur, India.

Mishra DK, Khare D, Bhale, MS and Koutu GK. 2011. *Handbook of Seed Certification*. Agrobios, Jodhpur, Rajasthan.

Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. *Seed Legislation in India*. Agrobios, Jodhpur, Rajasthan.

Trivedi PC. 2011. *Seed Technology and Quality Control*. Publications, Jaipur, Rajasthan.

VII. Suggested e-books

https://books.google.co.in/books?isbn=16118603932.
https://books.google.co.in/books?isbn=81894220303.
https://books.google.co.in/books?id=2FbwZwEACAAJ
https://books.google.co.in/books?id=J5bQtgAACAAJ
https:/books.google.co.in/books?isbn=0851997392
https://www.upov.int/edocs/tgdocs/en/tg023.pdf

VIII. Suggested websites

www.seedquest.com
www.ucanr.edu
www.sasa.gov.uk
www.ppvfra.org
https://www.upov.int/test_guidelines/en/
http://plantauthority.gov.in/crop-guidelines.htm
https://www.upov.int/resource/en/dus_guidance.html
https://www.upov.int/edocs/tgpdocs/en/tgp_6_section_2.pdf
https://www.upov.int/publications/en/tg_rom/introduction.html

I. Course Title : Seed Vigour and Crop Productivity

II. Course Code : SST 605

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Seed vigour – importance, concepts, definitions, vigour *vs* viability, historical development – ISTA vigour committee. Factors influencing seed vigour – genetic, agronomic, biotic and abiotic factors.

Unit II

Seed vigour and senescence – sequence of vigour loss – manifestations of seed vigour – physical, physiological, biochemical and molecular manifestations; vigour in relation to seed dormancy and germination; vigour in relation to value for cultivation and use.

Unit III

Vigour tests – history – definition – characteristics – types – direct and indirect tests – physical test – x-ray radiography, seed size; physiological test – seedling first count, radicle emergence, speed of germination, seedling measurement; stress tests – brick gravel test, cool test, cold test, paper piercing test, ethanol, ammonium chloride and NaCl soak tests, accelerated ageing test, exhaustion test, controlled deterioration test, osmotic stress test.

Unit IV

Chemical and biochemical tests – electrical conductivity test, free sugars and amino acids, tetrazolium chloride test, respiration quotient, GADA test, free fatty acid, DPPH, respiratory and hydrolytic enzymes tests, modern vigour tests – machine vision, Q_2 analyzer – standardization of vigour test.

Unit V

Influence of seed vigour – crop growth, field emergence, productivity and storage; vigour of vegetative propagules; role of seed vigour in field emergence, crop growth, yield and productivity. Seed vigour improvement and management techniques – pre-sowing and pre-storage – mid storage methods to improve seed vigour.

V. Practical

- Collection and evaluation of germination of seed lots with different vigour status;Evaluation of seed vigour by physical vigour test – seed size, colour, weight – turbidity test;Evaluation of seed vigour by physiological vigour test – imbibition pattern, speedof emergence, radicle emergence, germination, seedling measurement and computation of various index;Conducting different stress tests – brick gravel and paper piercing tests;Conducting accelerated ageing and controlled deterioration test;Conducting chemical stress test – NH_4Cl, NaCl, mannitol, PEG test;Special vigour tests – cool germination test – cold test – anaerobic test;Biochemical vigour test – electrical conductivity, free sugars and amino acid test in seed leachate;Estimation of dehydrogenase enzyme activity;Estimation of free fatty acids in seed lots in varying vigour levels;Bio-assay test for seed vigour;Estimation of volatile aldehydes in different crop seeds with varying vigour;Correlation studies between field emergence and different vigour tests;Seed vigour on field establishment, population maintenance and crop growth and productivity;Pre-sowing vigour management techniques;Pre-storage and mid storage vigour management techniques.

VI. Suggested Reading

Agrawal PK and Dadlani M. 1992. *Techniques in Seed Science and Technology*. 2nd Ed. South Asian Publications.

Bewley J and Black M. 1994. *Physiology of Development and Germination*. Springerlink, New York.

Chakrabarthi SK. 2010. *Seed Production and Quality Control*. Published by Kalyani Publisher., New Delhi, India.

Chalam GV, Singh A and Douglas JE. 1967. *Seed Testing Manual*. ICAR and United States Agency for International Development, New Delhi.

David R Murray. 1985. *Seed Physiology*. Saunders College Publishing/ Har court Brac.

International Seed Testing Association. 2018. *Handbook on Seedling Evaluation*, 4th Edition, Published by ISTA, Zurichstr, Switzerland.

ISTA. 1999. *Seed Science and Technology*, 27th supplement.

Khan AA. 1977. *The Physiology and Biochemistry of Seed Dormancy and Germination*. North–Holland Publishing Company, USA.

Kulkarni GN. 2011. *Principles of Seed Technology*. Kalyani Publishers, New Delhi, India.

Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of post harvest seed physiology and technology*. Agrobios., Jodhpur, India.

Mayer AM and Mayber AP. 1963. *Germination of Seeds*. Pergamon Press, Oxford, New York.

Roberts EH. 1972. *Viability of Seeds*. Springerlink, New York.

Sen S and Ghosh N. 2010. *Seed Science and Technology*. Kalyani Publishers., New Delhi, India.

Singhal NC. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi, India.

Trivedi PC. 2011. *Seed Technology and Quality Control Pointer Publications*., Jaipur, India.

Vasudevan SN, Doddagowder SR, Rakesh CM and Patil SB. 2013. *Seed Testing and Quality Control*. Agrotech Publications, Udaipur, Rajasthan.

VII. Suggested e-books

https://link.springer.com/chapter/10.1007/978-94-009-2764-3_71
https://link.springer.com/chapter/10.1007/978-1-4684-7747-4_8
https://link.springer.com/chapter/10.1007/978-1-4615-1783-2_7
https://doi.org/10.1079/9780851993959.0073
https://www.researchgate.net/publication/326255175_Seed_Vigour_Testing_ Principland_ Methods
https://www.springer.com/in/book/9789400956872
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4233836/
https://link.springer.com/chapter/10.1007/978-1-4615-1783-2_8
http://www.worldcat.org/title/techniques-in-seed-science-and-technology/oclc/600 47727
http://wrap.warwick.ac.uk/74767/1/WRAP_0380014-lf-271115-revised_darwin_ review_for_ submission_.pdf

VIII. Suggested websites

www.ista.org.in
www.cambridge.org
www.tandfonline.com
www.seednet.gov.in
www.seedtest.org
https://academic.oup.com/jxb/article/67/3/567/2893341
http://www.scielo.br/pdf/sa/v72n4/0103-9016-sa-72-4-0363.pdf
https://www.researchgate.net/publication/284279769_Seed_vigour_and_ crop_establishment_ Extending_performance_beyond_adaptation
https://www.semanticscholar.org/paper/Seed-vigour-and-crop-establishment%3A -eXtending-Finch-Savage-Bassel/a5af7beae17bd31058db0f645edd647cbb9e 9c2b

I. Course Title : Advances in Seed Science*

II. Course Code : SST 606

III. Credit Hours : 2 (2+0)

IV. Theory

Unit I

Physiological and molecular aspects of seed development – gene expression during seed development – selective elimination of cells – theories and concepts; physiological and molecular regulation of germination and dormancy; desiccation and stress tolerance – gene expression – mechanism – structural changes in membranes of developing seeds; prediction of seed dormancy and seed longevity using mathematical models; climate change effects on pollination, seed formation, development and quality.

Unit II

Recent techniques in seed production of self incompatible, protogyny, protandry and apomictic plant species – Gene Use Restriction Technology (GURT) – terminator and verminator technology – Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) *Cas* – gene editing; seed proteomics – principles, methods, applications in seed science- genetic analysis and QTL mapping of traits related to seed vigour, ageing and longevity – OMICS in related to seed science and technology; somatic embryogenesis – principles and methods of production of synthetic/ somatic seeds – merits and demerits.

Unit III

Modern techniques for identification of varieties and hybrids – principles and procedures; DNA fingerprinting and other molecular techniques and their utilization – GM seeds and their detection techniques; Use of machine vision and image analysis techniques for varietal identification. Application of artificial intelligence (AI) and machine learning (ML) and virtual reality (VR) in seed science.

Unit IV

Recent accomplishments in seed enhancement research – seed coating, pelleting and priming techniques – physiological, molecular and sub-cellular basis of seed priming – detection and identification of seed borne diseases and insect pests through advanced techniques – ELISA and PCR based techniques.

Unit V

International movement of seeds – OECD seed certification schemes – recent developments in seed laws and policies – ethical issues and IPR system related to seed trade and movement.

V. Suggested Reading

Baskin C and Baskin JM. 2014. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Academic Press, Cambridge, UK.

Benech-Arnold R and Rodolfo S. 2004. *Handbook of Seed Physiology: Applications to Agriculture*. CRC Press., Florida, United States.

Bewley JD and Black M. 1994. *Seeds: Physiology of Development and Germination*. Springer, New York, USA.

Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. *Seeds: Physiology of Development, Germination and Dormancy*. Springer, New York.

Black M and Bewley JD. 2000. *Seed Technology and its Biological Basis*. CRC Press. Florida, United States.

David R Murray. 1985. *Seed Physiology*. Volume 2: Germination and Reserve Mobilisation. Academic Press, London, UK.

Figeys D. 2005. Industrial Proteomics: Applications for Biotechnology and

Pharmaceuticals (No. TP248. 65. P76 I535 2005). United States.
Kozlowski TT. 2012. *Seed Biology: Importance, Development and Germination*. (Vol. I). Academic Press Inc., New York.
Lombardo L. 2014. Genetic Use Restriction Technologies: a review. *Plant biotechnology journal*. **12**(8): 995-1005.
Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios., Jodhpur, India.
Nicolas G, Bradford KJ, Come D and Pritchard HW. 2003. *The Biology of Seeds: Recent Research Advances*. Proceedings.
Patterson SD and Aebersold RH. 2003. Proteomics: the first decade and beyond. Nature genetics. **33**(3s): 311.
Rakshit A and Singh HB. 2018. *Advances in Seed Priming*. Springer Nature Singapore Ltd., Singapore.
Redenbaugh K. 1993. *Synseeds: Application of Synthetic Seeds to Crop Improvement*. CRC Press, London, UK.

VI. Suggested e-books

https://www.springer.com/gp/book/9783540574484
https://www.synthego.com/resources/crispr-101-ebook
https://link.springer.com/book/10.1007/978-981-13-0032-5
https://www.springer.com/gp/book/9780306447471#aboutBook
https://link.springer.com/chapter/10.1007/978-1-4615-1619-4_13
https://www.cambridge.org/core/journals/experimental-agriculture/article/biology-of-seeds-recent-research-advances-edited-by-g-nicolas-k-j-bradford-d-come-and-h-w-pritchard-wallingford-uk-cabi-international-2003-pp-472-9500-isbn-0851996 531/57DACB0A07CFD0246AAD11713540F1E6

https://www.researchgate.net/publication/240592094_Black_M_Bewley_JD_eds_ 2000_Seed_ technology_and_its_biological_basis_419_pp_Sheffield_ Sheffield_Academic_Press_ 89_hardback
https://www.crcpress.com/Handbook-of-Seed-Physiology-Applications-to-Agricu lture/Benech-Arnold-Snchez/p/book/9781560229292
https://www.elsevier.com/books/seeds/baskin/978-0-12-416677-6
https://international.neb.com/tools-and-resources/feature-articles/crispr-cas9-and-targeted-genome-editing-a-new-era-in-molecular-biology
https://www.omicsonline.org/scholarly/seed-science-and-technology-journals-articles-ppts-list.php
https://libgen.is/book/indeX.php?md5=F63727B21E14953F0003168A2452B3FE
https://www.researchgate.net/publication/228621809_Techniques_for_detecting_ genetically_ modified_crops_and_products
https://www.intechopen.com/books/new-challenges-in-seed-biology-basic-and-translational-research-driving-seed-technology/recent-advances-in-seed-enhancements
https://books.google.co.in/books/about/Advances_in_Seed_Priming.html?id= iBtfDwAAQBAJ&printsec=frontcover&source= kp_read_button&redir_esc= y#v=onepage&q&f=false

VII. Suggested websites

https://www.sbc.ucdavis.edu
https://www.seedbiotech.com
http://www.gmotesting.com/Testing-Options
https://www.ncbi.nlm.nih.gov/pubmed/25185773
https://www.oecd.org/agriculture/seeds/
https://www.addgene.org/crispr/guide/
https://www.yourgenome.org/facts/what-is-crispr-cas9
https://cban.ca/gmos/issues/terminator-technology/
https://www.nature.com/articles/s41598-017-08669-5
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5495694/
https://www.ias.ac.in/article/fullteXt/reso/006/05/0039-0047
https://www.cell.com/action/showPdf?pii=S1360-1385%2807%2900038-6
https://www.sciencedirect.com/science/article/pii/S2215017X16301400
https://www.broadinstitute.org/what-broad/areas-focus/project-spotlight/questions-and- answers-about-crispr

I. Course Title : Advances in Seed Quality Enhancement

II. Course Code : SST 607

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Seed quality – importance and enhancement – principles, concept, significance, strategies; types of seed enhancement – physical, physiological and biological enhancement techniques.

Unit II

Physical seed quality enhancement – concept and principles of grading – upgrading – magnetic, electromagnetic, irradiation, coating, pelleting, colouring; plasma treatment – thermal and cold plasma – treatment; application of nano formulations – concepts – principles – mode of action on improving germination.

Unit III

Physiological methods of seed quality enhancement – seed priming – principles, methods, mode of action – physiological, biochemical and molecular mechanism of priming techniques; seed infusion – principles and methods, mode of action – imparting abiotic stress tolerance – hardening – principles and methods.

Unit IV

Application of biological formulations – bacterial, fungal agents – concepts, formulations and compatibility; methods of application – growth promotion – protection – control over pest and disease infection and mode of action; designer/ smart seed – concept, methods, applicability to different crops.

Unit V

Effect of different treatments on crop establishment and modulation of seedling growth – crop geometry, phenology and yield improvement; storability of primed, coated and pelleted seeds – pre-storage and mid-storage enhancement techniques – hydration-dehydration techniques, moisture equilibrium drying and halogenations – principles, methods and application.

V. Practical

- Physical seed quality up gradation – specific gravity separator, density grading, floatation technique;Practicing seed pelleting – methods of pelleting for different crop species;Performing seed coating – polymer, colouring and nano emulsion coating;Study on the effect of magnetic and electromagnetic seed treatment on seed germination and vigour;Practicing seed priming – hydro, osmo, halo and solid matrix priming methods;Nutrient and bio priming and assessing the performance of primed seeds;Assessing the storability of primed seed;Study on seed hardening on the performance of seed under abiotic stress;Preparation of designer/ smart seed for different crops;Biological seed treatment – biological formulations, bacteria, fungi, protectantsand bio fertilizers;Study on the effect of biological seed treatment on seedling growth and diseaseincidence;Estimating the microbial population in biologically treated seeds;Assessing the storability and vigour potential of treated seeds;Performing mid-storage seed treatment – hydration-dehydration, moistureequilibrium and drying;Halogenation of seeds and their effect on seed performances;Assessing the performance of treated seeds under field condition.

IX. Suggested Reading

Bewley JD, Bradford KJ, Hilhorst HWM and Nonogaki H. 2013. *Seeds: Physiology of Development, Germination and Dormancy*, Third Edition. Springer, New York, United States.

Doijode SD. 2006. *Seed Quality in Vegetable Crops. In: Handbook of Seed Science and Technology*. Basra AS (Ed.). The Haworth Press, New York, United States. pp. 677–702.

Filatova I, Azharonok V, Lushkevich V, Zhukovsky A, Gadzhieva G, Spasic K, Zivkovic S, Puac N, Lazovic S, and Malovic G. 2013. *Plasma Seeds Treatment as a Promising Technique for Seed Germination Improvement*. 31st International Conference on Phenomena in Ionized Gases, Granada, Spain.

Glick BR. 2012. *Plant Growth-Promoting Bacteria: Mechanisms and Applications*. Hindawi Publishing Corporation, Scientifica.

Halmer P. 2003. 'Methods to improve seed performance.' In: Benech-Arnold RL, Sanchez RA (Eds.). *Seed Physiology, Applications to Agriculture*. Food Product Press, New York, United SStates.

Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios., Jodhpur, India.

McDonald MF and Copeland LO. 2012. *Seed Production: Principles and Practices*. Springer Science and Business Media., Boston, United States.

Thomas B, Murphy DJ and Murray BG. 2003. *Encyclopedia of Applied Plant Sciences* (3 volume set). Elsevier Science, Netherland.

X. Suggested e-books

https://www.springer.com/gp/book/9781461446927
https://link.springer.com/chapter/10.1007/978-1-4615-1619-4_13
https://www.intechopen.com/recent-advances-in-seed-enhancements
https://link.springer.com/content/pdf/bfm%3A978-981-13-0032-5%2F1.pdf
https://www.researchgate.net/publication/297732007_Advances_in_Seed_ Enhancements
https://www.researchgate.net/publication/309040118_Recent_Advances_in_Seed_ Enhancements
https://www.cambridge.org/core/journals/seed-science-research/article/seed enhancements/738B47B10C1C1B12C3D14D42E0B0A6C8
http://www.scientificpub.com/book-details/Seed-Quality-Enhancement-Principles-and-Practices-113.html

XI. Suggested websites

http://seedres.in/
http://agritech.tnau.ac.in/
http://www.bioline.org.br/pdf?cj17015
https://www.seedtest.org/en/home.html
www.niab.com/pages/id/24/Seed_Quality
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4109073/
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4746480/
https://content.ces.ncsu.edu/seed-and-seed-quality
http://greenpathindustries.com/plasma-seed-treatment/

I. Course Title : Germplasm Conservation Techniques

II. Course Code : SST 608

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Biological diversity in India – importance – need for conservation – concept of natural reserves and gene banks; post-exploration handling of germplasm collections, preservation of seed and plant specimens, importance and use of herbaria; *in-situ* conservation – components – biosphere reserve – natural park; factors influencing conservation; *in-situ* conservation – national programmes – on farm conservation.

Unit II

Ex-situ conservation – components – plant genetic resources conservation in gene banks – national gene banks – gene repositories – seed gene bank – types of collections – base, active and working collections – *perma-frost* seed conservation – guidelines for sending seeds to gene bank; handling of orthodox and recalcitrant seeds for conservation – clonal repositories.

Unit III

Methods of *in-vitro* conservation – short, medium and long term, concept of active and base *in-vitro* genebank; *in-vitro* storage – culture maintenance – problems and perspectives – gene bank maintenance for temperate and tropical fruit crops, spices, tubers, bulbs, medicinal and aromatic plants; conservation of embryos and ovules, meristem, cell/ suspension cultures – protoplast and callus cultures – pollen culture – micro propagation techniques – genetic stability under long term storage.

Unit IV

Cryopreservation – principle and method – handling of orthodox and recalcitrant seeds for cryopreservation – cryoprotectants – desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation and dehydration techniques; application of cryopreservation techniques for agricultural, horticultural and forest crops.

Unit V

Gene bank standards for various crops – monitoring viability of stored seed samples – multiplication and regeneration of stored germplasm materials – National and International organizations – NBPGR and NPGRI – roll and functions; Dooms-day safe seed vault – Biodiversity International – conservation guidelines.

V. Practical

- Study on *In-situ* conservation methods and case studies;
- Plant exploration, germplasm collection and documenting passport data;*Ex-situ* conservation techniques for long term conservation of germplasm collections;Preparation and handling of materials, packaging and documentation;Preparation of seed album and herbarium specimens for ex-situ conservation;Planning and designing of cold storage units and facilities for gene bank;Conservation protocols for orthodox seeds;Study of conservation protocols for recalcitrant seeds;Conservation techniques for vegetative propagules/ clones;Cryopreservation techniques – encapsulation, dehydration, freezing, thawing methods;Cryopreservation of *in-vitro* cultures – meristem, embryo, cell suspension and pollen cultures;Study on freezing and vitrification techniques;Conservation technique of forest tree species;Study on *in-vitro* cryo-genebanking and database management;Visit to national and regional seed gene

banks;Visit to on-farm conservation sites and Botanical Survey of India.

VI. Suggested Reading

Basra AS (Ed.). 1995. *Seed Quality: Basic Mechanisms and Agricultural Implications*. Food Product Press, USA.

Brush SB. 1999. *Genes in the field: On-farm Conservation of Crop Diversity*. Lewis Publishers, Boca Raton, Florida, USA.

Choudhary DR. 2009. *Guidelines for Storage and Maintenance of Registered Plant Varieties in the National Gene Bank*. Published by Protection of Plant Varieties and Farmer's Rights Authority. Ministry of Agriculture and Farmers Welfare, GoI, New Delhi.

Gupta D. 2009. *Seeds: Their Conservation Principles and Practices*. Sathish Serial Publishing House. New Delhi.

Jarvis DI, Meyer L, Klemick H, Guarino L, Smale M, Brown AHD, Sadiki M and Sthapit B. 2000. *A Training Guide for In-situ Conservation On-farm*. Version 1. International Plant Genetic Resources Institute, Rome, Italy.

Joshi AK and Singh BD. 2004. *Seed Science and Technology*, Kalyani Publishers, New Delhi.

Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios., Jodhpur.

McDonald MF and Copeland LO. 2012. *Seed Production: Principles and Practices*. Springer Science and Business Media., Boston, USA.

Meerabi G and Pullaiah T. 2015. *Plant Biodiversity Conservation and Management*, Daya Publishing House, Delhi.

Rao NK, Hanson J, Dulloo ME, Ghosh K, Nowell A and larinde M. 2006. *Manual of Seed Handling in Genebanks*. Bioversity International, Rome.

Vernoy R, Shrestha P and Sthapit B. 2015. *Community Seed Banks: Origins, Evolution and Prospects*, Oxford, Routledge, UK.

https://www.springer.com/gp/book/9783319225203

https://www.onlinelibrary.wiley.com/doi/10.1002/9781118316467.ch4

https://www.trove.nla.gov.au/work/10718000?q&versionId=12505038

http://www.libgen.io/book/index.php?md5=E4F14ADA7E2D7F05B1E7CA5C6EF F18E5

http://www.libgen.io/book/index.php?md5=ACEC8DC5834E84F9C13ACB780FA 760BC

http://www.libgen.io/book/index.php?md5=582A419EE2C82B58B98BFD7D856FDB91

http://www.libgen.io/book/index.php?md5=719F94827A8976F06BF2E6DC6FB9C093

http://www.cure.edu.uy/sites/default/files/04Libro%20Advances%2Bin% 2BPlant%202016.pdf

https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/germplasm-conservation

https://www.crcpress.com/Seed-Quality-Basic-Mechanisms-and-Agricultural-Implications/Gough/p/book/9781560228509

https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Establishment_and_management_of_field_genebank_786.pdf

XII. Suggested websites

http://www.nbpgr.ernet.in/

http://www.bioversityinternational.org

http://www.nap.edu/read/2116/chapter/7

http://www.ncbi.nlm.nih.gov/pubmed/18080461

http://www.regjeringen.no/en/topics/food-fisheries-and-agriculture/svalbard-global-seed -vault/id462220/

I. Course Title : Seed Ecology

II. Course Code : SST 609

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Introduction to ecology – seed ecology – importance – genetic effects – geographic adaptation of native and invasive species; ecological factors on seed germination and regeneration; reproductive allocation – reproductive effort; flowering phenology, assessment of resource allocation – positional and azimuth influence on flowering and reproduction; influence of climate change on reproduction, seed formation, germination and dormancy.

Unit II

Seed dispersal – definition – modes of dispersal, dispersal dynamics, aerial seed dispersal, pre and post dispersal hazards, seed predators and ecological significance. Seed polymorphism – types, causes, consequences on seedling adaptation.

Unit III

Soil seed bank – definition – classification – soil seed bank dynamics. Thermodynamic models – population dynamics in soil seed bank – seed longevity and germination models in soil seed bank – weed seed ecology and longevity – long term experiments in buried seeds; ecological significance of seed dormancy and seed polymorphism.

Unit IV

Influence of environment on seed germination – allelopathy, temperature, light, moisture and gaseous environment – eco-physiological role in seed storage.

Unit V

Effect of pollutants – air, water and soil pollutants on seed germination and seedling establishment – factors limiting seedling establishment – problem soils and seed management techniques – climate change and seed production – management strategies to overcome the effect of climate change on seed production and germination.

V. Practical

- Understanding flowering phenology of different crop species;Study of seed dispersal mechanism of different crop species;Study on agents and distance of dispersal of different crop species;Studies on pre and post dispersal hazards;Assessing the natural regeneration in relation to ecology;Assessing the problems related to natural regeneration;Experiment on naturally buried seeds – dormancy and longevity;Studies on effect of environmental factors on seed germination and dormancy;Influence of seed polymorphism on germination and dormancy;Assessing the allelopathy effect on seed germination in crop species;Effect of soil pollutants on seed germination;Effect of air pollutants on germination of crop seeds;Effect of water pollutants on growth on seed quality;Seed management practices for polluted environment and climate change effects;Visit to *in-situ* and *ex-situ* conservation sites;Visit to biological hotspots.

VI. Suggested Reading

Baskin CC and Baskin JM. 1998. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Elsevier, Netherlands.

Fenner M and Ken Thompson. 2005. *The Ecology of Seeds*. Cambridge University Press, London, United Kingdom.

Heydecker W. (Ed.). 1985. *Seed Ecology*. Penn State University Press.

Kozolowski TT. 1972. *Seed Biology* Vol. II, Academic Press., New York and London.

Maiti RK, Sarkar NC and Singh VP. 2006 *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, India.

Sinclair TR and Gardner FP. 1977. *Principles of Ecology in Plant Protection*. CAB International,

Wallingford, United Kingdom.

VII. Suggested e-books

https://www.springer.com/gp/book/9780412259302
https://www.cabi.org/bookshop/book/9781845936549
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2000770/
https://www.link.springer.com/chapter/10.1007/978-94-009-4844-0_4
http://www.libgen.io/book/index.php?md5=0CE8B3A7FC6224F8467E8D344B590741
http://www.libgen.io/book/index.php?md5=4AA6FDA278BAA40C1B47BA1EB9E8BC4
http://www.libgen.io/book/index.php?md5=31A06377ADC97C71831D82D4516A4DD7
http://www.libgen.io/book/index.php?md5=97028932B0E1278AE3BE17D231B41F23
http://www.ideal.egranth.ac.in/cgi-bin/koha/opacdetail.pl?biblionumber=116395&shelfbrowse_itemnumber=244623
http://fes.org.in/source-book/ecological-restoration-source-book.pdf?file=ZG93bmXvYWQvd3AxOS5wZGY=?file=ZG93bmXvYWQvd3AxOS5wZGY=
https://www.researchgate.net/profile/Arvind_Singh56/post/I_would_like_to_know_what_is_ the_ecological_restoration_of_a_fo rest_and_why_is_ it_so_important/attachment/59d641aa79197b807799d9af/AS%3A435934916288512%401480946391722/download/1.pdf

VIII. Suggested Websites

https://nieindia.org
http://www.uky.edu/hort/Propagation-Seed-Ecology
https://ecology.uni-hohenheim.de
https://www.biologie.uni-regensburg.de/seed ecology
https://researchonline.jcu.edu.au/52954/
http://agris.fao.org/agris-search/search.do?recordID=US201600101233
https://www.oxfordbibliographies.com/view/document/obo-9780199830060/obo-978019983 0060-0086.xml

I. Course Title : Seed Planning, Trade and Marketing

II. Course Code : SST 610

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Seed industry – genesis, history and growth – structure of seed industry in India – mission and objectives of seed Industry; status and role of seed industry in Indian agriculture.

Unit II

Seed production programmes – characters, types; planning and organizing seed programmes in public and private sectors – small, medium, large and more advanced seed programmes – local, national and international seed programmes; seed demand forecasting – purpose – methods and techniques – factors determining seed demand – seed multiplication ratio, seed replacement rate and variety replacement rate; seed production planning for varieties and hybrids – compact area approach and seed village – contractual seed production – custom seed production – public private partnership – transgenic seeds – demand assessment.

Unit III

New seed policy – genesis – functions; WTO – Indian seed industry – patenting and *suigeneris* system – The Seeds Bill, 2004 and 2011; role and contributions of MNC's in seed trade in India; International trade of seeds – government policies – International organizations involved in seed movement and trade – International Seed Federation (ISF), ISTA – OECD seed schemes – operational guidelines; import and export of seeds – Exim policies – guidelines and salient features; seed production and quality control systems in SAARC Nations and other developed countries; quarantine measures – procedures, guidelines and certificates in international seed movement and trade.

Unit IV

Seed production and distribution system in central and state governments, co-operative and private organisations – seed marketing – definition, concept, importance and type of markets – domestic and global market – problems and perspectives; marketing polices – seed marketing schemes, marketing channels – responsibilities of dealers – marketing mix; handling and management of sales return seed stocks.

Unit V

Seed pricing – local market rate – factors affecting prices and pricing policies – fixation of procurement and sale price of seeds – cost analysis – seed market intelligence – marketing promotional activities; seed supply chain management – missing link – risk and management.

V. Practical

- Data collection on status of Indian and global seed industry;Planning seed programmes for varieties and hybrids;Planning for establishment of small and medium seed enterprises;Planning for establishment of large scale seed enterprises;Planning for custom seed production and contractual seed production;Assessment of seed demand – demand forecasting methods;Assessment of seed multiplication ratio, seed replacement rate and variety replacement rates for different crops;Study on the economics of seed production and marketing;Exercise on fixing procurement and sale price of seeds;Study of seed marketing channels – survey and interaction with seed dealers anddistributors;Visit to plant quarantine station and study of quarantine requirements andcertificates for domestic and international seed trade;Visit to

modern seed processing unit, advanced seed storage complex and interactions;Visits to state seed corporations;Visit to MNCs and expert discussion;

- Case studies and SWOT analysis;Planning for establishment of new seed ventures and project preparations;

VI. Suggested Reading

Acharya SS and Agarwal NL. 2004. *Agricultural Marketing in India*, 4th Ed. Oxford and IBH.

Agrawal RL. 1996. *Seed Technology*. Oxford, IBH Publishing Co., New Delhi, India.

Broadway AC and Broadway A. 2003. *A Text Book of Agri-business Management*.

Dadheech PK. 1996. *Seed Programming, Management System and Concepts*. Lok Sahitna Kendra, Jodhpur.

Feistrizer P and Fenwickkelly A. 1978. *Improved Seed Production*. FAO, Rome, Italy.

Gurudev Singh and Asokan SR. 1997. *Management of Seed Production Activity*. Oxford and IBH Publishing Co., New Delhi, India.

Joshi AK and Singh BD. 2004. *Seed Science and Technology*. Kalyani Publishers, New Delhi, India.

Kalyani Singh AK and Pandey S. 2005. *Rural Marketing*. New Age Publications.

Krishnasamy V, Ponnuswamy AS, Balamurugan P, Srimathi P, Natarajan N and Raveendran TS. 2004. *Compendium on Seed Science and Technology*. Directorate of Publications, Tamil Nadu Agricultural University, Coimbatore, India.

Kugbei S. 2008. *Seed Economics*. Scientific Publishers, Jodhpur.

Singh G and Asokan SR. 1992. *Seed Replacement Rate: Some Methodological Issues*. Indian Institute of Management, Ahmedabad, India.

Singh S. 2004. *Rural Marketing – Focus on agricultural Inputs*. Vikas Publishing House.

VII. Suggested e-books

http://www.pondiuni.edu.in/storage/dde/downloads/mbaii_mm.pdf
http://agricoop.nic.in/divisiontype/seeds
https://www.audiencebloom.com/all-in-one-guide-to-planning-and-lauching-content- marketing-strategy/
https://link.springer.com/chapter/10.1007/978-1-4615-1783-2-15
http://www.fao.org/3/V4450E/V4450E00.htm
https://books.google.co.in/books?id=vPVlBos4WkYC
http://download.nos.org/srsec319new/319EL19.pdf
https://isengewant.de/Marketing-of-Seeds-By-Premjit-Sharma.pdf
https://www.kopykitab.com/A-Handbook-of-Seed-Processing-and-Marketing-by- Gaur-SC

VIII. Suggested websites

www.gov.mb.ca
www.agricoop.nic.in
www.agri.nic.in
https://sathguru.com/seed/
http://www.fao.org/3/V4450E/V4450E03.htm
https://www.seednet.gov.in/smis/SMIS-User%20Manual.pdf
https://www.icrisat.org/seed-systems-models-lessons-learned/
https://www.bookdepository.com/Seed-Industry-India-Gurdev-Singh/

Restructured and Revised
Syllabi of Post-graduate Programmes
Vol. 1

Plant Protection

– Entomology
– Plant Pathology
– Nematology

Contents

Course Title with Credit Load
M.Sc. (Ag) in Plant Protection - Entomology

Course Code	Course Title	Credit Hours	Semester
ENT 501*	Insect Morphology	3 (2+1)	I
ENT 502*	Insect Anatomy and Physiology	3 (2+1)	I
ENT 503*	Insect Taxonomy	3 (1+2) (2+1)	II
ENT 504*	Insect Ecology	3 (2+1)	II
ENT 505*	Biological Control of Insect Pests and Weeds	3 (2+1)	II
ENT 506*	Toxicology of Insecticides	3 (2+1)	I
ENT 507	Host Plant Resistance	2 (1+1)	I
ENT 508*	Concepts of Integrated Pest Management	2 (2+0)	I
ENT 509*	Pests of Field Crops	3 (2+1)	I
ENT 510*	Pests of Horticultural and Plantation Crops	3 (2+1)	II
ENT 511*	Post Harvest Entomology	2 (1+1)	II
ENT 512	Insect Vectors of Plant Pathogens	2 (1+1)	II
ENT 513	Principles of Acarology	2 (1+1)	I
ENT 514	Vertebrate Pest Management	2 (1+1)	II
ENT 515	Techniques in Plant Protection	1 (0+1)	I
ENT 516	Apiculture	3 (2+1)	II
ENT 517	Sericulture	3 (2+1)	I
ENT 518	Lac Culture	3 (2+1)	II
ENT 519	Molecular Approaches in Entomology	3 (2+1)	I
ENT 520	Plant Quarantine, Biosafety and Biosecurity	2 (2+0)	II
ENT 521	Edible and Therapeutic Insects	2 (1+1)	I
ENT 522	Medical and Veterinary Entomology	2 (1+1)	II
ENT 523	Forest Entomology	2 (1+1)	I
ENT 591	Master's Seminar	1 (0+1)	
ENT 599	Master's Research	30 (0+30)	

*Compulsory Major Courses

Course Contents
M.Sc. (Ag) in Plant Protection-Entomology

I. Course Title : Insect Morphology

II. Course Code : ENT 501

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

External Morphology: Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation.

Head- Origin, structure and modification; mouthparts, antennae, their types and functioning; tentorium and neck sclerites.

Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; legs: structure and modifications.

Abdomen- Segmentation and appendages; genitalia and their modifications; embryonic and post-embryonic development.

Unit II

Insect sense organs (mechano-, photo- and chemo- receptors); organogenensis at pupal stage; insect defense; chaetotaxy; morphological traits in relation to forensic entomology.

Unit III

Types of immature stages in insect orders, morphology of egg, nymph/ larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in hemi-metabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

V. Practical

- Preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia;
- Dissection of genitalia. Types of immature stages in insects; their collection, rearing and preservation;
- Identification of immature insects to orders and families, in endopterygote orders, viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using key;

VI. Suggested Reading

Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.

Chu HF. 1992. *How to Know Immature Insects*. William Brown Publication, Iowa.

Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publishers, New Delhi.

Evans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.

Gillott C. 1995. *Entomology*, 2nd Ed. Plenum Press, New York, London.

Gullan PJ and Cranston PS. 2000. *The Insects, An Outline of Entomology*, 2nd Ed. Blackwell Science, UK.

Peterson A. 1962. *Larvae of Insects*. Ohio University Press, Ohio.

Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman and Hall, London.

Snodgross RE. 1993. *Principles of Insect Morphology*. Cornell Univ. Press, Ithaca.

Tembhore DB. 2000. *Modern Entomology*, Himalaya Publishing House, Mumbai.

Stehr FW. 1998. *Immature Insects*. Vols. I, II. Kendall Hunt Publication, Iowa.

I. Course Title : Insect Anatomy and Physiology

II. Course Code : ENT 502

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Scope and importance of insect physiology; physiology of integument, moulting, chemistry of cuticle, biosysthesis of chitin; growth, hormonal control, metamorphosis and diapause; pheromone secretion, transmission, perception and reception.

Unit II

Physiology and mechanism of digestion, circulation, respiration, excretion, reproduction, secretiontransmission in insects. (exocrine and endocrine glands) and nerve impulse transmission in insects

Unit III

Importance of insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.

V. Practical

- Latest analytical techniques for analysis of free amino acids of haemolymph;
- Determination of chitin in insect cuticle;
- Examination and count of insect haemocytes; preparation and evaluation of various diets;
- Consumption, utilization and digestion of natural and artificial diets.

VI. Suggested Reading

Chapman RF. 1998. *Insects: Structure and Function*. ELBS Ed., London.

Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publishers, New Delhi.

Gullan PJ and Cranston PS. 2000. *The Insects*: *An Outline of Entomology*, 2nd Ed. Blackwell Science, UK.

Kerkut GA and Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, New York.

Patnaik BD. 2002. *Physiology of Insects*. Dominant Publishers, New Delhi.

Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Vol. 1. *Structure, Physiology and Development*. Chapman and Hall, New York.

Simpson SJ. 2007. *Advances in Insect Physiology*, Vol. 33, Academic Press (Elsevier), London, UK.

Wigglesworth VB. 1984. *Insect Physiology*. 8th Ed. Chapman and Hall, New York.

I. Course Title : Insect Taxonomy

II. Course Code : ENT 503

III. Credit Hours : 3 (1 + 2)

IV. Theory

Unit I

History of insect classification; principles of systematics and its importance. Identification, purpose, methods character matrix, taxonomic keys. Descriptions-subjects of descriptions, characters, nature of characters, analogy *v/s* homology, parallel *v/s* convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism. Brief evolutionary history of insects-introduction to phylogeny of insects and Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses. Process of speciation and interbreeding allopatric species. Molecular systemnatics, DNA barcoding, karyological and biochemical approaches in taxonomy. Insect labeling protocols and procedures.

Unit II

Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.

Unit III

Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

V. Practical

- Study of Orders of insects and their identification using taxonomic keys;
- Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera;
- Field visits to collect insects of different orders.

VI. Suggested Reading

CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers*. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.

Freeman S and Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.

Gullan PJ and Cranston PS. 2010. *The Insects: An outline of Entomology*. 4th Ed. Wiley-Blackwell Publications, West Sussex, UK.

Mayr E. 1971. *Principles of Systematic Zoology*. Tata McGraw Hill, New Delhi.

Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman and Hall, London.

Ross HH.1974. *Biological Systematics*. Addison Wesley Publ. Company.

Triplehorn CA and Johnson NF. 1998. *Borror and DeLong's Introduction to the Study of Insects*. 7th Ed. Thomson/ Brooks/ Cole, USA/ Australia.

I. Course Title : Insect Ecology

II. Course Code : ENT 504

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

History and definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance *vs* Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology.

Unit II

Basic concepts of abundance- Model *vs* Real world. Population growth basic models – Exponential *vs* Logistic models. Discrete *vs* Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) – aestivation, hibernation.

Unit III

Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions – The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of niche ecological homologues, competitive exclusion. Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.

Unit IV

Community ecology- Concept of guild, Organisation of communities- Hutchinson Ratio, May's d/w, Relation between the two and their association with Dyar's Law and Przibram's law. Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity- stability debate, relevance to pest management. Pest management as applied ecology. Climate change and insect pest/ natural enemy population; ecological engineering.

V. Practical

- Types of distributions of organisms;
- Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution;
- Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit;
- Fitting Holling's Disc equation;
- Assessment of prey-predator densities from natural systems and understanding the correlation between the two;
- Assessing and describing niche of some insects of a single guild;
- Calculation of niche breadth, activity breadth and diagrammatic representation

of niches of organisms;

- Calculation of diversity indices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values;
- Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

VIII. Suggested Reading

Begon M, Townsend CR and Harper JL. 2006. *Ecology: From Individuals to Ecosystems*. 4th Ed. Blackwell Publishing, USA/ UK/ Australia.

Chapman JL and Reiss MJ. 2006. *Ecology: Principles and Applications*. 2nd Ed. Cambridge Univ. Press, Cambridge.

Fowler J, Cohen L and Jarvis P. 1998. Practical Statistics for Field Biology. 2nd Ed. John Wiley & Sons, Chichester, West Sussex PO19 8SQ, England.

Gotelli NJ and Ellison AM. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Inc., Sunderland, MA.

Gotelli NJ. 2001. *A Primer of Ecology*. 3rd Ed. Sinauer Associates, Inc., Sunderland, MA

Gupta RK. 2004. *Advances in Insect Biodiversity*. Agrobios, Jodhpur.

Krebs CJ. 1998. *Ecological Methodology*. 2nd Ed. Benjamin-Cummings Publ. Co., New York.

Krebs CJ. 2001. *Ecology: The Experimental Analysis of Distribution and Abundance*. 5th Ed. Benjamin-Cummings Publ. Co., New York.

Magurran AE. 1988. *Ecological Diversity and its Measurement*. Princeton Univ. Press, Princeton.

Price PW. 1997. *Insect Ecology*. 3rd Ed. John Wiley, New York.

Real LA and Brown JH. (Eds). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, Chicago.

Schowalter Timothy D. 2011. *Insect Ecology – An Ecosystem Approach*. 3rd Ed. Academic Press, London, UK/ CA, USA.

Southwood TRE and Henderson PA. 2000. *Ecological Methods*. 3rd Ed. Methuen and Co. Ltd., London.

Speight MR, Hunta MD and Watt AD. 2006. *Ecology of Insects: Concepts and Application*. Elsevier Science Publ., The Netherlands.

Townsend Colin R, Begon Michael and Harper John L. 2008. *Essentials of Ecology*. 3rd Ed. Blackwell Publishing, USA/ UK/ Australia.

Wilson EO, William H and Bossert WH. 1971. *A Primer of Population Biology*. Harvard University, USA.

Wratten SD and Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold, London.

I. Course Title : Biological Control of Insect Pests And Weeds

II. Course Code : ENT 505

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.

Unit II

Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa, etc., their mode of action. Biological control of weeds using insects. Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

Unit III

Mass production of quality bio-control agents- techniques, formulations, economics, field release/ application and evaluation. Development of insectaries, their maintenance.

Unit IV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

V. Practical

- Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers;
- Visits to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds;
- Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

VI. Suggested Reading

Burges HD and Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites.* Academic Press, London.

De Bach P. 1964. *Biological Control of Insect Pests and Weeds.* Chapman and Hall, New York.

Dhaliwal GS and Arora R. 2001. *Integrated Pest Management: Concepts and Approaches.* Kalyani Publishers, New Delhi.

Gerson H and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual.* Chapman and Hall, New York.

Huffaker CB and Messenger PS. 1976. *Theory and Practices of Biological Control.* Academic Press, London.

Ignacimuthu SS and Jayaraj S. 2003. *Biological Control of Insect Pests*. PhoeniX Publ., New Delhi.

SaXena AB. 2003. *Biological Control of Insect Pests*. Anmol Publ., New Delhi.

Van Driesche and Bellows TS. Jr. 1996. *Biological Control.* Chapman and Hall, New York.

I. Course Title : Toxicology of Insecticides

II. Course Code : ENT 506

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

Unit II

Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature; categorization of insecticides on the basis of toxicity – criteria for bees, beneficial insects and other insects in general; structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds/ new insecticide molecules; nanopesticides; drawbacks of insecticide abuse.

Unit III

Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides-synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity. bioassay definition, objectives, criteria, factors, problems and solutions.

Unit IV

Insecticide metabolism; insect-pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

Unit V

Insecticide residues, their significance and environmental implications; procedures of insecticide residue analysis. Insecticide Act, registration procedures, label claim, and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

V. Practical

- Insecticide formulations and mixtures;
- Laboratory and field evaluation of bio-efficacy of insecticides;
- Bioassay techniques;
- Probit analysis;
- Evaluation of insecticide toxicity;
- Toxicity to beneficial insects;
- Pesticide appliances;
- Working out doses and concentrations of pesticides;
- Procedures of residue analysis.

VI. Suggested Reading

Chattopadhyay SB. 1985. *Principles and Procedures of Plant Protection*. Oxford and IBH, New Delhi.

Dodia DA, Petel IS and Petal GM. 2008. *Botanical Pesticides for Pest Management*. Scientific Publisher (India), Jodhpur.

Dovener RA, Mueninghoff JC and Volgar GC. 2002. Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA

Gupta HCL.1999. *Insecticides: Toxicology and Uses*. Agrotech Publ., Udaipur.

Ishaaya I and Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action*. Narosa Publ. House, New Delhi.

Ishaaya I and Degheele D. 1998. *Insecticides with Novel Modes of Action: Mechanism and Application*. Norosa Publishing House, New Delhi.
Krieger RI. 2001. *Handbook of Pesticide Toxicology*. Vol-II. Academic Press. Orlando Florida.
Mathews GA. 2002. *Pesticide Application Methods*. 4th Ed. Intercept. UK.
Matsumura F. 1985. *Toxicology of Insecticides.* Plenum Press, New York.
Otto D and Weber B. 1991. *Insecticides: Mechanism of Action and Resistance.* Intercept Ltd., UK.
Pedigo LP and Marlin ER. 2009. *Entomology and Pest Management*, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.
Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. *Insecticides in Agriculture and Environment.* Narosa Publ. House, New Delhi.
Prakash A and Rao J. 1997. *Botanical Pesticides in Agriculture*. Lewis Publication, New York.
Roy NK. 2006. *Chemistry of Pesticides*. Asia Printograph Shahdara Delhi.

I. Course Title : Host Plant Resistance

II. Course Code : 507

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

History and importance of resistance; principles, classification, components, types and mechanisms of resistance.

Unit II

Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

Unit III

Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance – acquired and induced systemic resistance.

Unit IV

Factors affecting plant resistance including biotypes and measures to combat them.

Unit V

Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

Unit VI

Role of biotechnology in plant resistance to insects.

V. Practical

- Screening techniques for measuring resistance;
- Measurement of plant characters and working out their correlations with plant resistance;
- Testing of resistance in important crops;
- Bioassay of plant extracts of susceptible/ resistant varieties;
- Demonstration of antibiosis, tolerance and antixenosis.

VI. Suggested Reading

Dhaliwal GS and Singh R. (Eds). 2004. *Host Plant Resistance to Insects -Concepts and Applications.* Panima Publ., New Delhi.

Maxwell FG and Jennings PR. (Eds). 1980. *Breeding Plants Resistant to Insects.* John Wiley and Sons, New York.

Painter RH. 1951. *Insect Resistance in Crop Plants.* MacMillan, London.

Panda N and Khush GS. 1995. *Plant Resistance to Insects.* CABI, London.

Smith CM. 2005. *Plant Resistance to Arthropods – Molecular and Conventional Approaches.* Springer, Berlin.

I. Course Title : Concepts of Integrated Pest Management

II. Course Code : ENT 508

III. Credit Hours : 2 (2+0)

IV. Theory

Unit I

History, origin, definition and evolution of various terminologies. Importance of resistance, principles, classification, components, types and mechanisms of resistance. National and international level crop protection organizations; insecticide regulatory bodies; synthetic insecticide, bio-pesticide and pheromone registration procedures; label claim of pesticides – the pros and cons.

Unit II

Concept and philosophy, ecological principles, economic threshold concept and economic consideration. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

Unit III

Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; semiochemicals, biotechnological and bio-rational approaches in IPM. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost- benefit ratios and partial budgeting; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organic farming; components of ecological engineering with successful examples.

Unit IV

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses; global and Indian scenario of crop losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system. Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

V. Suggested Reading

Dhaliwal GS and Arora R. 2003. *Integrated Pest Management – Concepts and Approaches.* Kalyani Publishers, New Delhi.

Horowitz AR and Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.

Ignacimuthu SS and Jayaraj S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.

Norris RF, Caswell-Chen EP and Kogan M. 2002. *Concepts in Integrated Pest Management*. Prentice Hall, New Delhi.

Pedigo RL. 2002. *Entomology and Pest Management*. 4th Ed. Prentice Hall, New Delhi.

Subramanyam B and Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products.* Marcel Dekker, New York.

I. Course Title : Pests of Field Crops

II. Course Code : ENT 509

III. Credit Hours : 3 (2+1)

IV. Aim of the course

To familiarize the students about nature of damage and seasonal incidence of pestiferous insects that cause loss to major field crops and their effective management by different methods.

V. Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors. Insect pest scenario in relation to climate change.

Unit I

Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs, etc.). Insect pests of cereals and millets and their management.

Unit II

Insect pests of pulses, tobacco, oilseeds and their management.

Unit III

Insect pests of fibre crops, forage crops, sugarcane and their management.

VI. Practical

- Field visits, collection and identification of important pests and their natural enemies;
- Detection and estimation of infestation and losses in different crops;
- Study of life history of important insect pests.

VII. Suggested Reading

David, BV and Ramamurthy, VV. 2001. *Elements of Economic Entomology*. Popular Book Depot, Chennai.

Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publishers, New Delhi.

Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publishers, New Delhi

Evans JW. 2005. *Insect Pests and their Control.* Asiatic Publ., New Delhi.

Nair MRGK. 1986. *Insect and Mites of Crops in India.* ICAR, New Delhi.

Prakash I and Mathur RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.

Saxena RC and Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Udaipur.

I. Course Title : Pests of Horticultural and Plantation Crops

II. Course Code : ENT 510

III. Credit Hours : 3 (2+1)

IV. Theory

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops.

Unit I

Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits.

Unit II

Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, French beans, chow-chow, brinjal, okra, all gourds, drumstick, leafy vegetables, etc.

Unit III

Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa, etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine, etc.

Unit IV

Ornamental, medicinal and aromatic plants and pests in polyhouses/ protected cultivation.

V. Practical

- Collection and identification of important pests and their natural enemies on different crops;
- Study of life history of important insect pests and non-insect pests.

VII. Learning outcome

VIII. Suggested Reading

Atwal AS and Dhaliwal GS. 2002. *Agricultural Pests of South Asia and theirManagement.* Kalyani Publishers, New Delhi.

Butani DK and Jotwani MG. 1984. *Insects and Vegetables.* Periodical Expert Book Agency, New Delhi.

Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essential of Agricultural Entomology*. Kalyani Publishers, New Delhi.

Srivastava RP. 1997. *Mango Insect Pest Management.* International Book Distr., Dehra Dun.

Verma LR, Verma AK and Goutham DC. 2004. *Pest Management in Horticulture Crops*: *Principles and Practices*. Asiatech Publ., New Delhi.

I. Course Title : Post Harvest Entomology

II. Course Code : ENT 511

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses *in toto vis-à-vis* total production of food grains in India. Scientific and socio-economic factors responsible for grain losses. Concept of seed vault.

Unit II

Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.

Unit III

Ecology of insect pests of stored commodities/ grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.

Unit IV

Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/ sanitation, disinfestations of stores/ receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical control- prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Insecticide resistance in stored product pests and its management; recent advances (MAS, PPP, HS) in storage pest management; integrated approaches to stored grain pest management.

V. Practical

- Collection, identification and familiarization with the stored grains/ seed insect pests and nature of damage caused by them;
- Detection of hidden insect infestation in stored food grains;
- Estimation of uric acid content in infested produce; estimation of losses in stored food grains;
- Determination of moisture content in stored food grains;
- Familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques;
- Treatment of packing materials and their effect on seed quality;
- Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, Mysore; IGSMRI, Hapur, etc. (only where logistically feasible).

VI. Suggesting Reading

Hall DW. 1970. *Handling and Storage of Food Grains in Tropical and Subtropical Areas.* FAO. Agricultural Development Paper No. 90 and FAO, Plant Production and Protection Series No. 19, FAO, Rome.

Jayas DV, White NDG and Muir WE. 1995. *Stored Grain Ecosystem*. Marcel Dekker, New York.

Khader V. 2004. *Textbook on Food Storage and Preservation*. Kalyani Publishers, New Delhi.

Khare BP. 1994. *Stored Grain Pests and Their Management.* Kalyani Publishers, New Delhi.

Subramanyam B and Hagstrum DW. 1995. *Interrelated Management of Insects in Stored Products.* Marcel Dekker, New York.

I. Course Title : Insect Vectors of Plant Pathogens

II. Course Code : ENT 512

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.

Unit II

Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.

Unit III

Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.

Unit IV

Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.

Unit V

Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

V. Practical

- Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes;
- Culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies;
- Vector rearing and maintenance;
- Estimating vector transmission efficiency, studying vector-virus host interaction.

VI. Suggested Reading

Basu AN. 1995. *Bemisia tabaci* (Gennadius) – *Crop Pest and Principal Whitefly Vector of Plant Viruses.* Oxford and IBH, New Delhi.

Harris KF and Maramarosh K. (Eds.). 1980. *Vectors of Plant Pathogens*. Academic Press, London.

Maramorosch K and Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.

Youdeovei A and Service MW. 1983. *Pest and Vector Management in the Tropics*. English Language Books Series, Longman, London.

I. Course Title : Principles of Acarology

II. Course Code : ENT 513

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

History of Acarology; importance of mites as a group; habitat, collection and preservation of mites. Soil arthropods and their classification, habitats and their identification.

Unit II

Introduction to morphology and biology of mites and ticks. Broad classification-major orders and important families of Acari including diagnostic characteristics. Estimation of populations; sampling and extraction methods for soil arthropods.

Unit III

Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens, etc. Culturing of phytophagous, parasitic and predatory mites. Mode of action of acaricides, resistance of mites and ticks to acaricides, its management.

V. Practical

- Collection of mites from plants, soil and animals;
- Extraction of mites from soil, plants and stored products;
- Preparation of mounting media and slide mounts;
- External morphology of mites;
- Identification of mites up to family level using keys;
- Studying different rearing techniques for mites.

VI. Suggested Reading

Anderson JM and Ingram JSI. 1993. *Tropical Soil Biology and Fertility: A Handbook of Methods.* CABI, London.

Chhillar BS, Gulati R and Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ. House, New Delhi.

Dindal DL. 1990. *Soil Biology Guide*. A Wiley-InterScience Publ., John Wiley and Sons, New York.

Gerson U and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual.* Chapman and Hall, NewYork.

Gupta SK. 1985. *Handbook of Plant Mites of India.* Zoological Survey of India, Calcutta.

Gwilyn O and Evans GO. 1998. *Principles of Acarology*. CABI, London.

Jeppson LR, Keifer HH and Baker EW. 1975. *Mites Injurious to Economic Plants*. University of California Press, Berkeley.

Krantz GW. 1970. *A Manual of Acarology*. Oregon State Univ. Book Stores, Corvallis, Oregon.

Pankhurst C, Dube B and Gupta, V. 1997. *Biological Indicators of Soil Health.* CSIRO, Australia.

Qiang Zhiang Z. 2003. *Mites of Green Houses- Identification, Biology and Control.* CABI, London.

Sadana GL. 1997. *False Spider Mites Infesting Crops in India.* Kalyani Publishers House, New Delhi.

Walter DE and Proctor HC. 1999. *Mites- Ecology, Evolution and Behaviou*r. CABI, London.

Veeresh GK and Rajagopal D. 1988. *Applied Soil Biology and Ecology*. Oxford and IBH Publ., New Delhi.

I. Course Title : Vertebrate Pest Management

II. Course Code : ENT 514

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Introduction to vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals.

Unit II

Bio-ecology of birds of agricultural importance, patterns of pest damage and assessment, roosting and nesting systems in birds; management of pestiferous birds; conservation of predatory birds.

Unit III

Bio-ecology of rodents of agricultural importance, patterns of pest damage and assessment, burrowing pattern and habitat of rodents; management of pestiferous rodents.

Unit IV

Bio-ecology of higher vertebrates of agricultural importance, patterns of damage and assessment, their habitat; management of pestiferous vertebrates.

Unit V

Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods – Operational practices- baiting, equipments and educative programmes.

V. Practical

- Identification of important rodents, birds and other vertebrate pests of agriculture, food preference and hoarding;
- Social behaviour, damage assessment, field survey, population estimation, management strategies: preventive and curative methods.

VI. Suggested Reading

Ali S. 1965. *The Book of Indian Birds*. The Bombay Natural History Society, Bombay.

Fitzwater WD and Prakash I. 1989. *Handbook of Vertebrate Pest Control.* ICAR, New Delhi.

Prakash I and Ghosh PK. 1997. *Rodents in Indian Agriculture*. Vol. I. State of Art Scientific Publ., Jodhpur.

Prakash I and Ghosh RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.

Prater SH. 1971. *The Book of Indian Animals*. The Bombay Natural History Society, Bombay.

Rahman A. 2020. *Protective and Productive Entomology* Narendra Publishing House, New Delhi

I. Course Title : Techniques in Plant Protection

II. Course Code : ENT 515

III. Credit Hours : 1 (0+1)

IV. Practical

- Pest control equipments, principles, operation, maintenance, selection, and application of pesticides;
- Release of bio-control agents;
- Seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticide application through irrigation water;
- Application of drones in plant protection;
- Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers;
- Uses of light, transmission and scanning electron microscopy;
- Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/ PAGE;
- Use of tissue culture techniques in plant protection;
- Computer application for predicting/ forecasting pest attack and identification.

V. Suggested Reading

Alford DV. 1999. *A Textbook of Agricultural Entomology*. Blackwell Science, London.

Crampton JM and Eggleston P. 1992. *Insect Molecular Science.* Academic Press, London.

I. Course Title : Apiculture

II. Course Code : ENT 516

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Historical development of apiculture at global level and in India; Classification of bees; global distribution of genus *Apis* and races; Morphology and anatomy of honey bee; Honey bee biology, ecology, adaptations; Honey bee behaviour – nest founding, comb construction, brood care, defense, other in-house and foraging activities; Bee pheromones; Honey bee communication.

Unit II

Commercial beekeeping as an enterprise; Design and use of bee hives; Apicultural equipment; Seasonal bee husbandry; Honey bee nutrition and artificial diets; Absconding, swarming, drifting – causes and management; Curbing drone rearing; Laying worker menace – causes, signs and management.

Unit III

Bee genetics; Principles and procedures of bee breeding; Screening of honey bee colonies; Techniques in mass queen bee rearing; Mating nuclei and their establishment; Selective mating; Queen bee management; Bee packages.

Unit IV

Ectoparasitic and endoparasitic bee mites – biology, ecology, nature and symptoms of damage, management tactics; Wax moths, wasps and ants – biology, ecology, nature and symptoms of damage, management tactics; Predatory birds, their damage potential and management tactics; Pesticide poisoning to honey bees, signs and protection; Protocols in evaluation of pesticide toxicity to honey bees.

Unit V

Honey – composition, properties, crystallization, post-harvest handling and processing; Honey quality standards and assessment; Apicultural diversification – potential and profitability; Production/ collection of bee pollen, propolis, royal jelly, bee venom and bees wax and their post-harvest handling; Apitherapy; Value addition of hive products; Development of apiculture project.

Unit VI

Non-*Apis* pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops.

V. Practical

- Morphological characteristics of honey bee;
- Mouthparts; digestive, respiratory and reproductive adaptations in different castes of honey bees;
- Recording of colony performance;
- Seasonal bee husbandry practices;
- Swarming, queenlessness, swarming, laying workers menaces, etc. and their remedies;
- Innovative techniques in mass queen bee rearing; selection and breeding of honey bees;
- Instrumental insemination; formulation of artificial diets and their feeding;
- Production technologies for various hive products;

- Bee enemies and diseases and their management;
- Recording pollination efficiency;
- Application of various models for determining pollination requirement of crop;
- Developing a beekeeping project.

VI. Suggested Reading

Abrol DP and Sharma D. 2009. *Honey Bee Mites and Their Management*. Kalyani Publishers, New Delhi, India.

Abrol DP. 2009. *Honey bee Diseases and Their Management*. Kalyani Publishers, New Delhi, India.

Abrol DP. 2010. *Beekeeping: A Compressive Guide to Bees and Beekeeping*. Scientific Publishers, India.

Abrol DP. 2010. *Bees and Beekeeping in India*. Kalyani Publishers, New Delhi, India.

Abrol DP. 2012. *Pollination Biology: Biodiversity Conservation and Agricultural Production*. Springer.

Atwal AS. 2001. *World of Honey Bees*. Kalyani Publishers, New Delhi- Ludhiana, India.

Atwal AS. 2000. *Essentials of Beekeeping and Pollination*. Kalyani Publishers, New Delhi-Ludhiana, India.

Bailey L and Ball BV. 1991. *Honey Bee Pathology*. Academic Press, London.

Crane Eva and Walker Penelope. 1983. *The Impact of Pest Management on Bees and Pollination*. Tropical Development and Research and Institute, London.

Free JB. 1987. *Pheromones of Social Bees*. Chapman and Hall, London.

Gatoria GS, Gupta JK, Thakur RK and Singh Jaspal. 2011. *Mass Multiplication of Honey Bee Colonies*. ICAR, New Delhi, India.

Grahm Joe M. 1992. *Hive and the Honey Bee*. Dadant & Sons, Hamilton, Illinois, USA.

Grout RA. 1975. *Hive and the Honey Bee*. Dadant & Sons, Hamilton, Illinois, USA.

Holm E. 1995. *Queen Rearing Genetics and Breeding of Honey Bees*. Gedved, Denmark.

Laidlaw HH Jr and Eckert JE. 1962. *Queen Rearing*. Berkeley, University of California Press.

Laidlaw HH. 1979. *Contemporary Queen Rearing*. Dadant & Sons, Hamilton, Illinois, USA.

Mishra RC. 2002. *Perspectives in Indian Apiculture*. Agro-Botanica, Jodhpur, India.

Mishra RC. 1995. *Honey Bees and their Management in India*. I.C.A.R., New Delhi, India.

Morse AA. 1978. *Honey Bee Pests, Predators and Diseases*. Cornell University Press, Ithaca and London.

Rahman, A. 2017. *Apiculture in India*, ICAR, New Delhi

Ribbands CR. 1953. *The Behaviour and Social Life of Honey Bees*. Bee Research Association Ltd., London, UK.

Rinderer TE. 1986. *Bee Genetics and Breeding*. Academic Press, Orlando.

Sardar Singh. 1962. *Beekeeping in India*. I.C.A.R., New Delhi, India (Reprint: 1982).

Seeley TD. 1985. *Honey Bee Ecology*. Princeton University Press, 216 pp.

Snodgrass RE. 1925. *Anatomy and Physiology of the Honey Bee*. Mc Graw Hill Book Co., New York & London.

Snodgrass RE. 1956. *Anatomy of the Honey Bee*. Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York.

I. Course Title : Sericulture

II. Course Code : ENT 517

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

History of Sericulture, importance, organizations involved in sericulture activities, silkworm types, distribution, area and silk production.

Unit II

Mulberry species, ecological requirements, cultivation, improved varieties, propagation methods, sapling production, planting and pruning techniques; pest and diseases, management strategies; intercropping, water and weed management. Food plants of eri silkworm, castor cultivation, intercultural operations, nutrient and water management; method of harvest; host plants of Tasar, nursery and cultivation, selection of seed, soaking and heap making, pruning techniques. Food plants of Muga silkworm, Som and Soalu propagation methods; nursery techniques; intercultural operations and weed management.

Unit III

Silkworm origin – classification based on voltinism, moultinism, geographical distribution and genetic nature – pure races –multivoltine and bivoltine races – cross breeds – bivoltine hybrids –Races and hybrids of mulberry, eri, tasar and muga silkworm- Morphology and biology of silkworm, sex limited characters; anatomy of digestive and excretory systems of larva; structure and function of silk glands.

Unit IV

Rearing house, types, disinfection, room and bed disinfectants; egg incubation methods, Chawki rearing, feeding, cleaning and spacing; rearing of late age worms, feeding, cleaning, spacing and moulting care; mountages, cocoon harvesting and marketing; pests and diseases of silkworms and their management.

Unit V

Post cocoon technology, stifling, cocoon cooking, brushing, reeling, re-reeling, bleaching, degumming, dyeing, printing and weaving, different reeling machines; value addition in sericulture; economics of sericulture.

V. Practical

- Morphology of mulberry plants;
- Identification of popular mulberry genotypes;
- Nursery bed and main field preparation;
- Planting methods;
- Identification of nutrient deficiency symptoms;
- Identification of weeds;
- Pruning and harvesting methods;
- Identification of pests and diseases of mulberry–*Terminalia arjuna*, *Terminalia tomentosa*, Som and Soalu- Nursery and pruning techniques – Intercultural operations;
- Morphology of silkworm – Identification of races – Dissection of mouth parts and silk glands – Disinfection techniques – rearing facilities – silkworm rearing – feeding, cleaning and spacing – Identification of pests and diseases of mulberry silkworm – hyperparasitoids and mass multiplication techniques – silkworm egg production technology –Tasar, Eri and muga silkworms – rearing methods–pests

and diseases of non-mulberry silkworms – Visit to grainage, cocoon market and silk reeling centre – Economics of silkworm rearing.

VI. Suggested Reading

Dandin SB and K Giridhar. 2014. Hand book of Sericulture Technologies. Central Silk Board, Bangalore, 423p.

Govindaiah G, VP, Sharma DD, Rajadurai S and Nishita V Naik. 2005. A text book on mulberry crop protection. Central Silk Board, Bangalore.450 p.

Jolly MS, Sen SK, Sonwalkar TN and Prasad GK. 1980. Non–mulberry Silks. FAO Agicultural Services Bulletin 29. Food and Agriculture Organization of the United Nations, Rome, 178 p.

Mahadevappa D, Halliyal VG, Shankar DG and Ravindra Bhandiwad. 2000. Mulberry Silk Reeling Technology. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi. 234 p.

Mohanty PK. 2003. Tropical wild cocoons of India. Daya Publications, Tri Nagar, New Delhi, 197 p.

Nataraju B, Sathyaprasad K, Manjunath D and Kumar A. 2005. Silkworm crop protection. CSB, Bangalore. 412 pp.

Rangaswami G, Narasimhanna MN, Kasiviswanathan K, Sastry CR and Jolly MS. 1976. Food Plants of non-mulberry silkworms. In: *Mulberry cultivation*. FAO Agricultural Services Bulletin. Vol.1, Chapter-13. Rome, Italy. 96 p.

Tribhuvan Singh and Saratchandra B. 2004. Principles and Techniques of silkworm seed production. Discovery publishing House, New Delhi, 360 pp.

VII. E-resources

www.silkwormgenomics.org; www.silkboard.com; ww.silkgermplasm.com; www.csrtimys.res.in

I. Course Title : Lac Culture

II. Course Code : ENT 518

III. Credit Hours : 3 (2+1)

IV. Aim of the course

To familiarize the students with entrepreneurial opportunities in entomology with an emphasis on lac culture in particular. To provide information on lac insect rearing, production and management.

V. Theory

Unit I

History of lac production; importance, potential of lac production in India; organizations involved in lac production activities; strains of lac insects and lac crops – distribution, area and production of different strains of lac.

Unit II

Steps and operation of lac production; lac host plant species, ecological requirements, their cultivation; seasons of host plants, harvest time of host plants, rearing seasons; grouping of host trees, pruning methods, timing; lac host plant pests and diseases; management strategies.

Unit III

Basic morphology and taxonomy of lac insect, strains of lac insect and their characteristics; composition of lac; biology of lac insect, species diversity and distribution.

Unit IV

Introduction, lac insect-host plant interaction; selection of brood lac, local practices, improved alternatives, coupe system; propagation of lac insects: natural self inoculation, artificial inoculation; inoculation process and duration; removal of phunki, harvesting of lac, immature harvesting, mature harvesting and time of harvesting. Predators and parasitoids of lac insect, hyperparasites, diseases and their management.

Unit V

Lac production stages; factors affecting yield and quality of shellac. Pure stock of host plants (kusum, palas, ber, pigeonpea, semialata); alternative method; technology of brood preserving. Host-specific technologies – cultivation on specific host plants; integration of lac cultivation with agro-forestry and horticulture; socio-economic potential of lac; export-import of lac/ lac products; marketing of lac and its products. Lac processing and value addition; entrepreneurship development.

VI. Practical

- Lac host cultivation and lac production practices;
- Equipments for lac production;
- Conventional and advanced methods;
- Coupe system of lac production;
- Cultivation of suitable host plants;
- Pruning of host trees;
- Herbarium of host plants;
- Strains of lac insects;
- Brood lac selection and treatment for pest management;
- Slide preparation of adult and immature stages;
- Inoculation of host tree;
- Identification of natural enemies of lac insect and their management;

- Molecular characterization of lac insect where possible;
- Harvesting;
- Process of manufacture of seed lac, shell lac from stick lac;
- Grading of seed lac and shellac;
- Marketing of lac products and by products.

VII. Suggested Reading

David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6th Edition, Namrutha Publications, Chennai.

Sharma KK and Ramani S. 2010. *Recent advances in lac culture*. ICAR-IINRG, Ranchi.

I. Course Title : Molecular Approaches In Entomology

II. Course Code : ENT 519

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Introduction to molecular biology, techniques used in molecular biology.

Unit II

DNA recombinant technology, identification of genes/ nucleotide sequences for traits of interest, techniques of interest in plants and microbes.

Unit III

Genes of interest in entomological research- marker genes for sex identification, peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Plant-derived enzyme inhibitors, protease inhibitors, trypsin inhibitors, á-amylase inhibitors, lectins, terepenes and terpenoids; genes of non-plant origin, *Bacillus thuringiensis* endotoxins, mode of action of cry genes, classification and properties, synthetic Bt toxin genes, Other toxin genes, genes derived from entomophagous viruses, transgenic plants for pest resistance.

Unit IV

Genetically engineered microbes and parasitoids in biological control-Genetic engineering in baculoviruses and fungal biocontrol agents for greater efficacy against insect pests. Effects of transgenic plants on pest biology and development, resistance management strategies in transgenic crops, molecular mechanism of insecticide resistance.

Unit V

Genetic-based methods for agricultural insect pest management-insect pest management through sterile insect technique and relase of insects carrying a dominant lethal gene. Methods and application of insect trangenesis, transgenics in silkworm and honeybees. Molecular tools for taxonomy and phylogeny of insect-pests, DNA-based diagnostics. Nano technology and its application.

V. Practical

- Isolation of DNA/ RNA;
- Agarose gel electrophoresis of DNA, quantification of DNA by spectrophotometirc and agarose gel analysis, PCR amplification of mitochondrial cytochrome oxidase subunit I gene (cox1) and 16S rRNA gene, cloning of PCR amplicons in standard plasmid vectors for sequencing, confirmation of the insert, miniprep of recombinant plasmid DNA, BLAST analysis and multiple sequence alignment of the sequence with sequences already available in GenBank;
- Isolation of host plant proteins, SDS-PAGE of the isolated proteins.

VI. Suggested Reading

Bhattacharya TK, Kumar P and Sharma A. 2007. *Animal Biotechnology*. 1st Ed., Kalyani Publication, New Delhi.

Hagedon HH, Hilderbrand JG, Kidwell MG and Law JH. 1990. *Molecular Insect Science.* Plenum Press, New York.

Hoy MA. 2003. *Insect Molecular Genetics: An Introduction to Principles and Applications*. 2nd Ed. Academic Press, New York.

Oakeshott J and Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer Verlag.

Rechcigl JE and Rechcigl NA. 1998. *Biological and Biotechnological Control of Insect Pests.* Lewis Publ., North Carolina.

Roy U and Saxena V. 2007. *A Hand Book of Genetic Engineering*. 1st Ed., Kalyani Publishers, New Delhi.

Singh BD. 2008. *Biotechnology (Expanding Horizons)*. Kalyani Publishers, New Delhi.

Singh P. 2007. *Introductory to Biotechnology*. 2nd Ed. Kalyani Publishers, New Delhi.

I. Course Title : Plant Quarantine, Bio-safety and Bio-security

II. Course Code : ENT 520

III. Credit Hours : 2 (2+0)

IV. Theory

Unit I

Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/ diseases and their status.

Unit II

Plant protection organization in India. Acts related to registration of pesticides and transgenics. Insecticide regulatory bodies, synthetic insecticides, bio-pesticides and pheromone registration procdures. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

Unit III

Identification of pest/ disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations; VHT and other safer techniques of disinfestation/ salvaging of infected material.

Unit IV

WTO regulations; non-tariff barriers; pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; sanitary and phytosanitary measures. Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops.

V. Suggested Reading

Rajeev K and Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.

Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental), CRC Press.

Shukla A and Veda OP. 2007. *Introduction to Plant Quarantine*. Samay Prakashan, New Delhi.

I. Course Title : Edible and Therapeutic Insects

II. Course Code : ENT 521

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Edible and therapeutic insects: the concept, definition, and importance.

Unit II

History and origin of insects as food, feed and medication; important insect species and insect products consumed.

Unit III

Edible insect ecology, conservation and management of edible insect resources; environmental opportunities of insect rearing.

Unit IV

Nutritional composition and role of insects in food security.

Unit V

Insect farming: the concept, definitions, and rearing techniques.

Unit VI

Processing edible insects for food and feed.

Unit VII

Food safety and preservation, edible insects for livelihood security.

V. Practical

- Survey and identification of edible and therapeutic insect species;
- Collection and preservation of edible and therapeutic insect specimens;
- Rearing techniques of edible insect species;
- Harvesting techniques of edible insects from natural environment;
- Analysis of proximate elemental composition, antioxidant and anti-nutritional properties and microbial aspects of preservation.

VI. Suggested Reading

Halloran A, Flore R, Vantomme P and Roos N 2018. Edible insects in sustainable food systems.

Van Huis A, Itterbeeck JK, Klunder H, Mertens E, Halloran A, Muir G and Vantomme. 2013. Edible insects: future prospects for food and feed security. Food and Agricultural Organization of the United Nations, Rome.

I. Course Title : Medical and Veterinary Entomology

II. Course Code : ENT 522

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Introduction to medical, veterinary and forensic entomology; Classification of Arthropod-borne diseases; Hematophagy, disease transmission and epidemiology; flies (Diptera) of medical and veterinary Importance; moth flies: Leishmaniasis and Bartonellosis; biting midges (Ceratapogonidae).

Unit II

Mosquito taxonomy, biology, and behavior; mosquito viruses: EEE, VEE, SLE, yellow fever,mosquito surveillance; malaria; horse flies, deer flies: EIA, anaplasmosis; muscid flies; Myiasis (Muscoidea); myiasis and louse flies; black flies of medical and veterinary Importance; filariasis: mansonellosis, onchocerciasis.

Unit III

Lice of medical and veterinary importance; rickettsial diseases: epidemic typhus, etc.; mites: rickettsial pox; mites and acariasis: mange, scabies, chiggers; spiders and scorpions; fleas (Siphonaptera) of medical and veterinary importance; plague and murine typhus.

Unit IV

Ticks of medical and veterinary importance; lyme disease, rocky mountain spotted fever, tularemia; true bugs (Hemiptera): kissing bugs and bedbugs; chagas disease; tsetse flies; Lepidoptera and Hymenoptera of medical and veterinary importance.

V. Practical

- Identification of arthropod Classes, Orders and Families of medical and veterinary importance;
- Collection, segregation, curing insect and arachnid specimens, their preservation;
- Management of insect and mite pests of medical and veterinary importance;
- Study of some practical aspects in forensic entomology.

VI. Suggested Reading

David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6th Edition, Namrutha Publications, Chennai.

Gullan PJ and Cranston PS. 2010. *The Insects: An Outline of Entomology*. 4th Edition, Wiley-Blackwell, West Sussex, UK & New Jersey, US.

Mullen G and Durden L. 2018. *Medical and Veterinary Entomology*, 3rd Edition, Academic Press.

I. Course Title : Forest Entomology

II. Course Code : ENT 523

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Introduction to forestry in the tropics, tropical forests: characteristics and types of tropical forests, management of tropical forests and the problems in their management; plantation forestry: beginnings, expansion and current status.

Unit II

History of tropical forest entomology, diversity of forest insects: structural and functional diversity – the feeding guilds, concept of pests, ecology of insects in forest environment, concept and functioning of ecosystem, role of insects in ecosystem processes of tropical forests: insects as primary consumers, secondary and tertiary consumers, as decomposers, as food, pollinators and other ecological interactions.

Unit III

Insect pests in natural forests, general pest incidence, pest outbreaks: Lepidoptera, Coleoptera, Hemiptera, and Hymenoptera; insect pests in plantations, nursery pests, sapling pests, pests of older plantations and their impact; insect pests of stored timber, categories of wood destroying insects and their damage: termites and beetles.

Unit IV

Population dynamics, characteristics of population growth, factors affection population growth, principles governing population dynamics, types and causes of forest insect outbreaks; general issues in forest entomology: enemies' hypothesis, resource concentration hypothesis, pest evolution hypothesis; pest problems in plantations of indigenous *vs* exotic species; pest problems in monocultures *vs* mixed plantations.

Unit V

Management of tropical forest insect pests, historical development and present status of tropical forest pest management, overview of pest management options: preventive measures, remedial measures; unique features of forest pest management; constraints to forest pest management in the tropics; guidelines for the practice of forest pest management in the tropics.

Unit VI

Insect pests in plantations: Location-specific case studies.

V. Practical

- Collection, identification and preservation of important insect pest specimens of forest plants and some damage material;
- Detection of insect infestation and assessment of losses due to insect pests;
- Habitat management for vertebrate and insects pests;
- Fire control methods and devices;
- Familiarization with the meteorological and plant protection equipment, application of pesticides and bio-control agents in the management of insect pests in nurseries and plantations.

VI. Suggested Reading

Jha LK and Sen Sarna PK. 1994. *Forest Entomology*. Ashish Publishing House, Delhi.

Nair KSS. 2007. *Tropical Forest Insect Pests: Ecology, Impact, and Management*, Cambridge University Press, Edinburgh/ New York.

Stebbings EP. 1977. *Indian Forest Insects*. JK Jain Brothers.

Course Title with Credit Load
Ph.D. in Plant Protection-Entomology

Course Code	Course Title	Credit Hours	Semester
ENT 601**	Insect Phylogeny and Systematics	3 (1+2)	II
ENT 602**	Insect Physiology and Nutrition	3 (2+1)	II
ENT 603**	Insect Ecology and Diversity	3 (2+1)	I
ENT 604	Insect Behaviour	2 (1+1)	II
ENT 605**	Bio-inputs for Pest Management	3 (2+1)	I
ENT 606**	Insect Toxicology and Residues	3 (2+1)	I
ENT 607	Plant Resistance to Insects	2 (1+1)	I
ENT 608	Acarology	2 (1+1)	II
ENT 609	Molecular Entomology	2 (1+1)	I
ENT 610	Integrated Pest Management	2 (2+0)	II
ENT 691	Doctoral Seminar – I	1 (0+1)	
ENT 692	Doctoral Seminar – II	1 (0+1)	
ENT 699	Doctoral Research	75 (0+75)	

**Core courses for Doctoral programme.

Course Contents
Ph.D. in Plant Protection-Entomology

I. Course Title : Insect Phylogeny and Systematics

II. Course Code : ENT 601

III. Credit Hours : 3 (1+2)

IV. Theory

Unit I

Detailed study of three schools of classification- numerical, evolutionary and cladistic. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts, speciation processes and evidences. Zoogeography.

Unit II

Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.

Unit III

Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; scientific ethics. Nomenclature and documentation protocols and procedures; report preparation on new species; deposition of holotypes, paratypes, and insect specimens as a whole in national and international repositories – requirements and procedures.

Unit IV

Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, works on revision of taxa, monographs, check lists, faunal volumes, etc. Websites related to insect taxonomy and databases. Molecular taxonomy, barcoding species and the progress made in molecular sytematics.

V. Practical

- Collection, curation and study of one taxon of insects- literature search, compilation of a checklist, study of characters, development of character table, and construction of taxonomic keys for the selected group;
- Development of descriptions, photographing, writing diagrams, and preparation of specimens for “type like” preservation, Submission of the collections made of the group;
- Multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms;
- Rooting and character polarization for developing cladograms and use of computer programmes to develop cladograms.

VI. Suggested Reading

CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers.* 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.

Dakeshott J and Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer-Verlag, Berlin.

Freeman S and Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.

Hennig W. 1960. *Phylogenetic Systematics*. Urbana Univ. Illinois Press, USA.

Hoy MA. 2003. *Insect Molecular Genetics: An Introduction to Principles and Applications*. 2nd Ed. Academic Press, New York.

Mayr E and Ashlock PD. 1991. *Principles of Systematic Zoology*. 2nd Ed. McGraw Hill, New York.

Mayr E.1969. *Principles of Systematic Zoology*. McGraw-Hill, New York.

Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy*. Blackie Academic and Professional, London.

Ross HH. 1974. *Biological Systematics*. Addison Wesley Publ. Co., London.

Wiley EO. 1981. *Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists*. Columbia Univ. Press, USA.

I. Course Title : Insect Physiology and Nutrition

II. Course Code : ENT 602

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, hardening of cuticlde.

Unit II

Digestive enzymes, digestive physiology in phytophagous, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development; physiology of excretion and osmoregulation, water conservation mechanisms.

Unit III

Detailed physiology of nervous system, transmission of nerve impulses, neuro-transmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.

Unit IV

Endocrine system and insect hormones, physiology of insect growth and development- metamorphosis, polymorphism and diapause. Insect behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

V. Practical

- Preparation of synthetic diets for different groups of insects;
- Rearing of insects on synthetic, semi-synthetic and natural diets;
- Determination of co-efficient of utilization;
- Qualitative and quantitative profile of bio-molecules: practicing analytical techniques for analysis of free amino acids of haemolymph;
- Zymogram analyses of amylase;
- Determination of chitin in insect cuticle;
- Examination and count of insect haemocytes.

VI. Suggested Reading

Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford and IBH, New Delhi.

Bernays EA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman and Hall, London.

Kerkut GA and Gilbert LI. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, Oxford, New York.

Muraleedharan K. 1997. *Recent Advances in Insect Endocrinology*. Association for Advancement of Entomology, Trivandrum, Kerala.

Rockstein, M. 1978. *Biochemistry of Insects*, Academic Press.

Simpson, SJ. 2007. *Advances in Insect Physiology*, Vol. 33, Academic Press (Elsevier), London, UK.

I. Course Title : Insect Ecology and Diversity

II. Course Code : ENT 603

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Characterization of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics- Life tables, Leslie Matrix, Stable age distribution, Population projections. Predator-Prey Models- Lotka-Volterra and Nicholson-Bailey Model. Crop Modeling- an introduction.

Unit II

Insect Plant Interactions. Fig-figwasp mutualism and a quantitative view of types of associations. Role of insects in the environment. Adaptations to terrestrial habitats. Evolution of insect diversity and role of phytophagy as an adaptive zone for increased diversity of insects. Evolution of resource harvesting organs, resilience of insect taXa and the sustenance of insect diversity- role of plants. Herbivory, pollination, predation, parasitism. Modes of insect-plant interaction, tri-trophic interactions. Evolution of herbivory, monophagy vs polyphagy. Role of plant secondary metabolites. Meaning of stress- plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses. Host seeking behavior of parasitoids.

Unit III

Biodiversity and Conservation- RET species, Ecological Indicators. Principles of Population genetics, Hardy Weinberg Law, Computation of Allelic and Phenotypic frequencies, Fitness under selection, Rates of Evolution under selection. Foraging Ecology- Optimal foraging theory, Marginal Value Theorem, and Patch departure rules, central place foraging, Mean-variance relationship and foraging by pollinators, Nutritional Ecology.

Unit IV

Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies – timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict. Agro-ecological vs Natural Ecosystems – Characterisation, Pest Control as applied ecology- case studies.

V. Practical

- Methods of data collection under field conditions;
- Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index, Index of Dispersion, etc.;
- Calculation of sample sizes by different methods;
- Fitting Poisson and Negative Binomial distributions and working out the data transformation methods;
- Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies – Calculation of changes under selection, Demonstration of genetic drift;
- Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/ *Goniozus*/ Female Bruchids, etc.;
- A test of reproductive effort and fitness;
- Construction of Life tables and application of Leslie Matrix – population projections, Stable age distribution;
- Exercises in development of Algorithms for crop modeling;

VI. Suggested Reading

Barbosa P and Letourneau DK. (Eds.). 1988. *Novel Aspects of Insect-Plant Interactions*. Wiley, London.

Elizabeth BA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman and Hall, New York.

Freeman S and Herron JC.1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.

Gotelli NJ and Ellison AM. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Sunderland, MA.

Gotelli NJ. 2001. *A Primer of Ecology*. 3rd Ed., Sinauer Associates, Sunderland, MA, USA.

Krebs C. 1998. *Ecological Methodology*. 2nd Ed. Benjamin-Cummings Publ. Co., New York.

Krebs CJ. 2001 *Ecology: The Experimental Analysis of Distribution and Abundance*. 5th Ed. Benjamin-Cummings Publ. Co., New York.

Magurran AE. 1988. *Ecological Diversity and its Measurement*. Princeton University Press, Princeton.

Real LA and Brown JH. (Eds.). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, USA.

Southwood TRE and Henderson PA. 2000. *Ecological Methods*. 3rd Ed. Wiley Blackwell, London.

Strong DR, Lawton JH and Southwood R. 1984. *Insects on Plants: Community Patterns and Mechanism*. Harward University Press, Harward.

Wratten SD and Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold Publ., London.

I. Course Title : Insect Behaviour

II. Course Code : ENT 604

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Defining Behaviour- Concept of umwelt, instinct, fixed action patterns, imprinting, complex behavior, inducted behavior, learnt behavior and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behavior- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behavior and behavioural polymorphism.

Unit II

Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.

Unit III

Reproductive behavior- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behavior- kin selection, parental manipulation and mutualism; Self organization and insect behavior.

Unit IV

Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behavior, pollination behavior, co-evolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

V. Practical

- Quantitative methods in sampling behavior;
- Training bees to artificial feeders;
- Sensory adaptation and habituation in a fly or butterfly model, physical cues used in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect (DBM or gram pod borer), colour discrimination in honey bee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees;
- Evaluation of different types of traps against fruit flies with respect to signals;
- Use of honey bees/ *Helicoverpa armigera* to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.

VI. Suggested Reading

Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford and IBH, New Delhi.

Awasthi VB. 2001. *Principles of Insect Behaviour*. Scientific Publ., Jodhpur.

Bernays EA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman and Hall, London.

Brown LB. 1999. *The Experimental Analysis of Insect Behaviour*. Springer, Berlin.

Krebs JR and Davies NB. 1993. *An Introduction to Behavioural Ecology*. 3rd Ed. Chapman and Hall, London.

Manning A and Dawkins MS. 1992. *An Introduction to Animal Behaviour*. Cambridge University Press, USA.

Mathews RW and Mathews JR. 1978. *Insect Behaviour*. A Wiley-InterScience Publ. John Wiley and Sons, New York.

I. Course Title : Bio-inputs for Pest Management

II. Course Code : ENT 605

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Scope of classical biological control and augmentative bio-control; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of bio-agents *vis-à-vis* target pest populations.

Unit II

Bio-inputs: mass production of bio-pesticides, mass culturing techniques of bio-agents, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.

Unit III

Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, large-scale production of bio-control agents, bankable project preparation.

Unit IV

Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in bio-control agents for introgressing and for progeny selections, breeding techniques of bio-control agents.

V. Practical

- Mass rearing and release of some commonly occurring indigenous natural enemies;
- Assessment of role of natural enemies in reducing pest populations;
- Testing side effects of pesticides on natural enemies;
- Effect of semio-chemicals on natural enemies, breeding of various bio-control agents, performance of efficiency analyses on target pests;
- Project document preparation for establishing a viable mass-production unit/ insectary;
- Observation of feeding behavior acts of predatory bugs/ beetles.

VI. Suggested Reading

Burges HD and Hussey NW. (Eds.). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.

Coppel HC and James WM. 1977. *Biological Insect Pest Suppression*. Springer Verlag, Berlin.

De Bach P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman and Hall, London.

Dhaliwal, GS and Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publishers, New Delhi.

Gerson H and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman and Hall, New York.

Huffakar CB and Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.

I. Course Title : Insecticide Toxicology and Residues

II. Course Code : ENT 606

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I

Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. Modes of action of newer insecticide molecules; developments in bio-rational approaches; SPLAT; RNAi technology for pest management.

Unit II

Biochemical and physiological target sites of insecticides in insects; developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.

Unit III

Joint action of insecticides; activation, synergism and potentiation.

Unit IV

Problems associated with pesticide use in agriculture: pesticide resistance; resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.

Unit V

Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; bound and conjugated residues, effect on soil fertility; insecticide laws and standards, and good agricultural practices.

V. Practical

- Residue sampling, extraction, clean-up and estimation of insecticide residues by various methods;
- Calculations and interpretation of data;
- Biochemical and biological techniques for detection of insecticide resistance in insects;
- Preparation of EC formulation using neem oil.

VI. Suggested Reading

Busvine JR. 1971. *A Critical Review on the Techniques for Testing Insecticides*. CABI, London.

Dhaliwal GS and Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publishers, New Delhi.

Hayes WJ and Laws ER. 1991. *Handbook of Pesticide Toxicology*. Academic Press, New York.

Ishaaya I and Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action*. Narosa Publ. House, New Delhi.

Matsumura F. 1985. *Toxicology of Insecticides*. Plenum Press, New York.

O' Brien RD. 1974. *Insecticides Action and Metabolism*. Academic Press, New York.

Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. *Insecticides in Agriculture and Environment*. Narosa Publ. House, New Delhi.

Prakash A and Rao J. 1997. *Botanical Pesticides in Agriculture*. Lewis Publ., New York.

I. Course Title : Plant Resistance to Insects

II. Course Code : ENT 607

III. Credit Hours : 2 (1+1)

IV. Aim of the course

To familiarize the students with recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.

V. Theory

Unit I

Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species – gene pool; insect sources – behaviour in relation to host plant factors.

Unit II

Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oXidase pathways, salicylic acid pathways; effects of induced resistance; eXogenous application of elicitors.

Unit III

Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker-aided selection in resistance breeding.

Unit IV

Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.

VI. Practical

- Understanding mechanisms of resistance for orientation, feeding, oviposition, etc., allelochemical bases of insect resistance;
- Macroculturing of test insects like aphids, leaf/ plant hoppers, mites and stored grain pests;
- Field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries;
- Determination of antiXenosis indeX, antibiosis indeX, tolerance indeX, plant resistance indeX.

VII. Suggested Reading

Panda N. 1979. *Principles of Host Plant Resistance to Insects*. Allenheld, Osum and Co., New York.

Rosenthal GA and Janzen DH. (Eds.). 1979. *Herbivores – their Interactions with Secondary Plant Metabolites*. Vol. I, II. Academic Press, New York.

Sadasivam S and Thayumanavan B. 2003. *Molecular Host Plant Resistance to Pests*. Marcel Dekker, New York.

Smith CM, Khan ZR and Pathak MD. 1994. *Techniques for Evaluating Insect Resistance in Crop Plants*. CRC Press, Boca Raton, Florida.

I. Course Title : Acarology

II. Course Code : ENT 608

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Comparative morphology of Acari, phylogeny of higher categories in mites, knowledge of commonly occurring orders and families of Acari in India. Diagnostic characteristics of commonly occurring species from families Tetranychidae, Tenuipalpidae, Eriophyidae, Tarsonemidae, Phytoseiidae, Bdellidae, Cunaxidae, Stigmaeidae, Pymotidae, Cheyletidae, Acaridae, Pyroglyphidae, Orthogalumnidae, Argasidae, Ixodidae, Sarcoptidae. Soil mites in India.

Unit II

Management of economical important species of mites in agriculture, veterinary and public health; storage acarology.

Unit III

Mites as vectors of plant pathogens; mode of action, structure-activity relationships of different groups of acaricides; problem of pesticide resistance in mites, resurgence of mites.

Unit IV

Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungi- identification, isolation and utilization.

V. Practical

- Identification of commonly occurring mites up to species, preparation of keys for identification;
- Collection of specific groups of mites and preparing their identification keys;
- Rearing phytoseiid mites and studying their role in suppression of spider mites;
- Management of mite pests of crops using acaricides, phytoseiid predators, fungal pathogens, etc.

VII. Learning outcome

VIII. Suggested Reading

Evans GO.1992. *Principles of Acarology*. CABI, London.

Gerson H and Smiley RL. 1990. *Acarine Bio-control Agents- An Illustrated Key and Manual*. Chapman and Hall, New York.

Gupta SK. 1985. *Handbook of Plant Mites of India*. Zoological Survey of India, Calcutta.

Krantz GW. 1970. *A Manual of Acarology*. Oregon State University Book Stores, Corvallis, Oregon.

Sadana GL. 1997. *False Spider Mites Infesting Crops in India*. Kalyani Publ. House, New Delhi.

I. Course Title : Molecular Entomology

II. Course Code : ENT 609

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I

Introduction to molecular biology; techniques used in molecular biology.

Unit II

DNA and RNA analysis in insects- transcription and translocation mechanisms. DNA recombinant technology, identification of genes/ nucleotide sequences for characters of interest. Genetic improvement of natural enemies. Cell lines, genetic engineering in baculoviruses, *Bt* and entomopathogenic fungi.

Unit III

Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, CPTI; lectins and proteases. Transgenic plants for pest resistance and diseases.

Unit IV

Insect gene transformation; biotechnology in relation to silkworms and honey bees; introduction of lectin genes for pest suppression; DNA finger printing for taxonomy and phylogeny. Genetic improvement of inebriate tolerance of natural enemies.

Unit V

DNA-based diagnostics; insect immune systems in comparison to vertebrates; molecular basis of metamorphosis; Sf transgenic technology and implications; molecular biology of baculoviruses; insecticide resistance. Resistance management strategies in transgenic crops.

V. Practical

- Isolation of DNA/ RNA;
- Purity determinations, purification of total DNA from animal tissues;
- Base pair estimation;
- Agarose gel electrophoresis;
- Quantitative enzyme profile of alimentary canal;
- Restriction mapping of DNA;
- Demonstration of PCR, RFLP and RAPD techniques.

VI. Suggested Reading

Bhattacharya TK, Kumar P and Sharma A. 2007. *Animal Biotechnology*. 1st Ed., Kalyani Publication, New Delhi.

Hagedon HH, Hilderbrand JG, Kidwell MG and Law JH. 1990. *Molecular Insect Science*. Plenum Press, New York.

Hoy MA. 2003. *Insect Molecular Genetics: An Introduction to Principles and Applications*. 2nd Ed. Academic Press, New York.

Oakeshott J and Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer Verlag.

Rechcigl JE and Rechcigl NA. 1998. *Biological and Biotechnological Control of Insect Pests*. Lewis Publ., North Carolina.

Roy U and Saxena V. 2007. *A Hand Book of Genetic Engineering*. 1st Ed., Kalyani Publishers, New Delhi.

Singh BD. 2008. *Biotechnology* (*Expanding Horizons*). Kalyani Publishers, New Delhi.

Singh P. 2007. *Introductory to Biotechnology*. 2nd Ed. Kalyani Publishers, New Delhi.

I. Course Title : Integrated Pest Management

II. Course Code : ENT 610

III. Credit Hours : 2 (2+0)

IV. Theory

Unit I

Principles of sampling and surveillance, database management and computer programming; simulation techniques, system analysis and modeling.

Unit II

Study of case histories of national and international programmes, their implementation, adoption and criticism; global trade and risk of invasive pests; updating knowledge on insect outbreaks and their management.

Unit III

Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes; application of IPM to farmers' real time situation.

Unit IV

Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

V. Suggested Reading

Dhaliwal GS and Arora R. 2003. *Integrated Pest Management – Concepts and Approaches.* Kalyani Publishers, New Delhi.

Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publishers, New Delhi.

Flint MC and Bosch RV. 1981. *Introduction to Integrated Pest Management.* Springer, Berlin.

Koul O and Cuperus GW. 2007. *Ecologically Based Integrated Pest Management.* CABI, London.

Koul O, Dhaliwal GS and Curperus GW. 2004. *Integrated Pest Management –Potential, Constraints and Challenges.* CABI, London.

Maredia KM, Dakouo D and Mota-Sanchez D. 2003. *Integrated Pest Management in the Global Arena.* CABI, London.

Metcalf RL and Luckman WH. 1982. *Introduction to Insect Pest Management.* John Wiley and Sons, New York.

Norris RF, Caswell-Chen EP and Kogan M. 2002. *Concepts in Integrated Pest Management*. Prentice Hall, New Delhi.

Pedigo RL. 1996. *Entomology and Pest Management.* Prentice Hall, New Delhi.

Subramanyam B and Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products.* Marcel Dekker, New York.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 1

Plant Protection

– Plant Pathology

Course Title with Credit Load
M.Sc. in Plant Pathology

Course Code	Course Title	Credit Hours	Semester
PL PATH 501*	Mycology	2+1	I
PL PATH 502*	Plant Virology	2+1	I
PL PATH 503*	Plant Pathogenic Prokaryotes	2+1	I
PL PATH 504*	Plant Nematology	2+1	II
PL PATH 505*	Principles of Plant Pathology	2+1	I
PL PATH 506*	Techniques in Detection and Diagnosis of Plant Diseases	0+2	I
PL PATH 507	Principles of Plant Disease Management	2+1	II
PL PATH 508	Epidemiology and Forecasting of Plant Diseases	1+0	I
PL PATH 509	Disease Resistance in Plants	2+0	II
PL PATH 510	Ecology of Soil-borne Plant Pathogens	1+1	I
PL PATH 511	Chemicals and Botanicals in Plant Disease Management	2+1	II
PL PATH 512	Detection and Management of Seed Borne Pathogens	2+1	II
PL PATH 513	Biological Control of Plant Diseases	1+1	II
PL PATH 514	Integrated Disease Management	2+1	I
PL PATH 515*	Diseases of Field and Medicinal Crops	2+1	II
PL PATH 516	Diseases of Fruits, Plantation and Ornamental Crops	2+1	I
PL PATH 517	Diseases of Vegetable and Spices Crops	2+1	II
PL PATH 518	Post Harvest Diseases	2+1	I
PL PATH 519	Plant Quarantine and Regulatory Measures	1+0	II
PL PATH 591	Master's Seminar	0+1	
PL PATH 521	Master's Research	0+30	

*Core Courses for Master's

Course Contents
M.Sc. in Plant Pathology

I. Course Title : Mycology
II. Course Code : PL PATH 501
III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs. History of mycology. Importance of culture collection and herbarium of fungi. Somatic characters and reproduction in fungi. Modern concept of nomenclature and classification, Classification of kingdom fungi: Stramenopila and Protists.

Unit II

The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota. Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.

Unit III

Kingdom fungi: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota, Zygomycota, Ascomycota; Archiascomycetes, Ascomycetous yeasts, Pyrenomycetes, Plectomycetes, Discomycetes, Loculoascomycetes, Erysiphales and anamorphs of ascomycetous fungi.

Unit IV

Basidiomycota; general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes. Uridinales and Ustilaginales; variability, host specificity and life cycle pattern in rusts and smuts. Mitosporic fungi; status of asexual fungi, their teliomorphic relationships, Molecular characterization of plant pathogenic fungi.

V. Practical

- Detailed comparative study of different groups of fungi;
- Collection of cultures and live specimens;
- Saccardoan classification and classification based on conidiogenesis;
- Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi;
- Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and aethalia. Oomycota;
- Somatic and reproductory structures of *Pythium*, *Phytophthora*, downy mildews and *Albugo*, Zygomycetes: Sexual and asexual structures of *Mucor*, *Rhizopus*, General characters of VAM fungi. Ascomycetes; fruiting structures, Erysiphales, and Eurotiales;
- General identification characters of Pyrenomycetes, Discomycetes, Loculo-ascomycetes and Laboulbenio-mycetes, Basidiomycetes; characters, ultrastructures

and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes;

- Characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states, Collection, preservation, culturing and identification of plant parasitic fungi;
- Application of molecular approaches and techniques for identification of fungal pathogens.

VI. Suggested Reading

Ainsworth GC, Sparrow FK and Susman HS. 1973. *The Fungi – An Advanced Treatise*. Vol. IV (A & B). Academic Press, New York.

Alexopoulos CJ, Mims CW and Blackwell M.2000. *Introductory Mycology*. 5th Ed. John Wiley & Sons, New York.

Maheshwari R. 2016. *Fungi: Experimental Methods in Biology* 2nd edn. CRC Press, US.

Mehrotra RS and Arneja KR. 1990. *An Introductory Mycology*. Wiley Eastern, New Delhi.

Sarbhoy AK. 2000. *Text book of Mycology*. ICAR, New Delhi.

Singh RS. 1982. *Plant Pathogens – The Fungi*. Oxford & IBH, New Delhi.

Webster J. 1980. *Introduction to Fungi*. 2nd Ed. Cambridge Univ. Press, Cambridge, New York.

I. Course Title : Plant Virology

II. Course Code : PL PATH 502

III. Credit Hours : 2+1

IV. Theory

Unit I

History and economic significances of plant viruses. General and morphological characters, composition and structure of viruses. Myco-viruses, arbo and baculo viruses, satellite viruses, satellite RNAs, phages, viroids and prions**.** Origin and evolution of viruses and their nomenclature and classification.

Unit II

Genome organization, replication in selected groups of plant viruses and their movement in host. Response of the host to virus infection: biochemical, physiological, and symptomatical changes. Transmission of viruses and virus-vector relationship. Isolation and purification of viruses.

Unit III

Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques. Natural (R-genes) and engineering resistance to plant viruses.

Unit IV

Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival). Management of diseases caused by plant viruses.

- Study of symptoms caused by plant viruses (followed by field visit);
- Isolation and biological purification of plant virus cultures;
- Bioassay of virus cultures on indicator plants and host differentials;
- Transmission of plant viruses (Mechanical, graft and vector and study of disease development);
- Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology;
- Antisera production, Detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR–LAMP, Later flow micro array and PCR based techniques);
- Exposure to basic bio-informatic tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bioedit tool, Claustal X/W, MEGA Software).

VII. Suggested Reading

Bos L. 1964. *Symptoms of Virus Diseases in Plants*. Oxford & IBH., New Delhi.

Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ and Watson L. 1995. *Virus of Plants: Descriptions and Lists from VIDE Database*. CABI, Wallington.

Gibbs A and Harrison B. 1976. *Plant Virology – The Principles*. Edward Arnold, London. Hull R. 2002. *Mathew's Plant Virology*. 4th Ed. Academic Press, New York.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Oxford & IBH, New Delhi.

Wilson C. 2014. *Applied Plant Virology*. CABI Publishing England.

I. Course Title : Plant Pathogenic Prokaryotes

II. Course Code : PL PATH 503

III. Credit Hours : 2+1

IV. Theory

Unit I

Prokaryotic cell: History and development of Plant bacteriology, history of plant bacteriology in India. Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins. Structure of bacterial cell. Structure and composition of gram negative and gram positive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccaride structure; Membrane transport; fimbrae and pili (Type IV pili); Mechanism of flagellar rotatory motor and locomotion, and bacterial movement; Glycocalyx (S-layer; capsule); the bacterial chromosomes and plasmids; Operon and other structures in cytoplasm; Morphological feature of fastidious bacteria, spiroplasmas and Phytoplasmas.

Unit II

Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopathogenic prokaryotes. Taxonomy of phytopathogenic prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma. The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes.

Unit IV

Variability among phytopathogenic prokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria-conjugation; transformation; transduction); and horizontal gene transfer.

Unit V

Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle; Classification of phages, Use of phages in plant pathology/ bacteriology, Lysogenic conversion; H Plasmids and their types, plasmid borne phenotypes.Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.

V. Practical

- Study of symptoms produced by phytopathogenic prokaryotes;
- Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria;
- Stains and staining methods;
- Biochemical and serological characterization;
- Isolation of genomic DNA plasmid;
- Use of antibacterial chemicals/ antibiotics;
- Isolation of fluorescent *Pseudomonas*;
- Preservation of bacterial cultures;
- Identification of prokaryotic organisms by using 16S rDNA, and other gene sequences;
- Diagnosis and management of important diseases caused by bacteria and mollicutes.

VI. Suggested Reading

Goto M. 1990. *Fundamentals of Plant Bacteriology*. Academic Press, New York.

Jayaraman J and Verma JP. 2002. *Fundamentals of Plant Bacteriology*. Kalyani Publishers, Ludhiana.

Mount MS and Lacy GH. 1982. *Phytopathogenic Prokaryotes*. Vols. I, II Academic Press, New York.

Salle AJ. 1979. *Fundamental Principles of Bacteriology 7th edn.*

Verma JP, Varma A and Kumar D. (Eds). 1995. *Detection of Plant Pathogens and their Management*. Angkor Publ., New Delhi.

I. Course Title : Plant Nematology

II. Course Code : PL PATH 504

III. Credit Hours : 2+1

IV. Aim of the course

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

V. Theory

Unit I

Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

Unit II

Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

Unit III

Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

Unit IV

Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

Unit V

Principles and practices of nematode management; integrated nematode management.

Unit VI

Emerging nematode problems, Importance of nematodes in international trade and quarantine.

VI. Practical

- Studies on kinds of nematodes- free-living, animal, insect and plant parasites;
- Nematode extraction from soil;
- Extraction of migratory endoparasites, staining for sedentary endoparasites;
- Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology.

VII. Suggested Reading

Dropkin VH. 1980. *An Introduction to Plant Nematology*. John Wiley & Sons, New York.

Maggenti AR. 1981. *General Nematology*. Springer-Verlag, New York.

Perry RN and Moens M. 2013. *Plant Nematology*. 2nd Ed. CABI Publishing: Wallingford, UK.

Perry RN, Moens M, and Starr JL. 2009. *Root-knot nematodes*, CABI Publishing: Wallingford, UK.

Sikora RA, Coyne D, Hallman J and Timper P. 2018. *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture*.3rd edn. CABI Publishing, England.

Thorne G. 1961. *Principles of Nematology*. McGraw Hill, New Delhi.

Walia RK and Bajaj HK. 2003. *Text Book on Introductory Plant Nematology*. ICAR, New Delhi.

Walia RK and Khan MR. 2018. *A Compendium of Nematode Diseases of Crop Plants*, ICAR-AICRP (Nematodes), IARI, New Delhi.

I. Course Title : Principles of Plant Pathology

II. Course Code : PL PATH 505

III. Credit Hours : 2+1

IV. Aim of the course

To introduce the subject of Plant Pathology, its concepts and principles.

V. Theory

Unit I

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

Unit II

Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

Unit III

Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

Unit IV

Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

VI. Practical

- Basic plant pathological techniques;
- Isolation, inoculation and purification of plant pathogens and proving Koch's postulates;
- Techniques to study variability in different plant pathogens;
- Purification of enzymes, toxins and their bioassay;
- Estimation of growth regulators, phenols, phytoalexins in resistant and susceptible plants.

VII. Suggested Reading

Agrios GN. 2005. *Plant Pathology*. 5th Ed. Academic Press, New York.

Heitefuss R and Williams PH. 1976. *Physiological Plant Pathology*. Springer Verlag, Berlin, New York.

Mehrotra RS and Aggarwal A. 2003. *Plant Pathology*. 2nd Ed. Oxford & IBH, New Delhi.

Singh RP. 2012. *Plant Pathology* 2nd edn. Kalyani Publishers, New Delhi.

Singh RS. 2017. *Introduction to Principles of Plant Pathology*. 5th edn. MedTech, New Delhi.

Singh DP and Singh A. 2007. *Disease and Insect Resistance in Plants*. Oxford & IBH, New Delhi.

Upadhyay RK. and Mukherjee KG. 1997. *Toxins in Plant Disease Development and Evolving Biotechnology*. Oxford & IBH, New Delhi.

I. Course Title : **Techniques for Detection and Diagnosis of Plant Diseases**

II. Course Code : **PL PATH 506**

III. Credit Hours : **0+2**

IV. Practical

- Detection of plant pathogens 1. Based on visual symptoms, 2. Biochemical test 3. Using microscopic techniques, 4. Cultural studies; (use of selective media to isolate pathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serological assays 7. Nucleic acid based techniques (Non-PCR–LAMP, Later flow microarray and PCR based- multiplex, nested, qPCR, immune capture PCR, etc.);
- Phenotypic and genotypic tests for identification of plant pathogens;
- Molecular identification (16S rDNA and 16s-23S rDNA intergenic spacer region sequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing;
- Volatile compounds profiling by using GC-MS and LC-MS;
- FAME analysis, Fluorescence *in-situ* Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors for detection of plant pathogens;
- Genotypic tools such as genome/ specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

V. Suggested Reading

Baudoin ABAM, Hooper GR, Mathre DE and Carroll RB. 1990. *Laboratory Exercises in Plant Pathology: An Instructional Kit*. Scientific Publ., Jodhpur.

Dhingra OD and Sinclair JB. 1986. *Basic Plant Pathology Methods*. CRC Press, London, Tokyo.

Fox RTV. 1993. *Principles of Diagnostic Techniques in Plant Pathology*, CABI Wallington.

Forster D and Taylor SC. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic Resistance. Methods in Molecular Biology*. Humana Press, Totowa, New Jersey.

Mathews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Boca Raton, Tokyo.

Matthews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Florida.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Cent. Agic. Pub. Doc. Wageningen.

Pathak VN. 1984. *Laboratory Manual of Plant Pathology*. Oxford & IBH, New Delhi.

Trigiano RN, Windham MT and Windham AS. 2004. *Plant Pathology-Concepts and Laboratory Exercises*. CRC Press, Florida.Chakravarti BP. 2005. *Methods of Bacterial Plant Pathology*. Agrotech, Udaipur.

I. Course Title : Principles of Plant Disease Management

II. Course Code : PL PATH 507

III. Credit Hours : 2+1

IV. Theory

Unit I

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.

Unit II

History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Label claim of fungicides.

Unit III

Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants, health *vis-a-vis* environmental hazards, residual effects and safety measures

- Phytopathometry;
- Methods of *in-vitro* evaluation of chemicals, antibiotics, bio agents against plant pathogens;
- Field evaluation of chemicals, antibiotics, bio agents against plant pathogens;
- Soil solarisation, methods of soil fumigation under protected cultivation;
- Methods of application of chemicals and bio control agents;
- ED and MIC values, study of structural details of sprayers and dusters;
- Artificial epiphytotic and screening of resistance.

VII. Suggested Reading

Fry WE. 1982. *Principles of Plant Disease Management*. Academic Press, New York.

Hewitt HG. 1998. *Fungicides in Crop Protection*. CABI, Wallington. Marsh RW. 1972. Systemic Fungicides. Longman, New York.

Nene YL and Thapliyal PN. 1993. *Fungicides in Plant Disease Control*. OXford & IBH, New Delhi.

Palti J. 1981. *Cultural Practices and Infectious Crop Diseases*. Springer Verlag, New York.

Vyas SC. 1993 *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

I. Course Title : Epidemiology and Forecasting of Plant Diseases

II. Course Code : PL PATH 508

III. Credit Hours : 1+0

IV. Theory

Unit I

Epidemic concepts, simple interest and compound interest disease, historical development. Elements of epidemics and their interaction.Structures and patterns of epidemics. Modelling, system approaches and expert systems in plant pathology.

Unit II

Genetics of epidemics. Models for development of plant disease epidemics. Common and natural logarithms, function fitting, area under disease progress curve and correction factors, inoculum dynamics. Population biology of pathogens, temporal and spatial variability in plant pathogens.

Unit III

Epidemiological basis of disease management. Survey, surveillance and vigilance. Remote sensing techniques and image analysis. Crop loss assessment.

Unit IV

Principles and pre-requisites of forecasting, systems and factors affecting various components of forecasting, some early forecasting and procedures based on weather and inoculum potential, modelling disease growth and disease prediction. Salient features of important forecasting models.

V. Suggested Reading

Campbell CL and Madden LV. 1990. *Introduction to Plant Disease Epidemiology*. John Wiley & Sons, New York

Cooke B, Jones DM and Gereth KB. 2018 *The Epidemiology of Plant Diseases*. Springer Publications.

Cowling EB and Horsefall JG. 1978. *Plant Disease*. Vol. II. Academic Press, New York.

Laurence VM, Gareth H and Frame Van den Bosch (Eds.). *The Study of Plant Disease Epidemics*. APS, St. Paul, Minnesota.

Nagarajan S and Murlidharan K. 1995. *Dynamics of Plant Diseases*. Allied Publ., New Delhi.

Thresh JM. 2006. *Plant Virus Epidemiology*. Advances in Virus Research 67, Academic Press, New York.

Van der Plank JE. 1963. *Plant Diseases Epidemics and Control*. Academic Press, New York.

Zadoks JC and Schein RD. 1979. *Epidemiology and Plant Disease Management*. Oxford Univ. Press, London.

I. Course Title : Disease Resistance in Plants

II. Course Code : PL PATH 509

III. Credit Hours : 2+0

IV. Theory

Unit I

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminologies. Disease escape,non-host resistance and disease tolerance.

Unit II

Genetic basis of disease resistance, types of resistance, identification of physiological races of pathogen, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

Unit III

Host defence system, morphological and anatomical resistance, pre-formed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms. Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

V. Suggested Reading

Deverall BJ. 1977. *Defence Mechanisms in Plants*. Cambridge Univ. Press, Cambridge, New York.

Mills Dallice *et al.*1996. *Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction*. APS, St Paul, Minnesota.

Parker J. 2008. *Molecular Aspects of Plant Diseases Resistance*. Blackwell Publ.

Robinson RA. 1976. *Plant Pathosystems*. Springer Verlag, New York.

Singh BD. 2005. *Plant Breeding – Principles and Methods*. 7th Ed. Kalyani Publishers, Ludhiana

Van der Plank JE. 1975. *Principles of Plant Infection*. Academic Press, New York.

Van der Plank JE. 1978. *Genetic and Molecular Basis of Plant Pathogenesis*. Springer Verlag. New York.

Van der Plank JE. 1982. *Host Pathogen Interactions in Plant Disease*. Academic Press, New York.

Van der Plank JE. 1984. *Disease Resistance in Plants*. Academic Press, New York.

I. Course Title : Ecology of Soil Borne Plant Pathogens

II. Course Code : PL PATH 510

III. Credit Hours : 1+1

IV. Theory

Unit I

Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Interaction of microorganisms.

Unit II

Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis. Conducive and suppressive soils.

Unit III

Biological control- concepts and potentialities for managing soil borne pathogens. Potential of *Trichoderma* and fluorescent *Pseudomonas* in managing plant diseases.

V. Practical

- Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens;
- Pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils;
- Suppression of test soil-borne pathogens by antagonistic microorganisms;
- Isolation and identification of different biocontrol agents;
- Study of various plant morphological structures associated with resistance, testing the effect of root exudates and extracts on spore germination and growth of plant pathogens;
- Estimating the phenolic substances, total reducing sugars in susceptible and resistant plants;
- Estimating the rhizosphere and root tissue population of microorganisms (pathogens) in plants.

VI. Suggested Reading

Baker KF and Snyder WC. 1965. *Ecology of Soil-borne Plant Pathogens*. John Wiley, New York.

Cook RJ and Baker KF. 1983. *The Nature and Practice of Biological Control of Plant Pathogens*. APS, St Paul, Minnesota.

Garret SD. 1970. *Pathogenic Root-infecting Fungi*. Cambridge Univ. Press,Cambridge, New York.

Hillocks RJ and Waller JM. 1997. *Soil-borne Diseases of Tropical Crops*. CABI, Wallington.

Mondia JL and Timper P 2016. Interactions of microfungi and plant parasitic nematodes. In: *Biology of Microfungi* (De-Wei-Lei Ed.). Springer Publications

Parker CA, Rovira AD, Moore KJ and Wong PTN. (Eds). 1983. *Ecology and Management of Soil-borne Plant Pathogens*. APS, St. Paul, Minnesota.

I. Course Title : Chemicals and Botanicals in Plant Disease Management

II. Course Code : PL PATH 511

III. Credit Hours : 2+1

IV. Theory

Unit I

History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals and botanicals.

Unit II

Classification of chemicals used in plant disease management and their characteristics.

Unit III

Chemicals in plant disease control, viz., fungicides, bactericides, nematicides, antiviral chemicals and botanicals. Issues related to label claim.

Unit IV

Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

Unit V

Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides. New generation fungicides and composite formulations of pesticides.

Unit VI

Efficacy of different botanicals used and their mode of action. Important botanicals used against diseases. General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

V. Practicals

- Acquaintance with formulation of different fungicides and plant protection appliances;
- Formulation of fungicides, bactericides and nematicides;
- *In-vitro* evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides against pathogens;
- Persistence, compatibility with other agro-chemicals;
- Detection of naturally occurring fungicide resistant mutants of pathogen;
- Methods of application of chemicals.

VI. Suggested Reading

Bindra OS and Singh H. 1977. *Pesticides – And Application Equipment*. Oxford & IBH, New Delhi.

Nene YL and Thapliyal PN. 1993. *Fungicides in Plant Disease Control.* 3rd edn. Oxford & IBH, New Delhi.

Torgeson DC. (Ed.). 1969. *Fungicides.* Vol. II. An Advanced Treatise. Academic Press, New York.

Vyas SC. 1993. *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

I. Course Title : Detection and Management of Seed Borne Pathogens

II. Course Code : PL PATH 512

III. Credit Hours : 2+1

IV. Theory

Unit I

History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

Unit II

Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

Unit III

Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.

Unit IV

Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogens/ diseases and procedure for healthy seed production. Seed health testing, methods for detecting microorganism.

V. Practical

- Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses;
- Relationship between seed-borne infection and expression of the disease in the field.

VI. Suggested Reading

Agarwal VK and Sinclair JB. 1993. *Principles of Seed Pathology*. Vols. I & II, CBS Publ., New Delhi.

Hutchins JD and Reeves JE. (Eds.). 1997. *Seed Health Testing: Progress Towards the 21st Century*. CABI, Wallington.

Paul Neergaard. 1988. *Seed Pathology*. McMillan, London.

Suryanarayana D. 1978. *Seed Pathology*. Vikash Publ., New Delhi.

I. Course Title : Biological Control of Plant Pathogens

II. Course Code : PL PATH 513

III. Credit Hours : 1+1

IV. Theory

Unit I

Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control.

Unit II

Types of biological interactions, competition: mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.

Unit III

Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, biocontrol agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of bioagents with agrochemicals and other antagonistic microbes.

Unit IV

Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents.

V. Practical

- Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen *in-vitro and in vivo* conditions;
- Preparation of different formulations of selected bioagents and their mass production;
- Quality parameters of biocontrol agents;
- One week exposure visit to commercial biocontrol agents production unit.

VI. Suggested Reading

Campbell R. 1989. *Biological Control of Microbial Plant Pathogens*. Cambridge Univ. Press, Cambridge.

Cook RJ and Baker KF. 1983. *Nature and Practice of Biological Control of Plant Pathogens.* APS, St. Paul, Minnesota.

Fokkemma MJ. 1986. *Microbiology of the Phyllosphere*. Cambridge Univ. Press, Cambridge.

Gnanamanickam SS (Eds). 2002. *Biological Control of Crop Diseases*. CRC Press, Florida.

Heikki MT and Hokkanen James M. (Eds.). 1996. *Biological Control – Benefits and Risks*. Cambridge Univ. Press, Cambridge.

Mukerji KG, Tewari JP, Arora DK and Saxena G. 1992. *Recent Developments in Biocontrol of Plant Diseases*. Aditya Books, New Delhi.

I. Course Title : Integrated Disease Management

II. Course Code : PL PATH 514

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications.

Unit II

Development of IDM-basic principles, biological, chemical and cultural disease management.

Unit III

IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed and mustard, pearl millet, pulses, vegetable crops, fruit, plantation and spice crops.

V. Practical

- Application of physical, biological and cultural methods;
- Use of chemical and biocontrol agents, theircompatibility and integration in IDM.Demonstration of IDM and multiple disease management in crops of regional importance as project work.

VI. Suggested Reading

Gupta VK and Sharma RC. (Eds). 1995. *Integrated Disease Management and Plant Health*. Scientific Publ., Jodhpur.

Mayee CD, Manoharachary C, Tilak KVBR, Mukadam DS and Deshpande Jayashree (Eds.). 2004. *Biotechnological Approaches for the Integrated Management of Crop Diseases*. Daya Publ. House, New Delhi.

Sharma RC and Sharma JN. (Eds). 1995. *Integrated Plant Disease Management*. Scientific Publ., Jodhpur.

I. Course Title : Diseases of Field and Medicinal Crops

II. Course Code : PL PAT 515

III. Credit Hours : 2+1

IV. Theory

Unit I

Diseases of Cereal crops- Rice, wheat, barley, pearl millet, sorghum and maize.

Unit II

Diseases of Pulse crops- Gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea.

Unit III

Diseases of Oilseed crops- Rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.

Unit IV

Diseases of Cash crops- Cotton, sugarcane.

Unit V

Diseases of Fodder legume crops- Berseem, oats, guar, lucerne.

Unit VI

Medicinal crops- *Plantago*, liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, *Aloe vera*.

- Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops;
- Collection and dry preservation of diseased specimens of important crops.

Suggested Reading

Joshi LM, Singh DV and Srivastava KD. 1984. *Problems and Progress of Wheat Pathology in South Asia*. Malhotra Publ. House, New Delhi.

Rangaswami G. 1999. *Diseases of Crop Plants in India*. 4th Ed. Prentice Hall of India, New Delhi.

Ricanel C, Egan BT, Gillaspie Jr AG and Hughes CG. 1989. *Diseases of Sugarcane, Major Diseases*. Academic Press, New York.

Singh RS. 2017. *Plant Diseases*. 10th Ed. Medtech, New Delhi.

Singh US, Mukhopadhyay AN, Kumar J and Chaube HS. 1992. *Plant Diseases of Internatiobnal Importance*. Vol. I. *Diseases of Cereals and Pulses*. Prentice Hall, Englewood Cliffs, New Jersey.

I. Course Title : Diseases of Fruits, Plantation and Ornamental Crops

II. Course Code : PL PTH 516

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm, custard apple and their management.

Unit II

Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconut and their management.

Unit III

Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, gerbera orchids, marigold, chrysanthemum and their management.

V. Practical

- Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops;
- Collection and dry preservation of diseased specimens of important crops.

VI. Suggested Reading

Gupta VK and Sharma SK. 2000. *Diseases of Fruit Crops*. Kalyani Publishers, New Delhi.
Pathak VN. 1980. *Diseases of Fruit Crops*. OXford & IBH, New Delhi.
Singh RS. 2000. *Diseases of Fruit Crops*. OXford & IBH, New Delhi.
Walker JC. 2004. *Diseases of Vegetable Crops*. TTPP, India.

I. Course Title : Diseases of Vegetable and Spices Crops

II. Course Code : PL PATH 517

III. Credit Hours : 2+1

IV. Theory

Unit I

Nature, prevalence, factors affecting disease development of tuber, bulb, leafy vegetable, crucifers, cucurbits and solanaceaous vegetables. Diseases of crops under protected cultivation.

Unit II

Symptoms and management of diseases of different root, tuber, bulb, leafy vegetables, crucifers, cucurbits and solanaceaous vegetable crops.

Unit III

Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, nutmeg, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger. Biotechnological approaches in developing disease resistant transgenics.

V. Practical

- Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

VI. Suggested Reading

Chaube HS, Singh US, Mukhopadhyay AN and Kumar J. 1992. *Plant Diseases of International Importance*. Vol. II. *Diseases of Vegetable and Oilseed Crops*. Prentice Hall, Englewood Cliffs, New Jersey.

Gupta VK and Paul YS. 2001. *Diseases of Vegetable Crops*. Kalyani Publishers, New Delhi

Gupta SK and Thind TS. 2006. *Disease Problem in Vegetable Production*. Scientific Publ., Jodhpur.

Sherf AF and Mcnab AA. 1986. *Vegetable Diseases and their Control*. Wiley Inter Science, Columbia.

Singh RS. 1999. *Diseases of Vegetable Crops*. Oxford & IBH, New Delhi.

Walker JC. 1952. *Diseases of Vegetable Crops*. McGraw-Hill, New York.

I. Course Title : Post-Harvest Diseases

II. Course Code : PL PATH 518

III. Credit Hours : 1+1

IV. Theory

Unit I

Concept of post-harvest diseases, definitions, importance with reference to management and health, principles of plant disease management as pre-harvest and post-harvest, Types of post-harvest problems both by biotic and abiotic factors.

Unit II

Role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists.

Unit III

Integrated approaches in controlling diseases and improving the shelf life of produce using nutritional, bio-control agents and other agents, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for health hazards.

Unit IV

Study of symptoms, toxicosis of various pathogens, knowledge of Codex Alimentarious for each product and commodity. Physical and biological agents/ practices responsible for development/ prevention of post-harvest diseases-traditional and improved practices.

V. Practical

- Isolation, characterization and maintenance of post-harvest pathogens, application of antagonists against pathogens *in vivo* condition;
- Comparative efficacy of different fungicides and bioagents;
- Study of different post-harvest disease symptoms on cereals, pulses, oilseed, commercial crops, vegetables, fruits and flowers;
- Visit to cold storage.

VI. Suggested Reading

Chaddha KL and Pareek OP. 1992. *Advances in Horticulture* Vol. IV, Malhotra Publ. House, New Delhi.

Pathak VN. 1970. *Diseases of Fruit Crops and their Control.* IBH Publ., New Delhi.

I. Course Title : Plant Quarentine and Regulations

II. Course Code : PL PATH 519

III. Credit Hours : 1+0

IV. Theory

Unit I

Historical development in plant quarantine, Definitions of pest, and transgenics as per Govt. notification; Organizational set up of plant quarantine in India. relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/ diseases and their status.

Unit II

Acts related to registration of pesticides and transgenics. History of quarantine legislations, Salient features of PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

Unit III

Identification of pest/ disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations; VHT and other safer techniques of disinfestation/ salvaging of infected material.

Unit IV

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures. Visit to plant quarantine station and PEQ facilities.

Suggested Reading

Rajeev K and Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.

Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

Course Course Title with Credit Load
Ph.D. in Plant Pathology

Course Code	Course Title	Credit Hours	Semester
PL PATH 601	Advances in Mycology	2+1	II
PL PATH 602	Advances in Virology	2+1	II
PL PATH 603	Advances in Plant Pathogenic Prokaryotes	2+1	II
PL PATH 604*	Molecular Basis of Host-pathogen Interaction	2+1	I
PL PATH 605	Principles and Procedures of Certification	1+0	I
PL PATH 606	Plant Biosecurity and Biosafety	2+0	I
PL PATH 691	Doctoral Seminar – I	0+ 1	
PL PATH 692	Doctoral Seminar – II	0+ 1	
PL PATH 699	Doctoral Research	0+75	

*Core Courses for Doctoral Programme

Course Contents
Ph.D. in Plant Pathology

I. Course Title : Advances in Mycology

II. Course Code : PL PATH 601

III. Credit Hours : 2+1

IV. Theory

Unit I

General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification. Serological, chemical (chemotaxonomy), molecular and numerical (computer based assessment) taxonomy. Interaction between groups: Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti.

Unit II

Population biology, pathogenic variability/ vegetative compatibility. Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation.

Unit III

Ultra structures and chemical constituents of fungal cells, functions of cell organelles. Mitosis, meiosis, gene action and regulation. Effects of fungal interaction with host plants and other microorganisms; parasitism, symbiosis and commensalism.

Unit IV

Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nano particles – characterization process and application. Mycotoxins problems and its management.

V. Practical

- Isolation, purification and identification of cultures, spores and mating type determination;
- Study of conidiogenesis-Phialides, porospores, arthospores;
- Study of fruiting bodies in Ascomycotina;
- Identification of fungi up to species level;
- Study of hyphal anastomosis;
- Morphology of representative plant pathogenic genera form different groups of fungi;
- Molecular characterization of fungi.

VI. Suggested Reading

Alexopoulos CJ, Mims CW and Blackwell M. 1996. *Introductory Mycology*. John Wiley & Sons, New York.

Dube HC. 2005. *An Introduction to Fungi.* 3rd Ed. Vikas Publ. House, New Delhi.

Kirk PM, Cannon PF, David JC and Stalpers JA. (Eds.). 2001. *Ainsworth and Bisby's Dictionary of Fungi*. 9th Ed., CABI, Wallington.

Maheshwari R. 2016. *Fungi: Experimental Methods in Biology* 2nd edn. CRC Press, US.

Ulloa M and Hanlin RT. 2000. *Illustrated Dictionary of Mycology*. APS, St. Paul, Minnesota.

Webster J and Weber R. 2007. *Introduction to Fungi.* Cambridge University Press, Cambridge.

I. Course Title : Advances in Plant Virology

II. Course Code : PL PATH 602

III. Credit Hours : 2+1

IV. Theory

Unit I

Origin, evolution and interrelationship with animal viruses. Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells. Mechanisms leading to the evolution of new viruses/ strains: mutation, recombination, pseudo-recombination, component re-assortment, etc.

Unit II

Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors. Terminologies used in immunology and serology. Classification, structure and functions of various domains of Immunoglobulins. Production of Polyclonal and monoclonal antibodies for detection of viruses. Immuno/ serological assays (Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay, and nucleic acid based assays for detection of plant viruses.

Unit III

Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/ q PCR) and non PCR based: LAMP, Fluorescent *in situ* hybridization (FISH), dot blot hybridization. Plant virus genome organization (General properties of plant viral genome- information content, coding and non-coding regions), replication, transcription and translational strategies of pararetroviruses, geminiviruses, tobamo-, poty-, bromo, cucumo, ilar, tospoviruses, satellite viruses and satellite RNA.

Unit IV

Gene expression, regulation and viral promoters.Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes. Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virus free planting materials. Phylogenetic grouping system based on partial/ complete sequences of virus genomes and using of next generation sequencing technology in plant virus discovery.

V. Practical

- Purification of viruses, SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation;
- Acquaintance with different serological techniques (i) DAC- ELISA (ii) DAS-ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA. Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation,and autoradiography;
- PCR application and viral genome cloning of PCR products, plasmid purification, enzyme digestion, sequencing, annotation of genes, analysis of viral sequences (use of gene bank, blast of viral sequences and phylogeny);
- Bioinformatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, Clustal X/W, Tm pred and Phylogeny programs).

VI. Suggested Reading

Davies 1997. *Molecular Plant Virology: Replication and Gene Expression*. CRC Press, Florida.
Fauquet *et al.* 2005. *Virus Taxonomy*. VIII Report of ICTV. Academic Press, New York.
Gibbs A and Harrison B. 1976. *Plant Virology – The Principles*. Edward Arnold, London.

Jones P, Jones PG and Sutton JM. 1997. *Plant Molecular Biology: Essential Techniques*. John Wiley & Sons, New York.

Khan J A and Dijkstra. 2002. *Plant Viruses as Molecular Pathogens*. Howarth Press, New York.

Maramorosch K, Murphy FA and Shatkin AJ. 1996. *Advances in Virus Research*. Vol. 46. Academic Press, New York.

Pirone TP and Shaw JG. 1990. *Viral Genes and Plant Pathogenesis*. Springer Verlag, New York.

Roger Hull. 2002. *Mathew's Plant Virology* (4th Ed.). Academic Press, New York.

Thresh JM. 2006. *Advances in Virus Research*. Academic Press, New York.

I. Course Title : Advances in Plant Pathogenic Prokaryotes

II. Course Code : PL PATH 603

III. Credit Hours : 2+1

IV. Theory

Unit I

Prokaryotic cell: Molecular basis for **o**rigin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins. Flagella structure, assembly and regulation. Structure and composition **(bacteria)** cell wall/ envelop, Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili), Bacterial chromosomes and plasmids, other cell organelles. Growth, nutrition and metabolism in prokaryotes (Embden-Meyerhof-Parmas (EMP) pathway, Phosphoketolase Pathway and Entner Doudoroff Pathway).

Unit II

Current trends in taxonomy and identification of phytopathogenic prokarya**:** International code of nomenclature, Polyphasic approach, New/ special detection methods for identification of bacterial plant pathogens. Taxonomic ranks hierarchy; Identification, Advances in classification and nomenclature.

Unit III

Bacterial genetics**:** General mechanism of variability (mutation), specialized mechanisms of variability. Transposable genetic elements in bacteria-integron and prophages, Mechanism of gene transfer. Pathogenicity islands, horizontal gene transfer, Bacterial Pan-Genome.

Unit I V

Bacteriophages: Composition, structure and infection. Classification and use of phages in plant pathology/ bacteriology. Host pathogen interactions: Molecular mechanism of pathogenesis: Pathogenicity factors of soft rot, necrosis, wilt, canker, etc. Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing. Bacterial pathogenicity and virulence**:** Molecular mechanism of virulence and pathogenesis, bacterial secretion systems, pathogenicity of bacterial enzymes that degrade the cell walls, Role of hrp/ hrc genes and TALE effectors. Synthesis and regulation of EPSs.

Unit V

Beneficial Prokaryotes-Endophytes, PGPR, Phylloplane bacteria and their role in disease management. Endosymbionts for host defence. Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9.

V. Practical

- Pathogenic studies and race identification, plasmid profiling of bacteria, fatty acid profiling of bacteria, RFLP profiling of bacteria and variability status, Endospore, Flagella staining, Test for secondary metabolite production, cyanides, EPS, siderophore, specific detection of phytopathogenic bacteria using species/ pathovar specific primers;
- Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts;
- Important and emerging diseases and their management strategies.

VI. Suggested Reading

Dale JW and Simon P. 2004. *Molecular Genetics of Bacteria*. John Wiley & Sons, New York.
Garrity GM, Krieg NR and Brenner DJ. 2006. *Bergey's Manual of Systematic Bacteriology: The*

Proteobacteria. Vol. II. Springer Verlag, New York.
Gnanamanickam SS. 2006. *Plant-Associated Bacteria*. Springer Verlag, New York.
Mount MS and Lacy GH. 1982. *Plant Pathogenic Prokaryotes*. Vols. I, II. Academic Press, New York.
Sigee DC. 1993. *Bacterial Plant Pathology: Cell and Molecular Aspects*. Cambridge Univ. Press, Cambridge.
Starr MP. 1992. *The Prokaryotes*. Vols. I–IV. Springer Verlag, New York.

I. Course Title : Molecular Basis of Host-pathogen Interaction

II. Course Code : PL PATH 604

III. Credit Hours : 2+1

IV. Theory

Unit I

History of host plant resistance and importance to Agriculture. Importance and role of biotechnological tools in plant pathology. Basic concepts and principles to study host pathogen relationship. Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions.

Unit II

Different forms of plant-microbe interactions and nature of signals/ effectors underpinning these interactions. Plant innate immunity: PAMP/ DAMP. Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction.

Unit III

Induction of defence responses- HR, Programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance, pathogenesis related proteins, phytoalexins and virus induced gene silencing. Molecular basis of gene- for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes. Gene for gene systems: Background, genetics, phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles), Coevolution-arms race and trench warfare models, Metapopulations, cost of resistance, cost of unnecessary virulence, GFG in agricultural crops vs. natural populations, Durability of resistance, erosion of quantitative resistance.

Unit IV

Pathogen population genetics and durability, viruses vs cellular pathogens.Gene deployment, cultivar mixtures. Disease emergence, host specialization. Circadian clock genes in relation to innate immunity. Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

V. Practical

- Protein, DNA and RNA isolation, plasmid extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation;
- Gene mapping and marker assisted selection;
- Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management.

VI. Suggested Reading

Chet I. 1993. *Biotechnology in Plant Disease Control.* John Wiley & Sons, New York.

Gurr SJ, McPohersen MJ and Bowlos DJ. (Eds.). 1992. *Molecular Plant Pathology – A Practical Approach.* Vols. I & II, Oxford Univ. Press, Oxford.

Mathew JD. 2003. *Molecular Plant Pathology*. Bios Scientific Publ., UK.

Ronald PC. 2007. *Plant-Pathogen Interactions: Methods in Molecular Biology*. Humana Press, New Jersey.

Stacey G and Keen TN. (Eds.). 1996. *Plant Microbe Interactions.* Vols. I-III. Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

I. Course Title : Principles and Procedures of Certification

II. Course Code : PL PATH 605

III. Credit Hours : (1+0)

IV. Theory

Unit I

Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD, etc. in certification and quality control. Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical purity, germination percentage, seed health, etc. Fixing tolerance limits for diseases and insect pests in certification and quality control programmes.

Unit II

Methods used in certification of seeds, vegetative propagules and *in-vitro* cultures. Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.

V. Reference

Association of Official Seed Certifying Agencies. Hutchins D and Reeves JE. (Eds.). 1997. Seed Health Testing: Progress Towards the 21st Century. CABI, UK. ISHI-veg Manual of Seed Health Testing Methods.

ISHI-F Manual of Seed Health Testing Methods.

ISTA Seed Health Testing Methods.

Tunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi. US National Seed Health System.

e-Resources

http://www.aosca.org/indeX.htm.
http://www.worldseed.org/enus/international_seed/ishi_vegetable.html
http://www.worldseed.org/en-us/international _seed/ ishi_f.html
http://www.seedtest.org/en/content—1—1132—241.html
http://www.seedhealth.org

I. Course Title : Plant Biosecurity and Biosafety

II. Course Code : PATH 606

III. Credit Hours : 2+0

IV. Theory

Unit I

History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases. Introduction and History of biosecurity and its importance.

Unit II

National Regulatory Mechanism and International Agreements/ Conventions, viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures. World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

Unit III

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops. Emerging/ resurgence of pests and diseases in the changing scenario of climatic conditions. Issues related to release of genetically modified crops.

V. Suggested Reading

Biosecurity: A Comprehensive Action Plan.

Biosecurity Australia.

Biosecurity for Agriculture and Food Production.

FAO Biosecurity Toolkit 2008.

Grotto Andrew J and Jonathan B Tucker. 2006. Biosecurity Guidance.

Khetarpal RK and Kavita Gupta 2006. Plant Biosecurity in India – Status and Strategy. Asian Biotechnology and Development Review **9**(2): 3963.

Randhawa GJ, Khetarpal RK, Tyagi RK and Dhillon BS (Eds.). 2001. Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.

e-Resources

http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.*sht ml*

www.fao.org/docrep/010/a1140e/a1140e00.htm Laboratory

http://www.who.int/csr/resources/publications/biosafety/WHO_CD S_EPR_2006.pdf

http://www.americanprogress.org/kf/biosecurity_ a_comprehensive_ action_plan.pdf

www.biosecurity.govt.nz DEFRA. www.defra.gov.uk/animalh/diseases/control/biosecurity/ indeX.htm

www.daff.gov.au/ba;www.affa.gov.au/biosecurityaustralia Biosecurity New Zealand.

http://www.fao.org/biosecurity/ CFIA.

VI. List of Journals

- *Annals of Applied Biology* – Cambridge University Press, London
- *Annals of Plant Protection Sciences*- Society of Plant Protection, IARI, New Delhi
- *Annual Review of Phytopathology* – Annual Reviews, Palo Alto, California
- *Annual Review of Plant Pathology* – Scientific Publishers, Jodhpur
- *Canadian Journal of Plant Pathology* – Canadian Phytopathological Society, Ottawa
- *Indian Journal of Biotechnology* – National Institute of Science Communication and Information Resources, CSIR, New Delhi
- *Indian Journal of Mycopathological Research* – Indian Society of Mycology, Kolkata.

- *Indian Journal of Plant Protection* – Plant Protection Association of India, NBPGR, Hyderabad.
- *Indian Journal of Virology* – Indian Virological Society, New Delhi
- *Indian Phytopathology*-Indian Phytopathological Society, IARI New Delhi.
- Journal of Mycology and Plant Pathology – Society of Mycology and Plant Pathology, Udaipur.
- *Journal of Plant Disease Science*- Association of Plant Pathologists (Central India) PDKV, Akola.
- *Journal of Phytopathology* – Blackwell Verlag, Berlin
- *Mycologia* – New York Botanical Garden, Pennsylvania
- *Mycological Research* – Cambridge University Press, London
- *Physiological Molecular Plant Pathology* – Academic Press, London – *Phytopathology* – American Phytopathological Society, USA
- *Plant Disease* – The American Phytopathological Society, USA
- *Plant Disease Research* – Indian Society of Plant Pathologists, Ludhiana
- *Plant Pathology* – British Society for Plant Pathology, Blackwell Publ.
- *Review of Plant Pathology* – CAB International, Wallingford
- *Virology*- New York Academic Press e-Resources
- www.shopapspress.org
- www.apsjournals.apsnet.org
- www.apsnet.org/journals
- www.cabi_publishing.org
- www.springer.com/life+Sci/agriculture
- www.backwellpublishing.com
- www.csiro.au
- www.annual-reviews.org

Restructured and Revised
Syllabi of Post-graduate Programmes
Vol. 1

Horticultural Sciences

- Fruit Science (FSC)
- Vegetable Sciences (VSC)
- Floriculture and Landscaping (FLS)
- Plantation, Spices, Medicinal and Aromatic Crops (PSMA)
- Post Harvest Management (PHM)

Contents

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 1

Horticultural Sciences
– Fruit Science

Course Title with Credit Load

M.Sc. (Hort.) in Fruit Science

Course Code	Course Title	Credit Hours	Semester
	Major Courses (20 Credits)		
FSC 501*	Tropical Fruit Production	2+1	II
FSC 502*	Sub-Tropical and Temperate Fruit Production	2+1	I
FSC 503*	Propagation and Nursery Management of Fruit Crops	2+1	II
FSC 504*	Breeding of Fruit Crops	2+1	I
FSC 505	Systematics of Fruit Crops	2+1	I
FSC 506	Canopy Management in Fruit Crops	1+1	II
FSC 507	Growth and Development of Fruit Crops	2+1	II
FSC 508	Nutrition of Fruit Crops	2+1	I
FSC 509	Biotechnology of Fruit Crops	2+1	I
FSC 510	Organic Fruit Culture	2+1	II
FSC 511	Export Oriented Fruit Production	2+1	II
FSC 512	Climate Change and Fruit Crops	1+0	I
FSC 513	Minor Fruit Production	2+1	I
	Minor Courses	**08**	
	Supporting Courses	**06**	
	Common compulsory courses	**05**	
FSC 591	Seminar	0+1	
FSC 599	Research	0+30	

*Compulsory among major courses

Course Contents
M.Sc. (Hort.) in Fruit Science

I. Course Title : Tropical Fruit Production
II. Course Code : FSC 501
III. Credit Hours : (2+1)

IV. Theory

Block 1: Introduction

Unit I: Importance and Background: Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements.

Block 2: Agro-techniques

Unit I: Propagation, Planting and Orchard Floor Management: Asexual and sexual methods of propagation, planting systems and planting densities, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Block 3: Crop Management

Unit I: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders – causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.
Mango, Banana, Guava, Pineapple, Papaya, Avocado, Jackfruit, Annonas, Aonla, Ber,etc.

V. Practicals

- Distinguished features of tropical fruit species, cultivars and rootstocks (2);
- Demonstration of planting systems, training and pruning (3);
- Hands on practices on pollination and crop regulation (2);
- Leaf sampling and nutrient analysis (3);
- Physiological disorders-malady diagnosis (1);
- Physico-chemical analysis of fruit quality attributes (3);
- Field/ Exposure visits to tropical orchards (1);
- Project preparation for establishing commercial orchards (1).

VI. Suggested Reading

Bartholomew DP, Paull RE and Rohrbach KG. 2002. *The Pineapple: Botany, Production, and Uses*. CAB International.

Bose TK, Mitra SK and Sanyal D. 2002. *Fruits of India – Tropical and Sub-Tropical*.3rd Edn. Naya Udyog, Kolkata.

Dhillon WS. 2013. *Fruit Production in India*. Narendra Publ. House, New Delhi.

Iyer CPA and Kurian RM. 2006. *High Density Planting in Tropical Fruits: Principlesand Practices*. IBDC Publishers, New Delhi.

Litz RE. 2009. *The Mango: Botany, Production and Uses*. CAB International.

Madhawa Rao VN. 2013. *Banana*. ICAR, New Delhi.

Midmore D. 2015. *Principles of Tropical Horticulture*. CAB International.

Mitra SK and Sanyal D. 2013. *Guava,* ICAR, New Delhi.

Morton JF. 2013. *Fruits of Warm Climates*. Echo Point Book Media, USA.
Nakasome HY and Paull RE. 1998. *Tropical Fruits*. CAB International.
Paull RE and Duarte O. 2011. *Tropical Fruits* (Vol. 1). CAB International.
Rani S, Sharma A and Wali VK. 2018. *Guava* (*Psidium guajava* L.). Astral, New Delhi.
Robinson JC and Saúco VG. 2010. *Bananas and Plantains*. CAB International.
Sandhu S and Gill BS. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi.
Schaffer B, Wolstenholme BN and Whiley AW. 2013. *The Avocado: Botany, Production and Uses*. CAB International.
Sharma KK and Singh NP. 2011. *Soil and Orchard Management*. Daya Publishing House, New Delhi.
Valavi SG, Peter KV and Thottappilly G. 2011. *The Jackfruit*. Stadium Press, USA.

I. Course Title : Subtropical and Temperate Fruit Production

II. Course Code : FSC 502

III. Credit Hours : (2+1)

IV. Theory

Block 1: Introduction

Unit I: Importance and Background: Origin, distribution and importance, major species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements.

Block 2: Agro-Techniques

Unit I: Propagation, Planting and Orchard Floor Management: Propagation, planting systems and densities, training and pruning, rejuvenation and replanting, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Block 3: Crop Management

Unit I: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders- causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

Crops

Citrus, Grapes, Litchi, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherries, Berries, Persimmon, Kiwifruit, Nuts- Walnut, Almond, Pecan, etc.

V. Practicals

- Distinguished features of fruit species, cultivars and rootstocks (2);
- Demonstration of planting systems, training and pruning (3);
- Hands on practices on pollination and crop regulation (2);
- Leaf sampling and nutrient analysis (3);
- Physiological disorders-malady diagnosis (1);
- Physico-chemical analysis of fruit quality attributes (3);
- Field/ Exposure visits to subtropical and temperate orchards (1);
- Project preparation for establishing commercial orchards (1).

VI. Suggested Reading

Chadha KL and Awasthi RP. 2005. *The Apple*. Malhotra Publishing House, New Delhi.

Chadha TR. 2011. *A Text Book of Temperate Fruits*. ICAR, New Delhi

Childers NF, Morris JR and Sibbett GS. 1995. *Modern Fruit Science: Orchard and Small Fruit Culture*. Horticultural Publications, USA.

Creasy G and Creasy L. 2018. *Grapes*. CAB International.

Davies FS and Albrigo LG. 1994. *Citrus*. CAB International.

Dhillon WS. 2013. *Fruit Production in India*. Narendra Publishing House, New Delhi.

Jackson D, Thiele G, Looney NE and Morley-Bunker M. 2011. *Temperate and Subtropical Fruit Production*. CAB International.

Ladanyia M. 2010. *Citrus Fruit: Biology, Technology and Evaluation*. Academic Press.

Layne DR and Bassi D. 2008. *The Peach: Botany, Production and Uses*. CABI.

Menzel CM and Waite GK. 2005. *Litchi and Longan: Botany, Production and Uses*. CAB International.

Pandey RM and Randey SN. 1996. *The Grape in India*. ICAR, New Delhi.

Rajput CBS, and Haribabu RS. 2006. *Citriculture*, Kalyani Publishers, New Delhi.

Sandhu S and Gill BS. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi.
Sharma RM, Pandey SN and Pandey V. 2015. *The Pear – Production, Post-harvest Management and Protection*. IBDC Publisher, New Delhi.
Sharma RR and Krishna H. 2018. *Textbook of Temperate Fruits*. CBS Publishers and Distributors Pvt. Ltd., New Delhi.
Singh S, Shivshankar VJ, Srivastava AK and Singh IP. 2004. *Advances in Citriculture*. NIPA, New Delhi.
Tromp J, Webster AS and Wertheim SJ. 2005. *Fundamentals of Temperate Zone Tree Fruit Production*.Backhuys Publishers, Lieden, The Netherlands.
Webster A and Looney N. *Cherries: Crop Physiology, Production and Uses*. CABI.
Westwood MN. 2009. *Temperate Zone Pomology:Physiology and Culture*. Timber Press, USA.

I. Course Title : Propagation and Nursery Management in Fruit Crops

II. Course Code : FSC 503

III. Credit Hours : (2+1)

IV. Theory

Block 1: Introduction

Unit 1: General Concepts and Phenomena: Introduction, understanding cellular basis for propagation, sexual and asexual propagation, apomixis, polyembryony, chimeras. Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seed germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing.

Block 2: Propagation

Unit I: Conventional Asexual Propagation: Cutting– methods, rooting of soft and hardwood cuttings under mist and hotbeds. Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

Budding and grafting – principles and methods, establishment and management of bud wood bank. Stock, scion and inter stock relationship – graft incompatibility, physiology of rootstock and top working.

Unit II: Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques – *in-vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules.

Block 3: Nursery

Unit I: Management Practices and Regulation: Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, nursery accreditation, import and export of seeds and planting material and quarantine.

V. Practical

- Hands on practices on rooting of dormant and summer cuttings (3);
- Anatomical studies in rooting of cutting and graft union(1);
- Hands on practices on various methods of budding and grafting (4);
- Propagation by layering and stooling (2);
- Micropropagation- explant preparation, media preparation, culturing – meristem tip culture, axillary bud culture, micro-grafting, hardening (4);
- Visit to commercial tissue culture laboratories and accredited nurseries (2).

VI. Suggested Reading

Bose TK, Mitra SK and Sadhu MK. 1991. *Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash, Kolkatta.

Davies FT, Geneve RL and Wilson SB. 2018. *Hartmann and Kester's Plant Propagation-Principles and Practices.* Pearson, USA/ PrenticeHall of India. New Delhi.

Gill SS, Bal JS and Sandhu AS. 2016. *Raising Fruit Nursery*. Kalyani Publishers,New Delhi.

Jain S and Ishil K. 2003. *Micropropagation of Woody Trees and Fruits*. Springer.

Jain S and Hoggmann H. 2007. *Protocols for Micropropagation of Woody Trees and Fruits.* Springer.

Joshi P. 2015. *Nursery Management of Fruit Crops in India.* NIPA, New Delhi.

Love *et al.* 2017. *Tropical Fruit Tree Propagation Guide.* UH-CTAHR F_N_49. College of Tropical

Agriculture and Human Resources University of Hawaii at Manwa, USA.
Peter KV, eds. 2008. *Basics of Horticulture*. New India Publishing Agency, New Delhi.
Rajan S and Baby LM. 2007. *Propagation of Horticultural Crops*. NIPA, New Delhi.
Sharma RR. 2014. *Propagation of Horticultural Crops*. Kalyani Publishers, New Delhi.
Sharma RR and Srivastav M. 2004. *Propagation and Nursery Management*. Intl. Book Publishing Co., Lucknow.
Singh SP. 1989. *Mist Propagation*. Metropolitan Book Co.
Singh RS. 2014. *Propagation of Horticultural Plants: Arid and Semi-Arid Regions*. NIPA, New Delhi.
Tyagi S. 2019. *Hi-Tech Horticulture*. Vol I: *Crop Improvement, Nursery and Rootstock Management*. NIPA, New Delhi.

I. Course Title : Breeding of Fruit Crops

II. Course Code : FSC 504

III. Credit Hours : (2+1)

IV. Theory

Block 1: Introduction

Unit I: Importance, Taxonomy and Genetic Resources: Introduction and importance, origin and distribution, taxonomical status – species and cultivars, cytogenetics, genetic resources.

Block 2: Reproductive Biology

Unit I: Blossom Biology and Breeding Systems: Blossom biology, breeding systems – spontaneous mutations, polyploidy, incompatibility, sterility, parthenocarpy, apomixis, breeding objectives, ideotypes.

Block 3: Breeding Approaches

Unit I: Conventional and Non-Conventional Breeding: Approaches for crop improvement – direct introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrusts.

Crops

Mango, Banana, Pineapple, Citrus, Grapes, Litchi, Guava, Pomegranate, Papaya, Apple, Pear, Plum, Peach, Apricot, Cherries, Strawberry, Kiwifruit, Nuts

V. Practicals

- Exercises on bearing habit, floral biology (2);
- Pollen viability and fertility studies (1);
- Hands on practices in hybridization (3);
- Raising and handling of hybrid progenies (2);
- Induction of mutations and polyploidy (2);
- Evaluation of biometrical traits and quality traits (2);
- Screening for resistance against abiotic stresses (2);
- Developing breeding programme for specific traits (2);
- Visit to research stations working on fruit breeding (1).

VI. Suggested Reading

Abraham Z. 2017. *Fruit Breeding*. Agri-Horti Press, New Delhi.

Badenes ML and Byrne DH. 2012. *Fruit Breeding*. Springer Science, New York.

Dinesh MR. 2015. *Fruit Breeding*, New India Publishing Agency, New Delhi.

Ghosh SN, Verma MK and Thakur A. 2018. *Temperate Fruit Crop Breeding- Domestication to Cultivar Development*. NIPA, New Delhi.

Hancock JF. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. Springer Science, New York.

Jain SN and Priyadarshan PM. 2009. *Breeding Plantation and Tree Crops: Tropical Species*. Springer Science, New York.

Jain S and Priyadarshan PM. 2009. *Breeding Plantation and Tree Crops: Temperate Species*. Springer Science, New York.

Janick J and Moore JN. 1996. *Fruit Breeding*. Vols. I–III. John Wiley & Sons, USA.

Kumar N. 2014. *Breeding of Horticultural Crops:Principles and Practices*. NIPA, N. Delhi.

Moore JN and Janick J. 1983. *Methods in Fruit Breeding*. Purdue University Press, USA.

Ray PK. 2002. *Breeding Tropical and Subtropical Fruits*. Narosa Publ. House, New Delhi.

I. Course Title : Systematics of Fruit Crops

II. Course Code : FSC 505

III. Credit Hours : (2+1)

IV. Theory

Block 1: Biosystematics

Unit I: Nomenclature and Classification: Biosystematics – introduction and significance; history of nomenclature of cultivated plants, classification and nomenclature systems; International code of nomenclature for cultivated plants

Block 2: Botanical Keys and Descriptors

Unit I: Identification and Description: Methods of identification and description of cultivated fruit and nut species and their wild relatives features; development of plant keys for systematic identification and classification.

Development of fruit crop descriptors- based upon Bioversity International Descriptors and UPOV/ DUS test guidelines, botanical and pomological description of major cultivars and rootstocks of tropical, subtropical and temperate fruits and nut crops

Block 3: Special Topics

Unit I: Registration and Modern Systematics: Registration, Use of chemotaxonomy, biochemical and molecular markers in modern systematics

V. Practicals

- Exercises on identification and pomological description of various fruit species and cultivars (6);
- Development of descriptive blanks *vis-a-vis* UPOV/ DUS test guidelines and Bioversity International (4);
- Descriptors for developing fruit species and cultivar descriptive databases (4);
- Visits to major germplasm centres and field genebanks (2).

VI. Suggested Reading

ASHS. 1997. *The Brooks and Olmo Register of Fruit and NutVarieties*. 3rd Ed. ASHS Press.

Bhattacharya B and Johri BM. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Pub. House, New Delhi.

Pandey BP. 1999. *Taxonomy of Angiosperms*. S. Chand & Co. New Delhi.

Pareek OP and Sharma S. 2017. *Systematic Pomology*. Scientific Publishers, Jodhpur.

Sharma G, Sharma OC and Thakur BS. 2009. *Systematics of Fruit Crops*. NIPA, New Delhi.

Simpson M. 2010. *Plant Systematics*. 2ndEdn. Elsevier.

Spencer RR, Cross R and Lumley P. 2003. *Plant Names*. 3rd Ed. *A Guide to Botanical Nomenclature,* CISRO, Australia.

Srivastava U, Mahajan RK, Gangopadyay KK, Singh M and Dhillon BS. 2001. *Minimal Descriptors of Agri-Horticultural Crops. I: Fruits*. NBPGR, New Delhi.

Zielinski QB. 1955. *Modern Systematic Pomology*. Wm. C. Brown Co., Iowa, USA.

I. Course Title : Canopy Management of Fruit Crops

II. Course Code : FSC 506

III. Credit Hours : (1+1)

IV. Theory

Block 1: Canopy Architecture

Unit I: Introduction, Types and Classification: Canopy management – importance and factors affecting canopy development. Canopy types and structures, canopy manipulation for optimum utilization of light and its interception. Spacing and utilization of land area – Canopy classification.

Block 2: Canopy Management

Unit I: Physical Manipulation and Growth Regulation: Canopy management through rootstock and scion. Canopy management through plant growth regulators, training and pruning and management practices. Canopy development and management in relation to growth, flowering, fruiting and fruit quality.

V. Practicals

- Study of different types of canopies (2);
- Training of plants for different canopy types (2);
- Canopy development through pruning (2);
- Understanding bearing behaviour and canopy management in different fruits (2);
- Use of plant growth regulators (2);
- Geometry of planting (1);
- Development of effective canopy with support system (2);
- Study on effect of different canopy types on production and quality of fruits (2).

VI. Suggested Reading

Bakshi JC, Uppal DK and Khajuria HN. 1988. *The Pruning of Fruit Trees and Vines*. Kalyani Publishers, New Delhi.

Chadha KL and Shikhamany SD. 1999. *The Grape, Improvement, Production and Post Harvest Management*. Malhotra Publishing House, Delhi.

Iyer CPA and Kurian RM. 2006. *High Density Planting in Tropical Fruits: Principles and Practices*. IBDC Publishers, New Delhi.

Pradeepkumar T. 2008. *Management of Horticultural Crops*. NIPA, New Delhi.

Singh G. 2010. *Practical Manual on Canopy Management in Fruit Crops*. Dept. of Agriculture and Co-operation, Ministry of Agriculture (GoI), New Delhi.

Srivastava KK. 2012. *Canopy Management in Fruits*. ICAR, New Delhi

I. Course Title : Growth and Development of Fruit Crops

II. Course Code : FSC 507

III. Credit Hours : (2+1)

IV. Theory

Block 1: Introduction

Unit I: General Concepts and Principles: Growth and development- definition, parameters of growth and development, growth dynamics and morphogenesis.

Block 2: Environment and Development

Unit I: Climatic Factors, Hormones and Developmental Physiology: Environmental impact on growth and development- effect of light, temperature, photosynthesis and photoperiodism, vernalisation, heat units and thermoperiodism. Assimilate partitioning, influence of water and mineral nutrition in growth and development; concepts of plant hormone and bioregulators, history, biosynthesis and physiological role of auXins, gibberellins, cytokinins, abscissic acid, ethylene, growth inhibitors and retardant, brasssinosteroids, other New PGRs. Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development.

Block 3: Stress Management

Unit I: Strategies for Overcoming Stress: Growth and developmental process during stress – manipulation of growth and development, impact of pruning and training, chemical manipulations and Commercial application of PGRs in fruit crops, molecular and genetic approaches in plant growth and development.

V. Practicals

- Understanding dormancy mechanisms in fruit crops and seed stratification (2);
- Techniques of growth analysis (2);
- Evaluation of photosynthetic efficiency under different environments (2);
- Exercises on hormone assays (2);
- Practicals on use of growth regulators (2);
- Understanding ripening phenomenon in fruits (2);
- Study on impact of physical manipulations on growth and development (1);
- Study on chemical manipulations on growth and development (1);
- Understanding stress impact on growth and development (1).

VI. Suggested Reading

Bhatnagar P. 2017. *Physiology of Growth and Development of Horticultural Crops*. Agrobios (India).

Buchanan B, Gruiessam W and Jones R. 2002. *Biochemistry and Molecular Biology of Plants*. John Wiley & Sons, NY, USA.

Dhillon WS and Bhatt ZA. 2011. *Fruit Tree Physiology*. Narendra Publishing House, New Delhi.

Durner E. 2013. *Principles of Horticultural Physiology*. CAB International.

Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. John Wiley & Sons, NY, USA.

Faust M. 1989. *Physiology of Temperate Zone Fruit Trees*. John Willey & Sons, NY, USA.

Fosket DE. 1994. *Plant Growth and Development: a Molecular Approach*. Academic Press, USA.

Leopold AC and Kriedermann PE. 1985. *Plant Growth and Development*. 3rd Ed. McGraw-Hill,

New Delhi.
Roberts J, Downs S and Parker P. 2002. Plant Growth Development. In: Salisbury FB and Ross CW. (Eds.) *Plant Physiology*. 4th Ed.Wadsworth Publications, USA.
Schafeer, B. and Anderson, P. 1994. *Handbook of Environmental Physiology of Fruit Crops.* Vol. 1 & 2. CRC Press. USA.
Seymour GB, Taylor JE and Tucker GA. 1993. *Biochemistry of Fruit Ripening*. Chapman & Hall, London.

I. Course Title : Nutrition of Fruit Crops

II. Course Code : FSC 508

III. Credit Hours : (2+1)

IV. Theory

Block 1: Introduction

Unit I: General Concepts and Principles: Importance and history of nutrition in fruit crops, essential plant nutrients, factors affecting plant nutrition; nutrient uptake and their removal from soil.

Block 2: Requirements and Applications

Unit I: Diagnostics, Estimation and Application: Nutrient requirements, root distribution in fruit crops, soil and foliar application of nutrients in major fruit crops, fertilizer use efficiency. Methods and techniques for evaluating the requirement of macro- and micro-elements, Diagnostic and interpretation techniques including DRIS. Role of different macro- and micro-nutrients, their deficiency and toxicity disorders, corrective measures to overcome deficiency and toxicity disorders.

Block 3: Newer Approaches

Unit I: Integrated Nutrient Management (INM): Fertigation in fruit crops, bio-fertilizers and their use in INM systems.

VII. Practicals

- Visual identification of nutrient deficiency symptoms in fruit crops (2);
- Identification and application of organic, inorganic and bio-fertilizers (1);
- Soil/ tissue collection and preparation for macro- and micro-nutrient analysis (1);
- Analysis of soil physical and chemical properties- pH, EC, Organic carbon (1);
- Determination of N,P,K and other macro- and micronutrients (6);
- Fertigation in glasshouse and field grown horticultural crops (2);
- Preparation of micro-nutrient solutions, their spray and soil applications (2).

VIII. Suggested Reading

Atkinson D, Jackson JE and Sharples RO. 1980. *Mineral Nutrition of Fruit Trees*. Butterworth – Heinemann.

Bould C, Hewitt EJ and Needham P. 1983. *Diagnosis of Mineral Disorders in Plants Vol.1 Principles*. Her Majesty's Stationery Office, London.

Cooke GW. 1972. *Fertilizers for maximizing yield*. Grenada Publishing Ltd, London.

Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. Wiley Eastern Ltd.

Kanwar JS. 1976. *Soil Fertility-Theory and Practice*. ICAR, New Delhi.

Marchner Horst. 1995. *Mineral Nutrition of Higher Plants*, 2nd Ed. Marschner, Academic Press Inc. San Diego, CA.

Mengel K and Kirkby EA. 1987. *Principles of Plant Nutrition*. 4th Ed. International Potash Institute, Worblaufen-Bern, Switzerland.

Prakash M. 2013. *Nutritional Disorders in Fruit Crops: Diagnosis and Management*. NIPA, New Delhi.

Tandon HLS. 1992. *Management of Nutrient Interactions in Agriculture*. Fertilizer Development and Consultation Organization, New Delhi.

Westerman RL. 1990. *Soil Testing and Plant Analysis*, 3rd Ed. Soil Science Society of America, Inc., Madison, WI.

Yawalkar KS, Agarwal JP and Bokde S. 1972. *Manures and Fertilizers*. 3rd Ed. Agri Horticultural Publishing House, Nagpur.

I. Course Title : Biotechnology of Fruit Crops

II. Course Code : FSC 509

III. Credit Hours : (2+1)

VI. Theory

Block 1: General Background

Unit I: Introduction, History and Basic Principles: Introduction and significance, history and basic principles, influence of explant material, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture.

Block 2: Tissue Culture

Unit I: *In-vitro* Culture and Hardening: Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis; Organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture. Use of bioreactors and *in-vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues. Hardening and *ex vitro* establishment of tissue cultured plants.

Block 3: Genetic Manipulation

Unit I: *In-vitro* Breeding, Transgenics and Gene Technologies: Somatic cell hybridisation, construction and identification of somatic hybrids and cybrids, wide hybridization, *in-vitro* pollination and fertilization, haploids, *in-vitro* mutation, artificial seeds, cryopreservation, *In-vitro* selection for biotic and abiotic stress. Genetic engineering- principles and methods, transgenics in fruit crops, use of molecular markers and genomics. Gene silencing, gene tagging, gene editing, achievements of biotechnology in fruit crops.

VII. Practicals

- An exposure to low cost, commercial and homestead tissue culture laboratories (2);
- Media preparation, Inoculation of explants for clonal propagation, callus induction and culture, regeneration of plantlets from callus (3);
- Sub-culturing techniques on anther, ovule, embryo culture, somaclonal variation (4);
- *In-vitro* mutant selection against abiotic stress (2);
- Protoplast culture and fusion technique (2);
- Development of protocols for mass multiplication (2);
- Project development for establishment of commercial tissue culture laboratory (1).

VIII. Suggested Reading

Bajaj YPS. Eds., 1989. *Biotechnology in Agriculture and Forestry*. Vol. V, *Fruits*. Springer, USA.

Brown TA. 2001. *Gene Cloning and DNA Analysis and Introduction*. Blackwell Publishing, USA.

Chahal GS and Gosal SS. 2010. *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches*. Narosa, New Delhi.

Chopra VL and Nasim A. 1990. *Genetic Engineering and Biotechnology – Concepts, Methods and Applications*. Oxford & IBH, New Delhi.

Kale C. 2013. Genome Mapping and Molecular Breeding in Plant, Vol 4. *Fruit and Nuts*. Springers.

Keshavachandran R and Peter KV. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer*. Orient & Longman, Universal Press, US.

Keshavachandran R, Nazeem PA, Girija D, John PS and Peter KV. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. Vols. I, II. NIPA, New Delhi.

Litz RE. 2005. *Biotechnology of Fruit and Nut Crops*. CABI, UK.
Miglani GS. 2016. *Genetic Engineering – Principles, Procedures and Consequences*. Narosa Publishing House, New Delhi.
Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK and Mohanadas S. 2001. *Biotechnology of Horticultural Crops*. Vols. I–III. Naya Prokash, Kolkata.
Peter KV. 2013. *Biotechnology in Horticulture: Methods and Applications*. NIPA, New Delhi.
Vasil TK, Vasi M, While DNR and Bery HR. 1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture*. Platinum Press, UK.

I. Course Title : Organic Fruit Culture

II. Course Code : FSC 510

III. Credit Hours : (2+1)

IV. Theory

Block 1: General Aspects

Unit I: Principles and Current Scenario: Organic horticulture, scope, area, production and world trade, definition, principles, methods and SWOT analysis.

Block 2: Organic Culture

Unit I: Farming System and Practices: Organic farming systems including biodynamic farming, natural farming, homa organic farming, rishi krishi, EM technology, cosmic farming; on-farm and off-farm production of organic inputs, role of bio-fertilizers, bio enhancers, legumes, inter cropping, cover crops, green manuring, zero tillage, mulching and their role in organic nutrition management. Organic seeds and planting materials, soil health management in organic production, weed management practices in organic farming, biological management of pests and diseases, trap crops, quality improvement in organic production of fruit crops.

Block 3: Certification

Unit I: Inspection, Control Measures and Certification: Inspection and certification of organic produce, participatory guarantee system (PGS), NPOP, documentation and control, development of internal control system (ICS), Concept of group certification, constitution of grower group as per NPOP, preparation of ICS manual, internal and external inspection, concept of third party verification, certification of small farmer groups (Group Certification), transaction certificate, group certificate, critical control points (CCP) and HACCP, IFOAM guidelines on certification scope and chain of custody, certification trademark – The Logo, accredited certification bodies under NPOP. Constraints in certification, IFOAM and global scenario of organic movement, postharvest management of organic produce. Economics of organic fruit production.

V. Practicals

- Design of organic orchards/ farms management (1);
- Conversion plan (1);
- Nutrient management and microbial assessment of composts and bio-enhancers (2);
- Preparation and application of composts, bio-enhancers and bio-pesticides (2);
- Organic nursery raising (1);
- Application of composts, bio-enhancers, bio-fertilisers and bio-pesticides, green manure, cover, mulching (2);
- Preparation and use of neem based products (1);
- Biodynamic preparations and their role in organic agriculture, EM technology and products, biological/ natural management of pests and diseases (2);
- Soil solarisation (1);
- Frame work for GAP (1);
- Documentation for certification (1).

VI. Suggested Reading

Claude A. 2004. *The Organic Farming Sourcebook*. Other India Press, Mapusa, Goa, India.

Dabholkar SA. 2001. *Plenty for All.* Mehta Publishing House, Pune, Maharashtra.

Das HC and Yadav AK. 2018. *Advances in Organic Production of Fruit Crops*. Westville Publishing House, New Delhi.

Deshpande MS. 2003. *Organic Farming with respect to Cosmic Farming*. Mrs. Pushpa Mohan Deshpandey, Kolhapur, Maharashtra.

Deshpande WR. 2009. *Basics of Organic Farming*. All India Biodynamic and Organic Farming Association, Indore. MP.

Gaur AC, Neblakantan S and Dargan KS. 1984 *Organic Manures*. ICAR, New Delhi.

Lampkin, N. and Ipswich, S. 1990. *Organic Farming*. Farming Press. London, UK.

Lind K, Lafer G, Schloffer K, Innershofer G and Meister H. 2003. *Organic Fruit Growing*. CAB International.

Palaniappan SP and Annadurai K. 2008. *Organic Farming- Theory and Practice*. Scientific Publishers, Jodhpur, Rajasthan, India.

Palekar S. 2004. *The Technique of Spritual Farming*. Chandra Smaritee, Sai Nagar, Amrawati, Maharashtra.

Proctor P. 2008. Biodynamic Farming and Gardening. Other India Press, Mapusa, Goa.

Ram RA and Pathak RK. 2017. Bioenhancers. Lap Lambert Academic Publishing, AP.

I. Course Title : Export Oriented Fruit Production

II. Course Code : FSC 511

III. Credit Hours : (2+1)

VI. Theory

Block 1: Introduction

Unit I: Statistics and World Trade: National and international fruit export and import scenario and trends; Statistics and India's position and potentiality in world trade; export promotion zones in India. Government Policies.

Block 2: Regulations

Unit I: Policies, Norms and Standards: Scope, produce specifications, quality and safety standards for export of fruits, viz., mango, banana, grape, litchi, pomegranate, walnut, apple and other important fruits. Processed and value-added products, post harvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; WTO and its implications, sanitary and phyto-sanitary measures.

Block 3: Quality Assurance

Unit I: Infrastructure and Plant Material: Quality fruit production under protected environment; different types of structures – Automated greenhouses, glasshouse, shade net, poly tunnels – Design and development of low cost greenhouse structures. Seed and planting material; meeting export standards, implications of plant variety protection – patent regimes.

VII. Practicals

- Export promotion zones and export scenario of fresh fruits and their products (1);
- Practical exercises on quality standards of fruits for export purpose (2);
- Quality standards of planting material and seeds (2);
- Hi-tech nursery in fruits (1);
- Practicals on ISO specifications and HACCP for export of fruits (3);
- Sanitary and phyto-sanitary measures during export of horticultural produce (2);
- Post harvest management chain of horticultural produce for exports (2);
- Visit to export oriented units/ agencies like APEDA, NHB, etc.

Suggested Reading

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House, New Delhi.

Chetan GF. 2015. *Export Prospects of Fruits and Vegetables from India: A study of Export market in EU. A project report*. Anand Agricultural University, Anand, Gujarat.

Dattatreylul M. 1997. *Export potential of Fruits, Vegetables and Flowers from India*. NABARD, Mumbai.

Islam, C.N. 1990. *Horticultural Export of Developing Countries: Past Preferences, Future Prospects and Policies*. International Institute of Food Policy Research, USA.

e-Resources

http://apeda.gov.in
http://nhb.gov.in
http://indiastat.com

I. Course Title : Climate Change and Fruit Crops

II. Course Code : FSC 512

III. Credit Hours : (1+0)

IV. Theory

Block 1: **General Aspects**

Unit I: Introduction, Global Warming and Climatic Variability: Introduction to climate change. Factors directly affecting climate change. Globalwarming, effect of climate change on spatio-temporal patterns of temperature and rainfall, concentrations of greenhouse gasses in atmosphere. pollution levels such as tropospheric ozone, change in climatic variability and extreme events.

Block 2: **Climate Change and Management**

Unit I: Impact Assessment and Mitigation: Sensors for recording climatic parameters, plants response to the climate changes, premature bloom, marginally overwintering or inadequate winter chilling hours, longer growing seasons and shifts in plant hardiness for fruit crops.

Climate mitigation measures through crop management- use of tolerant rootstocks and varieties, mulching – use of plastic- windbreak- spectral changes- protection from frost and heat waves. Climate management in greenhouse- heating – vents – CO_2 injection – screens – artificial light. Impact of climate changes on invasive insect, disease, weed, fruit yield, quality and sustainability. Climate management for control of pests, diseases, quality, elongation of growth and other plant processes- closed production systems.

Block 3: **Case Studies**

Unit I: Response to Climate Change: Case studies – responses of fruit trees to climatic variability *vis-a-vis* tolerance and adaptation; role of fruit tree in carbon sequestration.

V. Suggested Reading

Dhillon WS and Aulakh PS. 2011. *Impact of Climate Change in Fruit Production*. Narendra Publishing House, New Delhi.

Peter KV. 2008. *Basics in Horticulture*. New India Publishing Agency, New Delhi.

Ramirez F and Kallarackal J. 2015. *Responses of Fruit Trees to Global Climate Change*. Spinger-Verlag.

Rao GSLHV. 2008. *Agricultural Meteorology*. Prentice Hall, New Delhi.

Rao GSLHV, Rao GGSN, Rao VUM and Ramakrishnan YS. 2008. *Climate Change and Agriculture over India*. ICAR, New Delhi.

Schafeer B and Anderson P. 1994. *Handbook of Environmental Physiology of Fruit Crops*.Vol. 1 & 2. CRC Press. USA.

I. Course Title : Minor Fruit Production

II. Course Code : FSC 513

III. Credit Hours : (2+1)

IV. Theory

Block 1: Introduction

Unit I: Occurrence, Adoption and General Account: Importance – occurrence and distribution, climate adaptation in fragile ecosystem and wastelands.

Block 2: Agro-Techniques

Unit I: Propagation and Cultural Practices: Traditional cultural practices and recent development in agro-techniques; propagation, botany-floral biology, growth patterns, mode of pollination, fruit set, ripening, fruit quality.

Block 3: Marketing and Utilization

Unit I: Post-Harvest Management: Post harvest management, marketing; minor fruit crops in terms of medicinal and antioXidant values; their uses for edible purpose and in processing industry

Crops

Bael, chironji, fig, passion fruit, jamun, phalsa, karonda, woodapple, cactus pear, khejri, kair, pilu, lasoda, loquat, tamarind, dragon fruit, monkey jack, mahua, khirni, amra, kokum, cape gooseberry, kaphal, persimmon, pistachio, seabuckthorn, hazel nut and other minor fruits of regional importance

V. Practicals

- Visits to institutes located in the hot and cold arid regions of the country (2);
- Identification of minor fruits plants/ cultivars (2);
- Collection of leaves and preparation of herbarium (1);
- Allelopathic studies (2);
- Generating know-how on reproductive biology of minor fruits (4);
- Fruit quality attributes and biochemical analysis (3);
- Project formulation for establishing commercial orchards in fragile ecosystems (1).

X. Suggested Reading

Ghosh SN, Singh A and Thakur A. 2017. *Underutilized Fruit Crops: Importance and Cultivation.* Jaya Publication House, New Delhi.

Krishna H and Sharma RR, 2017. *Fruit Production: Minor Fruits.* Daya Publishing House, New Delhi.

Mazumdar BC. 2014. *Minor Fruit Crops of India: Tropical and Subtropical.* Daya Publication House, New Delhi.

Nath V, Kumar D, Pandey V and Pandey D. 2008. *Fruits for the Future*. Satish Serial Publishing House, New Delhi.

Pareek OP, Sharma S, and Arora RK. 2007. *Underutilised Edible Fruits and Nuts*, IPGRI, Rome.

Peter KV. 2010. *Underutilized and Underexploited Horticultural Crops*. NIPA, New Delhi.

Rana JC and Verma VD. 2011. *Genetic Resources of Temperate Minor Fruit* (*Indigenous and Exotic*). NBPGR, New Delhi.

Saroj PL and Awasthi OP. 2005. *Advances in Arid Horticulture*, Vol. II: *Production Technology of Arid and Semiarid Fruits*. IBDC, Lucknow.

Saroj PL, Dhandar DG and Vashishta BB. 2004. *Advances in Arid Horticulture*, Vol.-1 *Present Status*. IBDC, Lucknow.

Singh *et al.* 2011. *Jamun*. ICAR, New Delhi.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 1

Horticultural Sciences

– Vegetable Science

Course Title with Credit Load
M.Sc. (Hort.) in Vegetable Science

Course Code	Course Title	Credit Hours	Semester
	Major Courses (20 Credits)		
VSC 501*	Production of Cool Season Vegetable Crops	2+1	
VSC 502*	Production of Warm Season Vegetable Crops	2+1	
VSC 503*	Growth and Development of Vegetable Crops	2+1	
VSC 504*	Principles of Vegetable Breeding	3+0	
VSC 505	Breeding of Self Pollinated Vegetable Crops	2+1	
VSC 506	Breeding of Cross Pollinated Vegetable Crops	2+1	
VSC 507	Protected Cultivation of Vegetable Crops	1+1	
VSC 508	Seed Production of Vegetable Crops	2+1	
VSC 509	Production of Underutilized Vegetable Crops	2+1	
VSC 510	Systematics of Vegetable Crops	1+1	
VSC 511	Organic Vegetable Production	1+1	
VSC 512	Production of Spice Crops	2+1	
VSC 513	Processing of Vegetable	1+1	
VSC 514	Postharvest Management of Vegetable Crops	2+1	
VSC 591	Seminar	0+1	
VSC 599	Research	0+30	
	Total Credits	**70**	

*Compulsory among major courses

Course Contents
M.Sc. (Hort.) in Vegetable Science

I. Course Title : Production of Cool Season Vegetable Crops

II. Course Code : VSC 501

III. Credit Hours : (2+1)

IV. Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery, sowing/ planting time and methods,hrydroponics and aeroponics, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of crops.

Unit I

Bulb and tuber crops—Onion, garlic and potato.

Cole crops—Cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and kale.

Unit III

Root crops—Carrot, radish, turnip and beetroot.

Unit IV

Peas and beans—Garden peas and broad bean.

Unit V

Leafy vegetables—Beet leaf, fenugreek, coriander and lettuce.

V. Practical

- Scientific raising of nursery and seed treatment;
- Sowing and transplanting;
- Description of commercial varieties and hybrids;
- Demonstration on methods of irrigation, fertilizers and micronutrients application;
- Mulching practices, weed management;
- Use of plant growth substances in cool season vegetable crops;
- Study of nutritional and physiological disorders;
- Studies on hydroponics, aeroponics and other soilless culture;
- Identification of important pest and diseases and their control;
- Preparation of cropping scheme for commercial farms;
- Visit to commercial farm, greenhouse/ polyhouses;
- Visit to vegetable market;
- Analysis of benefit to cost ratio.

VI. Suggested Reading

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya udyog.

Bose TK, Som MG and Kabir J. (Eds.). 1993. *Vegetable crops*. Naya prokash.

Chadha KL and Kalloo G. (Eds.). 1993-94. *Advances in horticulture* Vols. V-X. Malhotra publ. house.

Chadha KL. (Ed.). 2002. *Hand book of horticulture*. ICAR.

Chauhan DVS. (Ed.). 1986. *Vegetable production in India*. Ram prasad and sons.

Fageria MS, Choudhary BR and Dhaka RS. 2000. *Vegetable crops: production technology*. Vol. II. Kalyani publishers.

Gopalakrishanan TR. 2007. *Vegetable crops*. New India publ. agency.

Hazra P and Banerjee MK and Chattopadhyay A. 2012. *Varieties of vegetable crops in India*, (Second edition), Kalyani publishers, Ludhiana, 199 p.
Hazra P. 2016. *Vegetable Science*. 2nd edn, Kalyani publishers, Ludhiana.
Hazra P. 2019. *Vegetable production and technology*. New India publishing agency, New Delhi.
Hazra P, Chattopadhyay A, Karmakar K and Dutta S. 2011. *Modern technology for vegetable production*, New India publishing agency, New Delhi, 413p
Rana MK. 2008. *Olericulture in India*. Kalyani publishers, New Delhi.
Rana MK. 2008. *Scientific cultivation of vegetables*. Kalyani publishers, New Delhi.
Rana MK. 2014. *Technology for vegetable production*. Kalyani publishers, New Delhi.
Rubatzky VE and Yamaguchi M. (Eds.). 1997. *World vegetables: principles, production and nutritive values*. Chapman and Hall.
Saini GS. 2001. *A text book of oleri and flori culture*. Aman publishing house.
Salunkhe DK and Kadam SS. (Ed.). 1998. Hand book of vegetable science and technology: production, composition, storage and processing. Marcel dekker.
Shanmugavelu KG. 1989. *Production technology of vegetable crops*. Oxford and IBH.
Singh DK. 2007. *Modern vegetable varieties and production technology*. International book distributing Co.
Singh SP. (Ed.). 1989. *Production technology of vegetable crops*. Agril. comm. res. centre.
Thamburaj S and Singh N. (Eds.), 2004. *Vegetables, tuber crops and spices*. ICAR.
Thompson HC and Kelly WC. (Eds.). 1978. *Vegetable crops*. Tata McGraw-Hill.

I. Course Title : Production of Warm Season Vegetable Crops

II. Course Code : VSC 502

III. Credit Hours : (2+1)

IV. Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery including grafting technique, sowing/ planting time and methods, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices namely hydroponics, aeroponics, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marking), pest and disease management and economics of crops.

Unit I

Fruit vegetables—Tomato, brinjal, hot pepper, sweet pepper and okra.

Unit II

Beans—French bean, Indian bean (Sem), cluster bean and cowpea.

Unit III

Cucurbits—Cucumber, melons, gourds, pumpkin and squashes.

Unit IV

Tuber crops—Sweet potato, elephant foot yam, tapioca, taro and yam.

Unit V

Leafy vegetables—Amaranth and drumstick.

V. Practical

- Scientific raising of nursery and seed treatment;
- Sowing, transplanting, vegetable grafting;
- Description of commercial varieties and hybrids;
- Demonstration on methods of irrigation, fertilizers and micronutrients application;
- Mulching practices, weed management;
- Use of plant growth substances in warm season vegetable crops;
- Study of nutritional and physiological disorders;
- Studies on hydroponics, aeroponics and other soilless culture;
- Identification of important pest and diseases and their control;
- Preparation of cropping scheme for commercial farms;
- Visit to commercial farm, greenhouse/ polyhouses;
- Visit to vegetable market;
- Analysis of benefit to cost ratio.

VI. Suggested Reading

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya udyog.

Bose TK, Som MG and Kabir J. (Eds.). 1993. *Vegetable crops*. Naya prokash.

Chadha KL and Kalloo G. (Eds.). 1993-94. *Advances in horticulture* Vols. V-X. Malhotra publ. house.

Chadha KL. (Ed.). 2002. *Hand book of horticulture*. ICAR.

Chauhan DVS. (Ed.). 1986. *Vegetable production in India*. Ram prasad and sons.

Fageria MS, Choudhary BR and Dhaka RS. 2000. *Vegetable crops: production technology*. Vol. II. Kalyani.
Gopalakrishanan TR. 2007. *Vegetable crops*. New India publ. agency.
Hazra P and Banerjee MK and Chattopadhyay A. 2012. *Varieties of vegetable crops in India*, (Second edition), Kalyani publishers, Ludhiana, 199 p.
Hazra P. 2016. *Vegetable science*. 2nd edn, Kalyani publishers, Ludhiana.
Hazra P. 2019. *Vegetable production and technology*. New India publishing agency, New Delhi.
Hazra P, Chattopadhyay A, Karmakar K and Dutta S. 2011. *Modern technology for vegetable production*, New India publishing agency, New Delhi, 413p
Rana MK. 2008. *Olericulture in India*. Kalyani Publishers, New Delhi.
Rana MK. 2008. *Scientific cultivation of vegetables*. Kalyani Publishers, New Delhi.
Rubatzky VE and Yamaguchi M. (Eds.). 1997. *World vegetables: principles, production and nutritive values*. Chapman and Hall.
Saini GS. 2001. *A text book of oleri and flori culture*. Aman publishing house.
Salunkhe DK and Kadam SS. (Ed.). 1998. *Hand book of vegetable science and technology: production, composition, storage and processing*. Marcel dekker.
Shanmugavelu KG., 1989. *Production technology of vegetable crops*. Oxford and IBH.
Singh DK. 2007. *Modern vegetable varieties and production technology*. International book distributing Co.
Singh SP. (Ed.). 1989. *Production technology of vegetable crops*. Agril. comm. res. centre.
Thamburaj S and Singh N. (Eds.). 2004. *Vegetables, tuber crops and spices*. ICAR.
Thompson HC and Kelly WC. (Eds.). 1978. *Vegetable crops*. Tata McGraw-Hill.

I. Course Title : Growth and Development of Vegetable Crops

II. Course Code : VSC 503

III. Credit Hours : (2+1)

IV. Theory

Unit I

Introduction and phytohormones—Definition of growth and development; Cellular structures and their functions; Physiology of phyto-hormones functioning/ biosynthesis and mode of action; Growth analysis and its importance in vegetable production.

Unit II

Physiology of dormancy and germination—Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auXins, gibberellilns, cyktokinins and abscissic acid; Application of synthetic PGRs including plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of action of morphactins, antitranspirants, anti-auXin, ripening retardant and plant stimulants in vegetable crop production.

Unit III

Abiotic factors—Impact of light, temperature, photoperiod, carbon dioXide, oXygen and other gases on growth, development of underground parts, flowering and seX eXpression in vegetable crops; Apical dominance.

Unit IV

Fruit physiology—Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening.

Unit V

Morphogenesis and tissue culture—Morphogenesis and tissue culture techniques in vegetable crops; Grafting techniques in different vegetable crops.

V. Practical

- Preparation of plant growth regulator's solutions and their application;
- EXperiments in breaking and induction of dormancy by chemicals;
- Induction of parthenocarpy and fruit ripening;
- Application of plant growth substances for improving flower initiation, changing seX eXpression in cucurbits and checking flower and fruit drops and improving fruit set in solanaceous vegetables;
- Growth analysis techniques in vegetable crops;
- Grafting techniques in tomato, brinjal, cucumber and sweet pepper.

VI. Suggested Reading

Bleasdale JKA. 1984. *Plant physiology in relation to horticulture* (2nd Edition) MacMillan.

Gupta US. Eds. 1978. *Crop physiology*. OXford and IBH, New Delhi.

Kalloo G. 2017. *Vegetable grafting: Principles and practices*. CAB International

Krishnamoorti HN. 1981. *Application growth substances and their uses in agriculture*. Tata McGraw Hill, New Delhi.

Leopold AC and Kriedemann PE. 1981. *Plant growth and development*, Tata McGraw-Hill, New Delhi.

Peter KV and Hazra P. (Eds). 2012. *Hand book of vegetables*.Studium Press LLC, P.O. BoX 722200, Houston, TeXas 77072, USA, 678p.

Peter KV. (Eds). 2008. *Basics of horticulture*. New India publication agency, New Delhi.

Rana MK. 2011. *Physio-biochemistry and Biotechnology of Vegetables*. New India Publishing Agency, Pritam Pura, New Delhi.

Saini *et al.* (Eds.). 2001. *Laboratory manual of analytical techniques in horticulture*. Agrobios, Jodhpur.

Wien HC. (Eds.). 1997. *The physiology of vegetable crops*. CAB International.

I. Course Title : Principles of Vegetable Breeding

II. Course Code : VSC 504

III. Credit Hours : (2+1)

VI. Theory

Unit I

Importance and history- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding.

Unit II

Selection procedures- Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture; Breeding for biotic stress (diseases, insect pests and nematode), abiotic stress (temperature, moisture and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE).

Unit III

Heterosis breeding- Types, mechanisms and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility and sex forms.

Unit IV

Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.

Unit V

Ideotype breeding- Ideotype breeding; varietal release procedure; DUS testing in vegetable crops; Application of *In-vitro* and molecular techniques in vegetable improvement.

VII. Practical

- Floral biology and pollination behaviour of different vegetables;
- Techniques of selfing and crossing of different vegetables, viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, etc.;
- Breeding system and handling of filial generations of different vegetables;
- Exposure to biotechnological lab practices;
- Visit to breeding farms.

X. Suggested Reading

Allard RW. 1960. *Principle of plant breeding*. John Willey and Sons, USA.

Kalloo G. 1988. *Vegetable breeding* (Vol. I, II, III). CRC Press, Fl, USA.

Kole CR. 2007. *Genome mapping and molecular breeding in plants-vegetables*. Springer, USA.

Peter KVand Pradeep Kumar T. 1998. Genetics and breeding of vegetables. ICAR, New Delhi, p. 488.

Prohens J and Nuez F. 2007. *Handbook of plant breeding-vegetables* (Vol I and II). Springer, USA.

Singh BD. 2007. *Plant breeding- principles and methods* (8th edn.). Kalyani Publishers, New Delhi.

Singh Ram J. 2007. *Genetic resources, chromosome engineering, and crop improvement-vegetable crops* (Vol. 3). CRC Press, Fl, USA.

I. Course Title : Breeding of Self Pollinated Vegetable Crops

II. Course Code : VSC 505

III. Credit Hours : (2+1)

IV. Theory

Origin, botany, taxonomy, wild relatives, cytogenetics and genetics, types of pollination and fertilization mechanism, sterility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation and polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stresses, breeding for protected environment and quality improvement, molecular markers and marker's assisted breeding; QTLs, PPV and FR Act.

Unit I

Tuber crops: Potato.

Unit II

Fruit vegetables- Tomato, eggplant, hot pepper, sweet pepper and okra.

Unit III

Leguminous vegetables- Garden peas and cowpea.

Unit IV

Leguminous vegetables: French bean, Indian bean, cluster bean and broad bean.

Unit V

Leafy vegetables- Lettuce and fenugreek.

VII. Practical

- Floral mechanisms favouring self and often cross pollination;
- Progeny testing and development of inbred lines;
- Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations;
- Palynological studies, selfing and crossing techniques;
- Hybrid seed production of vegetable crops in bulk;
- Screening techniques for biotic and abiotic stress resistance in above mentioned crops;
- Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques;
- Visit to breeding farms;

VIII. Suggested Reading

Allard RW. 1999. *Principles of plant breeding*. John Wiley and Sons.

Basset MJ. (Ed.). 1986. *Breeding vegetable crops*. AVI Publ.

Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005, Plant genetic resources: horticultural crops. Narosa Publ. House.

Fageria MS, Arya PS and Choudhary AK. 2000, *Vegetable crops: Breeding and seed production*. Vol. I. Kalyani.

Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.

Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.

Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. *Plant Breeding-principles and prospects*. Chapman and Hall.

Hazra P and Som MG. 2015. Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598 p.

Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani Publishers, Ludhiana, 459 p

Kalloo G. 1988. *Vegetable breeding*. Vols. I-III. CRC Press.
Kalloo G. 1998. *Vegetable breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
Kumar JC and Dhaliwal MS. 1990. *Techniques of developing hybrids in vegetable crops*. Agro Botanical Publ.
Paroda RS and Kalloo G. (Eds.). 1995. *Vegetable research with special reference to hybrid technology in Asia-Pacific Region*. FAO.
Peter KV and Pradeepkumar T. 2008. *Genetics and breeding of vegetables*. Revised, ICAR.
Peter KV and Hazra P. (Eds). 2012. *Hand book of vegetables*. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
Peter KV and Hazra P (Eds). 2015. *Hand book of vegetables* Volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume III.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
Rai N and Rai M. 2006. *Heterosis breeding in vegetable crops*. New India Publ. Agency.
Ram HH. 1998. *Vegetable breeding: principles and practices*. Kalyani Publishers, New Delhi.
Simmonds NW. 1978. *Principles of crop improvement*. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publishers, New Delhi.
Singh PK, Dasgupta SK and Tripathi SK. 2004. *Hybrid vegetable development*. International Book Distributing Co.
Swarup V. 1976. *Breeding procedure for cross-pollinated vegetable crops*. ICAR.

I. Course Title : Breeding of Cross Pollinated Vegetable Crops

II. Course Code : VSC 506

III. Credit Hours : (2+1)

III. Theory

Origin, botany, taxonomy, cytogenetics, genetics, types of pollination and fertilization, mechanism, sterility and incompatibility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation, polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stresses, quality improvement, molecular markers and marker assisted breeding, and QTLs, PPV and FR act

Unit I

Cucurbitaceous crops—Gourds, melons, cucumber, pumpkin and squashes.

Unit II

Cole crops—Cauliflower, cabbage, kohlrabi, broccoli and brussels sprouts.

Unit III

Root and bulb crops—Carrot, radish, turnip, beet root and onion.

Unit IV

Tuber crops—Sweet potato, tapioca, taro and yam.

Unit V

Leafy vegetables—Beet leaf, spinach, amaranth and coriander.

IV. Practical

- Floral mechanisms favouring cross pollination;
- Development of inbred lines;
- Selection of desirable plants from breeding population;
- Observations and analysis of various quantitative and qualitative traits in germplasm, hybrids and segregating generations;
- Induction of flowering, palynological studies, selfing and crossing techniques;
- Hybrid seed production of vegetable crops in bulk; Screening techniques for biotic and abiotic stress resistance in above mentioned crops;
- Demonstration of sib-mating and mixed population;
- Molecular marker techniques to identify useful traits in vegetable crops and special breeding techniques;
- Visit to breeding blocks.

X. Suggested Reading

Allard RW. 1999. *Principles of plant breeding*. John Wiley and Sons.

Basset MJ. (Ed.). 1986. *Breeding vegetable crops*. AVI Publ.

Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. *Plant genetic resources: horticultural crops*. Narosa publ. house.

Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable crops: breeding and seed production*. Vol. I. Kalyani.

Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.

Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.

Hayward MD, Bosemark NO and Romagosa I. (Eds.), 1993. *Plant breeding-principles and prospects*. Chapman and Hall.

Hazra P and Som MG. 2015. *Vegetable science* (Second revised edition), Kalyani publishers, Ludhiana, 598 p.

Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani Publishers, Ludhiana, 459 p

Kalloo G. 1988. *Vegetable breeding*. Vols. I-III. CRC Press.
Kalloo G. 1998. *Vegetable breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
Kumar JC and Dhaliwal MS. 1990. *Techniques of developing hybrids in vegetable crops*. Agro botanical publ.
Paroda RS and Kalloo G. (Eds.). 1995. *Vegetable research with special reference to hybrid technology in Asia-Pacific region*. FAO.
Peter KV and Pradeepkumar T. 2008. *Genetics and breeding of vegetables*. revised, ICAR.
Peter KV and Hazra P. (Eds). 2012. *Hand book of vegetables*. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume II and III.Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
Prohens J and Nuez F. 2007. *Handbook of Plant Breeding- Vegetables* (Vol I and II), Springer, USA.
Rai N and Rai M. 2006. *Heterosis breeding in vegetable crops*. New India Publ. Agency.
Ram HH. 1998. *Vegetable breeding: principles and practices*. Kalyani Publishers, New Delhi.
Simmonds NW. 1978. *Principles of crop improvement*. Longman.
Singh BD. 1983. *Plant breeding*. Kalyani Publishers, New Delhi.
Singh PK, Dasgupta SK and Tripathi SK. 2004. *Hybrid vegetable development*. International book distributing Co.
Swarup V. 1976. *Breeding procedure for cross-pollinated vegetable crops*. ICAR.

I. Course Title : Protected Cultivation of Vegetable CropS
II. Course Code : VSC 507
III. Credit Hours : (2+1)
VI. Theory

Unit I

Scope and importance- Concept, scope and importance of protected cultivation of vegetable crops; Principles, design, orientation of structure, low and high cost polyhouses/ greenhouse structures.

Unit II

Types of protected structure- Classification and types of protected structures-greenhouse/ polyhouses, plastic-non plastic low tunnels, plastic walk in tunnels, high roof tunnels with ventilation, insect proof net houses, shed net houses, rain shelters, NVP, climate control greenhouses, hydroponics and aeroponics; Soil and soilless media for bed preparation; Design and installation of drip irrigation and fertigation system.

Unit III

Abiotic factors- Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity, etc. on growth and yield of different vegetables.

Unit IV

Nursery raising- High tech vegetable nursery raising in protected structures using plugs and portrays, different media for growing nursery under protected cultivation; Nursery problems and management technologies including fertigation.

Cultivation of crops- Regulation of flowering and fruiting in vegetable crops; Technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, including varieties and hybrids, training, pruning and staking in growing vegetables under protected structures.

Unit VI

Solutions to problems- Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for seed production; Economics of greenhouse crop production.

VII. Practical

- Study of various types of protected structure;
- Study of different methods to control temperature, carbon dioxide and light;
- Study of different types of growing media, training and pruning systems in greenhouse crops;
- Study of fertigation and nutrient management under protected structures;
- Study of insect pests and diseases in greenhouse and its control;
- Use of protected structures in hybrid seed production of vegetables;
- Economics of protected cultivation (Any one crop);
- Visit to established green/ polyhouses/ shade net houses in the region.

VIII. Suggested Reading

Chadha KL and Kalloo G. (Eds.). 1993-94. *Advances in horticulture*. Malhotra Pub. House.

Chandrs and Som V. 2000. *Cultivating vegetables in green house*. Indian horticulture 45:17-18.

Kalloo G and Singh K. (Eds.). 2000. *Emerging scenario in vegetable research and development*.Research periodicals and Book publ. house.

Parvatha RP. 2016. *Sustainable crop protection under protected cultivation*. E-Book Springer.

Prasad S and Kumar U. 2005. *Greenhouse management for horticultural crops*. 2nd Ed.Agrobios.

Resh HM. 2012. *Hydroponic food production*. 7thEdn. CRC Press.

Singh B. 2005. *Protected cultivation of vegetable crops*. Kalyani publishers, New Delhi

Singh DK and Peter KV. 2014. *Protected cultivation of horticultural crops* (1st Edition) New India publishing agency, New Delhi.

Singh S, Singh B and Sabir N. 2014. *Advances in protected cultivation*. New India publishing agency, New Delhi.

Tiwari GN. 2003. *Green house technology for controlled environment*. Narosa publ. house.

I. Course Title : Seed Production of Vegetable Crops
II. Course Code : VSC 508
III. Credit Hours : (2+1)

II. Theory

Unit I

Introduction, history, propagation and reproduction—Introduction, definition of seed and its quality, seed morphology, development and maturation; Apomixis and fertilization; Modes of propagation and reproductive behaviour; Pollination mechanisms and sex forms in vegetables; History of vegetable seed production; Status and share of vegetable seeds in seed industry status and share of vegetable seeds in seed industry.

Unit II

Agro-climate and methods of seed production—Agro-climate and its influence on quality seed production; Deterioration of crop varieties, genetical and agronomic principles of vegetable seed production; Methods of seed production, hybrid seeds and techniques of large scale hybrid seed production; Seed village concept

Unit III

Seed multiplication and its quality maintenance—Seed multiplication ratios and replacement rates in vegetables; Generation system of seed multiplication; Maintenance and production of nucleus, breeder, foundation, certified/ truthful label seeds; Seed quality and mechanisms of genetic purity testing

Unit IV

Seed harvesting, extraction and its processing—Maturity standards; Seed harvesting, curing and extraction; Seed processing, viz., cleaning, drying and treatment of seeds, seed health and quality enhancement, packaging and marketing; Principles of seed storage; Orthodox and recalcitrant seeds; Seed dormancy

Unit V

Improved agro-techniques and field and seed standards—Improved agro-techniques; Field and seed standards in important solanaceous, leguminous and cucurbitaceous vegetables, cole crops, leafy vegetables, bulbous and root crops and okra; clonal propagation and multiplication in vegetative propagated crops; Seed plot technique and true potato seed production in potato

III. Practical

- Study of floral biology and pollination mechanisms in vegetables;
- Determination of modes of pollination;
- Field and seed standards;
- Use of pollination control mechanisms in hybrid seed production of important vegetables;
- Maturity standards and seed extraction methods;
- Seed sampling and testing;
- Visit to commercial seed production areas;
- Visit to seed processing plant;
- Visit to seed testing laboratories.

VIII. Suggested Reading

Agarwaal PK and Anuradha V. 2018. *Fundamentals of seed science and technology*. Brilliant publications, New Delhi.

Agrawal PK and Dadlani M. (Eds.). 1992. *Techniques in seed science and technology*. South

asian Publ.
Agrawal RL. (Ed.). 1997. *Seed technology*. Oxford and IBH.
Basra AS. 2000. *Hybrid seed production in vegetables*. CRC press, Florida, USA.
Bench ALR and Sanchez RA. 2004. *Handbook of seed physiology*. Food products press, NY/ London.
Bendell PE. (Eds.). 1998. *Seed science and technology: Indian forestry species*. Allied Publ.
Chakraborty SK, Prakash S, Sharma SP and Dadlani M. 2002. *Testing of distinctiveness, uniformity and stability for plant variety protection*. IARI, New Delhi
Copland LO and McDonald MB. 2004. *Seed science and technology*, Kluwer Academic Press.
Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable crops: breeding and seed production*. Vol. I. Kalyani Publishers, New Delhi.
George RAT. 1999. *Vegetable seed production* (2nd Edition). CAB International.
Kalloo G, Jain SK, Vari AK and Srivastava U. 2006. *Seed: A global perspective*. Associated publishing company, New Delhi.
Hazra P and Som HG. 2015. *Seed production and hybrid technology of vegetable crops*. Kalyani publishers, Ludhiana.
Kumar JC and Dhaliwal MS. 1990. *Techniques of developing hybrids in vegetable crops*. Agro botanical publ.
More TA, Kale PB and Khule BW. 1996. *Vegetable seed production technology*. Maharashtra state seed corp.
Rajan S and Markose BL. 2007. *Propagation of horticultural crops*. New India publ. agency.
Singh NP, Singh DK, Singh YK and Kumar V. 2006. *Vegetable seed production technology*. International book distributing Co.
Singh SP. 2001. *Seed production of commercial vegetables*. Agrotech publ. academy.
Singhal NC. 2003. *Hybrid seed production*. Kalyani publishers, New Delhi

I. Course Title : Production of Underutilized Vegetable Crops

II. Course Code : VSC 509

III. Credit Hours : (2+1)

III. Theory

Importance and scope, botany and taxonomy, climate and soil requirement, commercial varieties/ hybrids, improved cultural practices, physiological disorders, harvesting and yield, plant protection measures and post harvest management of:

Unit I

Stem and bulb crops—Asparagus, leek and chinese chive

Unit II

Cole and salad crops—Red cabbage, chinese cabbage, kale, sweet corn and baby corn

Unit III

Leafy vegetables—Celery, parsley, indian spinach (poi), spinach, chenopods, chekurmanis and indigenous vegetables of regional importance

Unit IV

Gourds and melons—Sweet gourd, spine gourd, teasle gourd, round gourd, and little/ Ivy gourd, snake gourd, pointed gourd, kachri, long melon, snap melon and gherkin

Unit V

Yam and beans—Elephant foot yam, yam, yam bean, lima bean and winged bean

IV. Practical

- Identification and botanical description of plants and varieties;
- Seed/ planting material;
- Production, lay out and method of planting;
- Important cultural operations;
- Identification of important pests and diseases and their control;
- Maturity standards and harvesting;
- Visit to local farms.

Suggested Reading

Bhat KL. 2001. *Minor vegetables-untapped potential*. Kalyani publishers, New Delhi.

Indira P and Peter KV. 1984. *Unexploited tropical vegetables*. Kerala agricultural university, Kerala.

Pandey AK. 2011. *Aquatic vegetables*. Agrotech publisher academy, New Delhi.

Peter KV. (Eds.). 2007-08. *Underutilized and underexploited horticultural crops*. Vol.1-4, New India publishing agency, Lucknow.

Peter KV and Hazra P. (Eds). 2012. *Hand book of vegetables*. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.

Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume II and III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.

Rana MK. 2018. *Vegetable crop science*. CRC Press Taylor and Francis Group 6000 Broken Sound Parkway NW, Suite 300 Boca Raton, FL 33487-2742 ISBN: 978-1-1380-3521-8

Rubatzky VE and Yamaguchi M. 1997. *World vegetables: vegetable crops*. NBPGR, New Delhi.

I. Course Title : Systematics of Vegetable Crops

II. Course Code : VSC 510

III. Credit Hours : (1+1)

II. Theory

Unit I

Significance of systematic—Significance of systematics and crop diversity in vegetable crops; Principles of classification; different methods of classification; Salient features of international code of nomenclature of vegetable crops

Unit II

Origin and evolution—Origin, history, evolution and distribution of vegetable crops

Unit III

Botanical and morphological description—Botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables; Morphological keys to identify important families, floral biology, floral formula and diagram; Morphological description of all parts of vegetables

Unit IV

Cytology—Cytological level of various vegetable crops with descriptive keys

Unit V

Molecular markers—Importance of molecular markers in evolution of vegetable crops; Molecular markers as an aid in characterization and taxonomy of vegetable crops

III. Practical

- Identification, description, classification and maintenance of vegetable species and varieties;
- Survey, collection of allied species and genera locally available;
- Preparation of keys to the species and varieties;
- Methods of preparation of herbarium and specimens.

IV. Suggested Reading

Chopra GL. 1968. *Angiosperms- systematics and life cycle.* S. Nagin

Dutta AC. 1986. *A class book of botany*. Oxford Univ. Press.

Pandey BP. 1999. *Taxonomy of angiosperm*. S. Chand and Co

Peter KV and Pradeepkumar T. 2008. *Genetics and breeding of vegetables*. (Revised), ICAR.

Peter KV and Hazra P. (Eds). 2012. *Hand book of vegetables*. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.

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Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume III.Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p.

Simmonds NW and Smartt J. 1995. *Evolution of crop plants*. Wiley-Blackwell.

Soule J. 1985. *Glossary for Horticultural Crops*. John Wiley and Sons.

Srivastava U, Mahajan RK, Gangopadyay KK, Singh M and Dhillon BS. 2001. *Minimal descriptors of agri-horticultural crops*. Part-II: Vegetable Crops. NBPGR, New Delhi.

Vasistha. 1998. *Taxonomy of angiosperm*. Kalyani Publishers, New Delhi.

Vincent ER and Yamaguchi M. 1997. *World vegetables*. 2nd Ed. Chapman and Hall.

I. Course Title : Organic Vegetable Production

II. Course Code : VSC 511

III. Credit Hours : (1+1)

IV. Theory

Unit I

Importance and principles—Importance, principles, perspective, concepts and components of organic farming in vegetable crops

Unit II

Organic production of vegetables—Organic production of vegetable crops, viz., Solanaceous, Cucurbitaceous, Cole, root and tuber crops

Unit III

Managing soil fertility—Managing soil fertility, mulching, raising green manure crops, weed management in organic farming system; Crop rotation in organic production; Processing and quality control of organic vegetable produce

Unit IV

Composting methods—Indigenous methods of composting, Panchyagavvya, Biodynamics preparations and their application; ITKs in organic vegetable farming; Role of botanicals and bio-control agents in the management of pests and diseases in vegetable crops

Unit V

Certification and export—Techniques of natural vegetable farming, GAP and GMP-certification of organic products; Export- opportunity and challenges

V. Practical

- Methods of preparation and use of compost, vermicompost, biofertilizers and biopesticides;
- Soil solarisation;
- Use of green manures;
- Waste management; Organic soil amendments in organic production of vegetable crops;
- Weed, pest and disease management in organic vegetable production;
- Visit to organic fields and marketing centres.

VI. Suggested Reading

Dahama AK. 2005. *Organic farming for sustainable agriculture.* 2nd Ed. Agrobios.

Gehlot G. 2005. *Organic farming; standards, accreditation certification and inspection*. Agrobios.

Palaniappan SP and Annadorai K. 2003. *Organic farming, theory and practice.* Scientific publ.

Pradeepkumar T, Suma B, Jyothibhaskar and Satheesan KN. 2008. *Management of horticultural crops*. New India Publ. Agency.

Shivashankar K. 1997. *Food security in harmony with nature. 3rd IFOAMASIA,* Scientific Conf. 1- 4 December, UAS, Bangalore.

I. Course Title : Production of Spice Crops

II. Course Code : VSC 512

III. Credit Hours : (2+1)

IV. Theory

Introduction and importance of spice crops- historical accent, present status (national and international), future prospects, botany and taxonomy, climatic and soil requirement, commercial cultivars/ hybrids, site selection, layout, sowing/ planting

time and methods, seed rate and seed treatment, nutritional and irrigation requirement, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures, quality control and pharmaceutical significance of crops mentioned below:

Unit I

Fruit spices- Black pepper, small cardamom, large cardamom and allspice

Unit II

Bud and kernel- Clove and nutmeg

Unit III

Underground spices- Turmeric, ginger and garlic

Unit IV

Seed spices- Coriander, fenugreek, cumin, fennel, ajowain, dill and celery

Unit V

Tree spices- Cinnamon, tamarind, garcinia and vanilla

V. Practical

- Identification of seeds and plants;
- Botanical description of plant;
- Preparation of spice herbarium;
- Propagation;
- Nursery raising;
- Field layout and method of planting;
- Cultural practices;
- Harvesting, drying, storage, packaging and processing;
- Value addition;
- Short term experiments on spice crops.

VI. Suggested Reading

Agarwal S, Sastry EVD and Sharma RK. 2001. *Seed spices: production, quality, export*. Pointer Publication.

Arya PS. 2003. *Spice crops of India*. Kalyani.

Bhattacharjee SK. 2000. *Hand book of aromatic plants*. Pointer publications.

Bose TK, Mitra SK, Farooqi SK and Sadhu MK. (Eds.). 1999. *Tropical horticulture*.Vol.I. Naya Prokash.

Chadha KL and Rethinam P. (Eds.). 1993. *Advances in horticulture.* Vols. IX-X. *Plantation crops and spices*. Malhotra Publ. House.

Gupta S. (Ed.). *Hand book of spices and packaging with formulae*. engineers India research institute, New Delhi.

Kumar NA, Khader P, Rangaswami and Irulappan I. 2000. *Introduction to spices, plantation crops, medicinal and aromatic plants*. Oxford and IBH.

Nybe EV, Miniraj N and Peter KV. 2007. *Spices*. New India Publ. Agency.

Parthasarthy VA, Kandiannan V and Srinivasan V. 2008. *Organic spices*. New India Publ. Agency.

Peter KV. 2001. *Hand book of herbs and spices*. Vols. I-III. Woodhead Publ. Co. UK and CRC USA.

Pruthi JS. (Ed.). 1998. *Spices and condiments*. National Book Trust

Pruthi JS. 2001. *Minor spices and condiments- crop management and post harvest technology*. ICAR.

Purseglove JW, Brown EG, Green CL and Robbins SRJ. (Eds.). 1981. *Spices*. Vols. I, II. Longman.

Shanmugavelu KG, Kumar N and Peter KV. 2002. *Production technology of spices and plantation crops*. Agrobios.

Thamburaj S and Singh N. (Eds.). 2004. *Vegetables, tuber crops and spices*. ICAR.

Tiwari RS and Agarwal A. 2004. *Production technology of spices*. International Book Distr. Co.
Varmudy V. 2001. *Marketing of spices*. Daya Publ. House.

I. Course Title : Processing of Vegetable Crops
II. Course Code : VSC 513
III. Credit Hours : (1+1)

Theory

Unit I

Present status—Present status and future prospects of vegetable preservation industry in India

Unit II

Spoilage and biochemical changes—Spoilage of fresh and processed vegetable produce; biochemical changes and enzymes associated with spoilage of vegetable produce; Principal spoilage organisms, food poisoning and their control measures; Role of microorganisms in food preservation

Unit III

Processing equipments—Raw material for processing; Primary and minimal processing; Processing equipments; Layout and establishment of processing industry; FPO licence; Importance of hygiene; Plant sanitation

Unit IV

Quality control—Quality assurance and quality control, TQM, GMP; Food standards- FPO, PFA, etc.; Food laws and regulations; Food safety- hazard analysis and critical control points (HACCP); Labeling and labeling act and nutrition labeling

Value addition—Major value added vegetable products; Utilization of byproducts of vegetable processing industry; Management of processing industry waste; Investment analysis; Principles and methods of sensory evaluation of fresh and processed vegetables

IV. Practical

- Study of machinery and equipments used in processing of vegetable produce;
- Chemical analysis for nutritive value of fresh and processed vegetable;
- Study of different types of spoilage in fresh as well as processed vegetable produce;
- Classification and identification of spoilage organisms;
- Study of biochemical changes and enzymes associated with spoilage;
- Laboratory examination of vegetable products;
- Sensory evaluation of fresh and processed vegetables;
- Study of food standards- National, international, CODEX Alimentarius;
- Visit to processing units to study the layout, hygiene, sanitation and waste management.

V. Suggested Reading

Arthey D and Dennis C. 1996. *Vegetable processing*. Blackie/ Springer-Verlag.

Chadha DS. 2006. *The Prevention of food adulteration act*. Confed. of Indian Industry.

Desrosier NW. 1977. *Elements and technology*. AVI Publ. Co.

FAO. 1997. *Fruit and Vegetable processing*. FAO.

FAO. *CODEX Alimentarius: Joint FAO/ WHO food standards programme*. 2nd Ed. Vol. VB. *tropical fresh fruits and vegetables*. FAO.

FAO. *Food quality and safety systems- training manual on food hygiene and haccp*. FAO.

Fellow's P. 1988. Food processing technology. Ellis Horwood International.

Frazier WC and Westhoff DC. 1995. *Food microbiology*. 4th Ed. Tata McGraw Hill.

Giridharilal GS Siddappa and Tandon GL. 1986, *Preservation of fruits and vegetables*. ICAR.

Gisela J. 1985. *Sensory evaluation of food- theory and practices*. Ellis Horwood.

Graham HD. 1980. *Safety of foods*. AVI Publ. Co.

Hildegrade H and Lawless HT. 1997. *Sensory evaluation of food*. CBS.

Joslyn M and Heid *Food processing operations*.AVI Publ. Co.

Mahindru SN. 2004. *Food safety: concepts and reality*. APH Publ. Corp.

Ranganna S. 1986. *Handbook of analysis and quality control for fruit and vegetable products*. 2nd Ed. Tata-McGraw Hill.

Shapiro R. 1995. *Nutrition labeling handbook*. Marcel Dekker.
Srivastava RP and Kumar S. 2003. *Fruit and vegetable preservation: principles and practices*. 3rd Ed. International Book Distri. Co.
Tressler and Joslyn MA. 1971. *Fruit and vegetable juice processing technology*. AVI Publ. Co.
Verma LR and Joshi VK. 2000. *Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management*. Indus Publ. Co.

I. Course Title : Postharvest Management of Vegetable Crops
II. Course Code : VSC 514

III. Credit Hours : (2+1)

IV. Theory

Unit I

Importance and scope—Importance and scope of post-harvest management of vegetables

Unit II

Maturity indices and biochemistry—Maturity indices and standards for different vegetables; Methods of maturity determination; Biochemistry of maturity and ripening; Enzymatic and textural changes; Ethylene evolution and ethylene management; Respiration and transpiration along with their regulation methods

Unit III

Harvesting and losses factors—Harvesting tools and practices for specific market requirement; Postharvest physical and biochemical changes; Preharvest practices and other factors affecting postharvest losses

Unit IV

Packing house operations—Packing house operations; Commodity pretreatments chemicals, wax coating, precooling and irradiation; Packaging of vegetables, prevention from infestation, management of postharvest diseases and principles of transportation

Unit V

Methods of storage—Ventilated, refrigerated, modified atmosphere and controlled atmosphere storage, hypobaric storage and cold storage; Zero-energy cool chamber, storage disorders like chilling injury in vegetables

V. Practical

- Studies on stages and maturing indices;
- Ripening of commercially important vegetable crops;
- Studies of harvesting, pre-cooling, pre-treatments, physiological disorders- chilling injury;
- Improved packaging;
- Use of chemicals for ripening and enhancing shelf life of vegetables;
- Physiological loss in weight, estimation of transpiration, respiration rate and ethylene release;
- Storage of important vegetables;
- Cold chain management;
- Visit to commercial packinghouse, cold storage and control atmosphere storage.

VI. Suggested Reading

Chadha KL and Pareek OP. 1996. *Advances in horticulture*. Vol. IV. Malhotra Publ. House.

Chattopadhyay SK. 2007. *Handling, transportation and storage of fruit and vegetables*. Gene-Tech books, New Delhi.

Haid NF and Salunkhe SK. 1997. *Postharvest physiology and handling of fruits and vegetables.* Grenada Publ.

Mitra SK. 1997. *Postharvest physiology and storage of tropical and sub-tropical fruits*. CABI.

Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest biology and technology of Fruits, vegetables and flowers*. Wiley-Blackwell, ISBN: 9780813804088.

Ranganna S. 1997. *Handbook of analysis and quality control for fruit and vegetable products.* Tata McGraw-Hill.

Stawley JK. 1998. *Postharvest physiology of perishable plant products*. CBS publishers.

Sudheer KP and Indira V. 2007. *Postharvest technology of horticultural crops*. New India Publ.

Agency.

Thompson AK. (Ed.). 2014. *Fruit and vegetables: harvesting, handling and storage* (Vol. 1 and 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.

Verma LR and Joshi VK. 2000. *Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.

Willis R, McGlassen WB, Graham D and Joyce D. 1998. *Postharvest: An introduction to the physiology and handling of fruits, vegetables and ornamentals*. CABI.

Wills RBH and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.

Wills RBH and Golding J. 2017. *Advances in postharvest fruit and vegetable technology*, CRC Press, ISBN 9781138894051.

Course Title with Credit Load
Ph.D. (Hort.) in Vegetable Science

Course Code	Course Title Credit	Hours
	Major Courses (12 Credits)	
VSC 601*	Recent Trends in Vegetable Production	3+0
VSC 602*	Advances in Breeding of Vegetable Crops	3+0
VSC 603	Abiotic Stress Management in Vegetable Crops	2+1
VSC 604	Seed Certification, Processing and Storage of Vegetable Crops	2+1
VSC 605	Breeding for Special Traits in Vegetable Crops	2+0
VSC 606	Biodiversity and Conservation of Vegetable Crops	2+1
VSC 607	Biotechnological Approaches in Vegetable Crops	2+1
VSC 608	Advanced Laboratory Techniques for Vegetable Crops	1+2
VSC 691	Seminar I	0+1
VSC 692	Seminar II	0+1
VSC 699	Research	0+75
	Total Credits	100

*Compulsory among major courses

Course Contents
Ph.D. (Hort.) in Vegetable Science

I. Course Title : Recent Trends in Vegetable Production

II. Course Code : VSC 601

III. Credit Hours : (3+0)

IV. Theory

Present status and prospects of vegetable cultivation; nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching; Protected cultivation of vegetables, containerized culture for year round vegetable production; low cost polyhouse; nethouse production; crop modelling, organic gardening; vegetable production for pigments, export and processing of:

Unit I

Solanaceous crops: Tomato, brinjal, chilli, sweet pepper and potato.

Unit II

Cole crops: Cabbage, cauliflower and knol-khol, sprouting broccoli.

Unit III

Okra, onion, peas and beans, amaranth and drumstick.

Unit IV

Root crops and cucurbits: Carrot, beet root, turnip and radish and cucurbits

Unit V

Tuber crops: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.

V. Suggested Reading

Bose TK and Som NG. 1986. *Vegetable crops of India*. Naya prokash.

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya Udyog.

Brewster JL. 1994. *Onions and other vegetable alliums*. CABI.

Chadha KL and Kalloo G (Eds.). 1993-94. *Advances in horticulture* Vols. V-X. Malhotra Publ. House.

Chadha KL (Ed.). 2002. *Hand book of horticulture*. ICAR.

Chauhan DVS (Ed.). 1986. *Vegetable production in India*. Ram prasad and Sons.

Fageria MS, Choudhary BR and Dhaka RS. 2000. *Vegetable crops: production technology*. Vol. II. Kalyani.

FFTC. *Improved vegetable production in Asia*. Book Series No. 36.

Ghosh SP, Ramanujam T, Jos JS, Moorthy SN and Nair RG. 1988. *Tuber crops*. Oxford and IBH.

Gopalakrishanan TR. 2007. *Vegetable crops*. New India Publ. Agency.

Hazra P and Som MG. 2015. *Seed production and hybrid technology of vegetable crops*. Kalyani publishers, Ludhiana.

Hazra P. 2016. *Vegetable science*. 2nd edn, Kalyani publishers, Ludhiana.

Hazra P. 2019. *Vegetable production and technology*. New India publishing agency, New Delhi.

Kallo G and Singh K. (Ed.). 2001. *Emerging scenario in vegetable research and development*. Research periodicals and Book Publ. House.

Kurup GT, Palanisami MS, Potty VP, Padmaja G, Kabeerathuma S and Pallai SV. 1996. *Tropical tuber crops, problems, prospects and future strategies*. Oxford and IBH.

Rana MK. 2008. *Olericulture in India*. Kalyani Publishers, New Delhi.

Rana MK. 2008. *Scientific cultivation of vegetables*. Kalyani Publishers, New Delhi.

Rubatzky VE and Yamaguchi M. (Eds.). 1997. *World vegetables: principles, production and nutritive values*. Chapman and Hall.

Saini GS. 2001. *A Text Book of oleri and flori culture*. Aman Publishing House.

Salunkhe DK and Kadam SS. (Ed.). 1998. *Hand book of vegetable science and technology: production, composition, storage and processing*. Marcel Dekker.

Shanmugavelu KG. 1989. *Production technology of vegetable crops*. Oxford and IBH.

Sin MT and Onwueme IC. 1978. *The tropical tuber crops*. John Wiley and Sons.

Singh DK. 2007. *Modern vegetable varieties and production technology*. International book distributing Co.

Singh NP, Bhardwaj AK, Kumar A and Singh KM. 2004. *Modern technology on Vegetable production*. International book distr. Co.

Singh PK, Dasgupta SK and Tripathi SK. 2006. *Hybrid vegetable development*. International book distr. Co.

Singh SP. (Ed.). 1989. *Production technology of vegetable crops*. Agril. Comm. Res. Centre.

Thamburaj S and Singh N. (Eds.). 2004. *Vegetables, tuber crops and spices*. ICAR.

Thompson HC and Kelly WC. (Eds.). 1978. *Vegetable crops*. Tata McGraw-Hill.

I. Course Title : Advances in Breeding of Vegetable Crops

II. Course Code : VSC 602

III. Credit Hours : (3 +0)

III. Theory

Evolution, distribution, cytogenetics, Genetics and genetic resources, wild relatives, genetic divergence, hybridization, inheritance of qualitative and quantitative traits, heterosis breeding, plant idotype concept and selection indices, breeding mechanisms, pre breeding, mutation breeding, ploidy breeding, breeding for biotic and abiotic stresses, breeding techniques for improving quality and processing characters, bio-fortification, *in-vitro* breeding, marker assisted breeding, haploidy, development of transgenic.

Unit I

Solanaceous crops—Tomato, Brinjal, Hot Peeper, Sweet Pepper, Okra and Potato

Unit II

Cucurbits and Cole crops

Unit III

Legumes and leafy vegetables—Peas and Beans, Amaranth, Palak, Chenopods and Lettuce.

Unit IV

Root crops and onion—Carrot, Beetroot, Radish, Turnip, Onion

Unit V

Tuber crops—Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea

IV. Suggested Reading

Allard RW. 1999. *Principle of plant breeding*. John Willey and Sons, USA.

Basset MJ. (Ed.). 1986. Breeding vegetable crops. AVI Publ.

Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. *Plant genetic resources: horticultural crops*. Narosa Publ. House.

Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable crops: Breeding and seed production*. Vol. I. Kalyani.

Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.

Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.

Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. *Plant Breeding-principles and prospects*. Chapman and Hall.

Hazra P and Som MG. 2015. *Vegetable science* (Second revised edition), Kalyani publishers, Ludhiana, 598 p

Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani Publishers, Ludhiana, 459 p

Kalloo G. 1988. *Vegetable breeding* (Vol. I, II, III). CRC Press, Fl, USA.

Kalloo G. 1998. *Vegetable breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.

Kumar JC and Dhaliwal MS. 1990. *Techniques of developing hybrids in vegetable crops*. Agro Botanical Publ.

Paroda RS and Kalloo G. (Eds.). 1995. *Vegetable research with special reference to hybrid technology in Asia-Pacific Region*. FAO.

Peter KV and Pradeepkumar T. 2008. *Genetics and breeding of vegetables*. Revised, ICAR.

Peter KV and Hazra P. (Eds). 2012. *Hand book of vegetables*. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.

Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p.

Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume III.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p.

Rai N and Rai M. 2006. *Heterosis breeding in vegetable crops*. New India Publ. Agency.

Ram HH. 1998. *Vegetable breeding: principles and practices*. Kalyani Publishers, New Delhi.
Simmonds NW. 1978. *Principles of crop improvement*. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publishers, New Delhi.
Singh BD. 1983. *Plant breeding*. Kalyani Publishers, New Delhi.
Singh PK, Dasgupta SK and Tripathi SK. 2004. *Hybrid vegetable development*. International Book Distributing Co.
Swarup V. 1976. *Breeding procedure for cross-pollinated vegetable crops*. ICAR.

I. Course Title : Abiotic Stress Management in Vegetable Crops

II. Course Code : VSC 603

III. Credit Hours : (2+1)

IV. Theory

Unit I

Environmental stress—its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.

Unit II

Mechanism and measurements—tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

Unit III

Soil-plant-water relations—under different stress conditions in vegetable crops production and their management practices.

Unit IV

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

Unit V

Use of chemicals—techniques of vegetable growing under high and low temperature conditions, use of chemicals and antitranspirants in alleviation of different stresses.

V. Practical

- Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops;
- Measurement of tolerance to various stresses in vegetable crops;
- Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions;
- Use of chemicals for alleviation of different stresses.

VI. Suggested Reading

Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. *Plant genetic resources: horticultural crops*. Narosa Publ. House.

Dwivedi P and Dwivedi RS. 2005. *Physiology of abiotic stress in plants*. Agrobios.

Janick JJ. 1986. *Horticultural science.* 4th Ed. WH Freeman and Co.

Kaloo G and Singh K. 2001. *Emerging scenario in vegetable research and development*. Research periodicals and book publ. house.

Kaloo G. 1994.*Vegetable breeding*. Vols. I-III. Vedams eBooks.

Lerner HR. (Eds.). 1999. *Plant responses to environmental stresses*. Marcel Decker.

Maloo SR. 2003. *Abiotic stresses and crop productivity*.Agrotech Publ. Academy.

Narendra T. *et al.* 2012. *Improving crops resistance to abiotic stress*. Wiley and Sons.US.

Peter KV and Pradeep Kumar T. 2008. *Genetics and breeding of vegetables*. (Revised Ed.). ICAR.

Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p.

Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p.

Ram HH. 2001. *Vegetable breeding*. Kalyani.

Rao NK. (Eds.). 2016. *Abiotic stress physiology of horticultural crops*. Springer publication.

I. Course Title: Seed Certification, Processing and Storage of Vegetable Seeds

II. Course Code : VSC 604

III. Credit Hours : (2+1)

IV.Theory

Unit I

Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian Minimum seed Certification standards, Planning and management of seed certification programmes.

Unit II

Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification Schemes.

Unit III

Principles of seed processing, Methods of seed drying and cleaning, seed processing plant- Layout and design, seed treatment, seed quality enhancement, packagingand marketing.

Unit IV

Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open, bulk, controlled, germplasm, cryopreservation), factors affecting seed longevity in storage (Pre and post harvest factors).

Unit V

Seed aging and deterioration, maintenance of seed viability and vigor during storage,storage methods, storage structures, transportation and marketing of seeds.

V. Practical

- General procedures of seed certification;
- Field inspection and standards;
- Isolation and rouging;
- Inspection and sampling at harvesting, threshing and processing;
- Testing physical purity, germination and moisture, grow-out test;
- Visit to regulatory seed testing and plant quarantine laboratories;
- Seed processing plants and commercial seed stores.

VI. Suggested Reading

Agarwaal PK and Anuradha V. 2018. *Fundamentals of seed science and technology*. Brilliant publications, New Delhi.

Basra AS. 2000. *Hybrid seed production in vegetables*. CRC press, Florida, USA.

Bench ALR and Sanchez RA. 2004. *Handbook of seed physiology*. Food products press, NY/ London.

Chakraborty SK, Prakash S, Sharma SP and Dadlani M. 2002. *Testing of distinctiveness,uniformity and stability for plant variety protection*. IARI, New Delhi

Copland LO and McDonald MB. 2004. *Seed science and technology*, Kluwer academic press. Fageria MS, Arya PS and Choudhry AK. 2000. *Vegetable crops: breeding and seed production*

Vol 1. Kalyani publishers, New Delhi.

George RAT. 1999. *Vegetable seed production* (2nd Edition). CAB International.

Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani publishers, Ludhiana, 459p

Kalloo G, Jain SK, Vari AK and Srivastava U. 2006. *Seed: A global perspective*. Associated publishing company, New Delhi.

Singhal NC. 2003. *Hybrid seed production*. Kalyani publishers, New Delhi.

I. Course Title : Breeding for Special Traits in Vegetable Crops

II. Course Code : VSC 605

III. Credit Hours : (2+0)

VI. Theory

Important nutrient constituents in vegetables and their role in human diet. Genetics of nutrients. Genetic and genomic resources for improving quality traits in vegetables, breeding strategies for developing varieties with improved nutrition for market and industrial purposes. Molecular and biotechnological approaches in breeding suitable cultivars of different crops for micronutrients and color content.

Unit I

Brassica group, carrot and beetroot.

Unit II

Tomato, brinjal, peppers and potato.

Unit III

Green leafy vegetables, Legume crops and okra.

Unit IV

Cucurbitaceous vegetable crops and edible Alliums.

Unit V

Biofortification in vegetable crops, genetic engineering for improvement of quality traits in vegetable crops, bioavailability of dietary nutrients from improved vegetable crops and impact on micronutrient malnutrition, achievements and future prospectsin breeding for quality traits in vegetables.

VII. Suggested Reading

Allard RW. 1999. *Principles of plant breeding*.
John Wiley and Sons. Basset MJ. (Ed.). 1986.
Breeding vegetable crops. AVI Publ.
Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. *Plant genetic resources: horticultural crops*. Narosa Publ. House.
Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable crops: Breeding and seed production*.
Vol. I. Kalyani.
Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.
Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.
Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. *Plant Breeding-principles and prospects*. Chapman and Hall.
Hazra P and Som MG. 2015. *Vegetable science* (Second revised edition), Kalyani publishers, Ludhiana, 598p. Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani Publishers, Ludhiana, 459p
Kalloo G. 1988. *Vegetable breeding*. Vols. I-III. CRC Press.
Kalloo G. 1998. *Vegetable breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency. Kumar JC and Dhaliwal MS. 1990. *Techniques of developing hybrids in vegetable crops*. Agro
Botanical Publ.
Paroda RS and Kalloo G. (Eds.). 1995. *Vegetable research with special reference to hybridtechnology in Asia-Pacific Region*. FAO.
Peter KV and Pradeepkumar T. 2008. *Genetics and breeding of vegetables*. Revised, ICAR. Peter KV and Hazra P. (Eds). 2012. *Hand book of vegetables*. Studium press LLC, P.O. Box
722200, Houston, Texas 77072, USA, 678p
Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume II.Studium Press LLC,
P.O. Box 722200, Houston, Texas 77072, USA, 509p.

Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume III.Studium Press LLC,
P.O. Box 722200, Houston, Texas 77072, USA, 634p.
Rai N and Rai M. 2006. *Heterosis breeding in vegetable crops*. New India Publ. Agency.
Ram HH. 1998. *Vegetable breeding: principles and practices*. Kalyani Publishers, New Delhi. Rout GR and Peter KV. 2008. *Genetic engineering of horticultural crops*. Academic press, Elsevier,
USA
Simmonds NW. 1978. *Principles of crop improvement*. Longman. Singh BD. 1983. Plant Breeding.
Kalyani Publishers, New Delhi.
Singh PK, Dasgupta SK and Tripathi SK. 2004. *Hybrid vegetable development*. InternationalBook Distributing Co.
Swarup V. 1976. *Breeding procedure for cross-pollinated vegetable crops*. ICAR.

I. Course Title : Biodiversity and Conservation of Vegetable Crops

II. Course Code : VSC 606

III. Credit Hours : (2+1)

IV. Theory

Unit I

General aspects: issues, goals and current status: Biodiversity and conservation; issues and goals- needs and challenges; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/ database of fruit crops in India

Unit II

Germplasm conservation: collection, maintenance and characterization: Exploration and collection of germplasm; sampling frequencies; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- insitu and ex situ strategies, on farm conservation; problem of recalcitrance- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

Unit III

Regulatory horticulture: Germplasm exchange, quarantine and intellectual property rights germplasm exchange, quarantine and intellectual property rights regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPVandFR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits ofGI protection; GI tagged fruit varieties in India.

V. Practical

- Documentation of germplasm- maintenance of passport data and other records ofaccessions;
- Field exploration trips and sampling procedures;
- Exercise on *ex situ* conservation – cold storage, pollen/ seed storage
- Cryopreservation;
- Visits to national gene bank and other centers of PGR activities;
- Detection of genetic constitution of germplasm;
- Germplasm characterization using a standardised DUS test protocol;
- Special tests with biochemical and molecular markers.

VI. Suggested Reading

Dhillon BS, Tyagi RK, Lal A and Saxena S. 2004. *Plant genetic resource management. – horticultural crops*. Narosa publishing house, New Delhi.

Engles JM, Ramanath RV, Brown AHD and Jackson MT. 2002. *Managing plant genetic resources*,CABI, Wallingford, UK.

Frankel OH and Hawkes JG. 1975. *Crop genetic resources for today and tomorrow*. Cambridge University Press, USA.

Hancock J. 2012. *Plant evolution and the origin of crops species*. CAB International.

Jackson M, Ford-Lloyd B and Parry M. 2014, *Plant genetic resources and climate change*. CABI,Wallingford, UK

Moore JN and Ballington JR. 1991. *Genetic resources of temperate Fruit and nut crops*. ISHS,Belgium.

Peter KV. 2008. *Biodiversity of horticultural crops*. Vol. II. Daya Publ. House, Delhi. Peter KV. 2011. *Biodiversity in horticultural*

crops. Vol.III. Daya Publ. House, Delhi.
Rajasekharan PE, Rao V and Ramanatha V. 2019. *Conservation and utilization of horticultural genetic resources*. Springer.
Rana JC and Verma VD. 2011. *Genetic resources of temperate minor fruits (indigenous andexotic*).
NBPGR, New Delhi.
Sthapit *et al.* 2016. *Tropical fruit tree diversity (good practices for in situ and ex situ conservation*).
Bioversity international. routledge, Taylor and Francis Group.
Virchow D. 2012. *Conservation of genetic resources*, Springer Verlag, Berlin

I. Course Title : Biotechnological Approaches in Vegetable Crops

II. Course Code : VSC 607

III. Credit Hours : (2+1)

IV. Theory

Unit I

Importance and scope of biotechnology – in vegetable crop improvement. *In-vitro* culture, micropropagation, anther culture, pollen culture, ovule culture, embryo culture, endosperm culture.

Unit II

Somatic embryogenesis – somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion. Somatic hybrids and cybrids and their application in vegetable improvement programme.

Unit III

Blotting techniques, DNA finger printing – Molecular markers/ DNA based markers and role. RFLP, AFLP, RAPD, SSR, SNPs, DNA probes. QTL mapping. MAS and its application in vegetable crop improvement. Allele mining by TILLING and Eco-TILLING.

Unit IV

Plant genetic engineering – Scope and importance, Concepts of cisgenesis, intragenesis and transgenesis. Gene cloning, direct and indirect methods of gene transfer. Role of RNAi based gene silencing in vegetable crop improvement. Bio- safety issue, regulatory issues for commercial approval.

Unit V

Concepts and methods of next generation sequencing (NGS)-Genome sequencing, transcriptomics, proteomics, metabolomics. Genome editing (ZFN, TALENS and CRISPER)

Crops

Solanaceous crops, cole crops, cucurbitaceous crops, root vegetables, garden pea,onion, potato and leafy vegetables

V. Practical

- Micropropagation, Pollen- Ovule and Embryo culture-Synthetic seed production(2);
- *In-vitro* mutation induction, *in-vitro* rooting – hardening at primary and secondary nurseries (3);
- DNA isolation from economic vegetable crop varieties – Quantification and amplification (2);
- DNA and Protein profiling – molecular markers, PCR Handling (2);
- Vectors for cloning and particle bombardment (3);
- DNA fingerprinting of flower crop varieties (3);
- Project preparation for establishment of low, medium and high cost tissue culturelaboratories (1).

VI. Suggested Reading

Bajaj YPS. (Ed.). 1987. *Biotechnology in agriculture and forestry*. Vol. XIX. Hitech and Micropropagation. Springer.

Chadha KL, Ravindran PN and Sahijram L. (Eds.). 2000. *Biotechnology of horticulture andplantation crops*. Malhotra Publ. House.

Debnath M. 2005. *Tools and techniques of biotechnology*. Pointer publication, New Delhi.

Glover MD. 1984. *Gene cloning: the mechanics of DNA manipulation*. Chapman and Hall

Gorden H and Rubsell S. 1960. *Hormones and cell culture*. AB Book Publ.

Keshavachandran R. 2007. *Recent trends in biotechnology of horticultural crops*. New IndiaPubl. Agency.

Keshavachandran R and Peter KV. 2008. *Plant biotechnology; tissue culture and gene transfer*. Orient and Longman, USA.

Keshavachandran R. 2007. *Recent trends in biotechnology of horticultural crops*. New-IndiaPublication Agency, New Delhi.

Panopoulas NJ. (Ed.). 1981. *Genetic engineering in plant sciences*. Praeger Publ.

Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK and Mohanadas S. 2001. *Biotechnologyof horticultural crops*. Vols. I-III. Naya Prokash.

Pierik RLM. 1987. *In-vitro culture of higher plants*. Martinus Nijhoff Publ.

Prasad S. 1999. *Impact of plant biotechnology on horticulture*. 2nd Ed. Agro Botanica.

Rout GR and Peter KV. 2018. *Genetic engineering of horticultural crops*. Academic Press Elsveer, USA.

Sharma R. 2000. *Plant tissue culture*. Campus Books.

Singh BD. 2010. *Biotechnology- expanding horizons*. Kalyani Publishers, New Delhi.

Skoog Y and Miller CO. 1957. *Chemical regulation of growth and formation in plant tissue cultured in-vitro*. Attidel. II Symp. On biotechnology action of growth substance.

Vasil TK, Vasi M, While DNR and Bery HR. 1979. *Somatic hybridization and geneticmanipulation in plants, plant regulation and world agriculture*. Planum Press.

I. Course Title : Advanced Laboratory Techniques for Vegetable Crops

II. Course Code : VSC 608

III. Credit Hours : (1+2)

IV. Theory

Unit I

Safety measures and laboratory maintenance – Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.

Unit II

Destructive and non-destructive analysis methods – Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops.

Unit III

Chromatographic and microscopic analysis- basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in horticultural produce.

Unit IV

Sensory analysis – Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.

V. Practical

- Determination of moisture, relative water content and physiological loss in weight;
- Determination of biochemical components in horticultural produce;
- Calibration and standardization of instruments;
- Textural properties of harvested produce;
- Determination of starch index (SI);
- Specific gravity for determination of maturity assessment, and pH of produce;
- Detection of adulterations in fresh as well as processed products;
- Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids,sugars and starch;
- Estimation of rate of ethylene evolution using gas chromatograph (GC);
- Use of advanced microscopes (fluorescent, scanning electron microscope, phasecontrast, etc.).

VI. Suggested Reading

AOAC International. 2003. *Official methods of analysis of AOAC international.* 17th Ed. Gaithersburg, MD, USA, association of analytical communities, USA.

Clifton M and Pomeranz Y. 1988. *Food analysis – laboratory experiments.* AVI publication, USA.

Linskens HF and Jackson JF. 1995. *Fruit analysis.* Springer.

Leo ML. 2004. *Handbook of food analysis*, 2nd Ed. Vols. I-III, USA.

Pomrenz Y and Meloan CE. 1996. *Food analysis – theory and practice*. CBS, USA.

Ranganna S. 2001. *Handbook of analysis and quality control for fruit and vegetable products.* 2nd Ed. Tata-McGraw-Hill, New Delhi.

Thompson AK. 1995, *Postharvest technology of fruits and vegetables.* Blackwell

sciences. USA.

Selected Journals

Sr. No.	Name of the Journal	IS
SN No.	*American Journal of Horticultural Sciences*	00
03-1062		
1.	*American Potato Growers*	
2.	*American Scientst*	1545-2786
3.	*Annals of Agricultural Research*	9703179
4.	*Annual Review of Plant Physiology*	0066-4294
5.	*California Agriculture*	1097-0967
6.	*Haryana Journal of Horticultural Sciences*	0970-2873
7.	*HAU Journal of Research*	0379-4008
8.	*Horticulture Research*	2052-7276
9.	*HortScience*	2327-9834
10.	*IIVR Bulletins*	1462-0316
11.	*Indian Horticulture*	0019-4875
12.	*Indian Journal of Agricultural Sciences*	0019-5022
13.	*Indian Journal of Horticulture*	0974-0112
14.	*Indian Journal of Plant Physiology*	2662-2548
15.	*Journal of American Society for Horticutural Sciences*	0003-1062
16.	*Journal of Arecanut and Spice Crops*	
17.	*Journal of Food Science and Technology*	0975-8402
18.	*Journal of Plant Physiology*	0176-1617
19.	*Journal of Biology and Technology*	0925-5214
20.	*Postharvest Biology and Technology*	0925-5214
21.	*Scientia Horticulturae*	0304-4238
22.	*Seed Research*	2151-6146
23.	*Seed Science*	23171537
24.	*South Indian Horticulture*	0038-3473
25.	*Vegetable Grower*	2330-2321
26.	*Vegetable Science*	2455-7552

VOL. 2

Azadi Ka Amrit Mahotsav

Agriculture and Allied Sciences

Restructured and Revised Syllabi of Post-graduate Programmes

- Physical Sciences
- Biotechnology & Bioinformatics
- Social Sciences
- Statistical Sciences
- Basic Sciences

भाकृअनुप
ICAR

Education Division
Indian Council of Agricultural Research
New Delhi

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त्रिलोचन महापात्र, पीएच.डी.
एफ एन ए, एफ एन ए एस सी, एफ एन ए ए एस
सचिव एवं महानिदेशक

TRILOCHAN MOHAPATRA, Ph.D.
FNA, FNASc, FNAAS
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
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Foreword

THE ICAR has been continuously striving to bring necessary reforms for quality assurance in agricultural education. The Council has appointed National Core Group and BSMA Committees for revision and restructuring of Post-graduate and Doctoral syllabi in consultation with all the stakeholders to meet the challenges and harness opportunities in various disciplines of agriculture and allied sciences. It has been observed that a paradigm shift is necessary in academic regulations to comply with various provisions of National Education Policy-2020. It is heartening to note that the respective Committees have taken due care by following flexible, multi-disciplinary and holistic approach while developing the syllabus and academic regulations. The students are given opportunities to select the courses to support their planned research activities, to register for online courses and to pursue internship for development of entrepreneurship during Masters' programme. Further, the Teaching Assistantship has been introduced to provide experience to the Ph.D. scholars on teaching, evaluation and other related academic matters. This is an important part of doctoral training all over the world and it is expected to address the shortage of faculty in many institutions/universities. By intensive discussion with the subject experts and based on the feedback from the faculty and students, the syllabus of Masters' and Doctoral programmes in 79 disciplines was restructured and new courses were introduced. The syllabus has been revised suitably with the view to equip the students to gain knowledge, enhance their employability and skill sets to mould towards entrepreneurship and build themselves to prepare for global competitiveness. The opinions and suggestions invited from the concerned institutions, eminent scientists and other stakeholders were also reviewed by the Committees.

The Council sincerely thanks Dr Arvind Kumar, Chairman of the National Core Group and its members for the guidance to develop the syllabus in line with contemporary and projected national and global agricultural trends. The Council acknowledges the dedicated efforts and contribution of all the Chairpersons and members of 19 BSMA Committees for preparation of the syllabus. It gives me immense pleasure to express profuse thanks to the Agricultural Education Division for accomplishing this mammoth task under the guidance of Dr N.S. Rathore, former DDG and Dr R.C. Agrawal, DDG. I compliment Dr G. Venkateshwarlu, former ADG (EQR) for his sincere efforts and overall coordination of the meetings. Special thanks to DKMA for bringing out the entire syllabus in six volumes.

(T. Mohapatra)

Date: 13th August 2021
Place: New Delhi-110 001

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12. Definitions of academic terms

1. Academic Year and Registration

- An academic year shall be normally from July to June of the following calendar year otherwise required under special situations. It shall be divided into two academic terms known as semesters. Dates of registration, commencement of instructions, semester end examination, end of semester and academic year, etc. The Academic Calendar shall be developed by the concerned University from time to time and notified accordingly by the Registrar in advance.
- An orientation programme shall be organized by the Director (Education)/ Dean PGS for the benefit of the newly admitted students immediately after commencement of the semester.
- On successful completion of a semester, the continuing students shall register for subsequent semester on the date specified in the Academic/ Semester Calendar or specifically notified separately. Every enrolled student shall be required to register at the beginning of each semester till the completion of his/ her degree programmes.

2. Credit requirements

Framework of the courses

The following nomenclature and Credit Hrs need to be followed while providing the Syllabus for all the disciplines:-

	Masters' Programme	Doctoral Programme
(i) Course work		
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	–
Seminar	01	02
(ii) Thesis Research	30	75
Total	70	100

Major courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken may be given *mark

Minor courses: From the subjects closely related to a student's major subject

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overallcompetence.

Common Courses: The following courses (one credit each) will be offered to all students undergoing Master's degree programme:

1. Library and Information Services
2. Technical Writing and Communications Skills
3. Intellectual Property and its management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approval of the Head of Department (HoD)/ Board of Studies (BoS).

Supporting Courses

The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. If required, the contents may be modified to suit the individual discipline with approval of the concerned BoS:

Code	Course Title	Credit Hours
STAT 501	Mathematics for Applied Sciences	2+0
STAT 502	Statistical Methods for Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 512	Basic Sampling Techniques	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1

Course Code	Course Title	Credit Hours
MCA 501	Computers Fundamentals and Programming	2+1
MCA 502	Computer Organization and Architecture	2+0
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques in Biochemistry	2+2

Syllabus of Common Courses for PG programmes

LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

To equip the students/ scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
- Writing of abstracts, summaries, précis, citations, etc.;
- Commonly used abbreviations in the theses and research communications;
- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading;
- Writing of a review article;

- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- Accentual pattern: Weak forms in connected speech;
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

Suggested Readings

1. Barnes and Noble. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language.*
2. *Chicago Manual of Style*. 14th Ed. 1996. Prentice Hall of India.
3. *Collins' Cobuild English Dictionary*. 1995.
4. Harper Collins. Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed.
5. Holt, Rinehart and Winston. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English.* 6th Ed. Oxford University Press.
6. James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
7. Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
8. Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
9. Richard WS. 1969. *Technical Writing.*
10. Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
11. Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

1. Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
2. Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

3. *Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC and Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
6. Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralisation of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taXonomy.

Suggested Readings

1. Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
2. Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I History of agriculture in brief; Global agricultural research system: need,

scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS and Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.
2. Punia MS. *Manual on International Research and Research Ethics*. CCS Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.
4. Singh K. 1998. *Rural Development - Principles, Policies and Management*. Sage Publ.

Mandatory requirement of seminars

- It has been agreed to have mandatory seminars one in Masters (One Credit) and two in Doctoral programmes (two Credits).
- The students should be encouraged to make presentations on the latestdevelopments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills.

3. Residential requirements

- The minimum and maximum duration of residential requirement for Masters'

P.G. Degree Programmes	Duration of Residential Requirement	
	Minimum	Maximum
Masters' Degree	2 Academic Years (4 Semesters)	5 Academic Years (10 Semesters)
Ph.D.*	3 Academic Years (6 Semesters)	7 Academic Years (14 Semesters)

*Student may be allowed to discontinue temporarily only after completion of course work

In case a student fails to complete the degree programme within the maximum duration of residential requirement, his/ her admission shall stand cancelled. The requirement shall be treated as satisfactory in the cases in which a student submits his/ her thesis any time during the 4th and 6th semester of his/ her residentship

at the University for Masters' and Ph.D. programme, respectively.

4. Evaluation of course work and comprehensive examination

- For M.Sc., multiple levels of evaluation (First Test, Midterm and Final semester) is desirable. However, it has been felt that the comprehensive examination is redundant for M.Sc. students.
- For Ph.D., the approach should be research oriented rather than exam oriented. In order to provide the student adequate time to concentrate on the research work and complete the degree in stipulated time, the examination may have to be only semester final. However, the course teacher may be given freedom to evaluate in terms of assignment/ seminar/ first test.
- For Ph.D., the comprehensive examination (Pre-qualifying examination) is required. As the students are already tested in course examinations, the comprehensive examinationshould be based onoral examinationby an external expert and the evaluation should cover both the research problem and theoretical background to execute the project. This shall assess the aptitude of the student and suitability of the student for the given research topic. The successful completion of comprehensive examination is to obtain the "Satisfactory" remark by the external expert.

5. Advisory System

Advisory Committee

- There shall be an Advisory Committee for every student consisting of not fewer than three members in the case of a candidate for Masters' degree and four in the case of Ph.D. degree with the Advisor as Chairperson. The Advisory Committee should have representatives from the major and minor fields amongst the members of the Post-graduate faculty accredited for appropriate P.G. level research. However, in those departments where qualified staff exists but due to unavoidable reasons Post-graduate degree programmes are not existing, the staff having Post-graduate teaching experience of two years or more may be included in the Advisory Committee as member representing the minor.
- At any given time, a P.G. teacher shall not be a Chairperson, Advisory Committee (including Master's and Ph.D. programmes) for more than five students.
- The Advisor should convene a meeting of the Advisory Committee at least once in a Semester. The summary record should be communicated to the Head of Department, Dean of the College of concerned, Director (Education)/ Dean PGS and Registrar for information.

Advisor/ Co-guide/ Member, Advisory Committee from other collaborating University/ Institute/ Organization

- In order to promote quality Post-graduate research and training in cutting edge areas, the University may enter into Memorandum of Understanding (MOU) with other Universities/ Institutions for conducting research. While constituting an Advisory Committee of a student, if the Chairperson, Advisory Committee feels the requirement of involving of a faculty member/ scientist of such partnering university/ Institute/ Organization, he/ she may send a proposal to this effect to Director (Education)/ Dean PGS along with the proposal for consideration of Student's Advisory Committee (SAC).
- The proposed faculty member from the partnering institution can be allowed to act as Chairperson/ Co-guide/ Member, SAC, by mutual consent, primarily on the basis of intellectual input and time devoted for carrying out the research work at the particular institution. The faculty member/ scientist of partnering institutions in the SAC shall become a temporary faculty member of the University by following the procedure approved by the Academic Council.

Allotment of students to the retiring persons

Normally, retiring person may not be allotted M. Sc. Student if he/ she is left with less than 2 years of service and Ph.D. student if left with less than 3 years of service. However, in special circumstances, permission may be obtained from the Director (Education)/ Dean PGS, after due recommendation by the concerned Head of the Department.

Changes in the Advisory Committee:

(i) Change of the Chairperson or any member of the Advisory Committee is not ordinarily permissible. However, in exceptional cases, the change may be effected with due approval of the Director of Education/ Dean PGS.

(ii) Normally, staff members of the university on extra ordinary leave or on study leave or who leave the University service will cease to continue to serve as advisors of the Post-graduate students of the University. However, the Director (Education)/ Dean PGS may permit them to continue to serve as advisor subject to the following conditions:

  (a) The concerned staff member must be resident in India and if he/ she agrees to guide research and must be available for occasional consultations;

  (b) An application is made by the student concerned duly supported by the Advisory Committee;

  (c) In case of a Ph.D. student, he/ she must have completed his/ her comprehensive examinations and the research work must be well in progress and it is expected that the student will submit the thesis within a year;

  (d) The Head of the Department and the Dean of the College concerned agree to the proposal;

  (e) The staff member, after leaving the University service is granted the status of honorary faculty's membership by the Vice-Chancellor on the recommendation of the Director (Education)/ Dean PGS for guiding as Chairperson or Member, Advisory Committee the thesis/ theses of the student(s) concerned only.

(iii) In case the Chairperson/ member of a Student's Advisory Committee retires, he/ she shall be allowed to continue provided that the student has completed his course work and minimum of 10 research credits and the retiring Chairperson/ member stays at the Headquarters of the College, till the thesis is submitted.

(iv) If the Chairperson/ member proceeds on deputation to another organization, he/ she may be permitted to guide the student provided his/ her new organization is at the Headquarters of the College and his/ her organization is willing for the same.

(v) The change shall be communicated to all concerned by the Head of Department.

6. Evaluation of research work

- It is highly desirablefor Ph.D. programme and this should be done annually as an essential part of research evaluation. The Student Advisory Committee shallreview the progress of research and scrutinize annual progress reports submitted by the student.
- Midterm evaluation of Ph.D. (to move from JRF to SRF) is a mandatory requirement for all the funding agencies. Hence, the second review of annual progress report need to be done after completion of two years. The successful completion enables the students to become eligible for SRF.

Prevention of plagiarism

- An institutional mechanism should be in place to check the plagiarism. The students must be made aware that manipulation of the data/ plagiarism is punishable with serious consequences.

7. Learning through online courses

- In line with the suggestion in new education policy and the initiatives taken by ICAR and MHRD in the form of e-courses, MOOCs, SWAYAM, etc. and also changes taking place globally in respect of learning through online resources it has been agreed to permit the students to enrol for online courses. It is expected that the provision of integrating available online courses with the traditional system of education would provide the students opportunities to improve their employability by imbibing the additional skills and competitive edge.

The Committee recommends the following points while integrating the online courses:

1. Board of Studies (BoS) of each Faculty shall identify available online courses and a student may select from the listed courses. The interested students may provide the details of the on-line courses to the BoS for its consideration.
2. A Postgraduate student may take up to a maximum of 20% credits in a semester through online learning resources.
3. The host institute offering the course does the evaluation and provide marks/ grades. The BoS shall develop the conversion formula for calculation of GPA and it may do appropriate checks on delivery methods and do additional evaluations, if needed.

8. Internship during Masters programme

Internship for Development of Entrepreneurship in Agriculture (IDEA)

Currently, a provision of 30 credits for dissertation work in M.Sc./ M.Tech/ M.F.Sc./ M.V.Sc. programmes helps practically only those students who aspire to pursue their career in academic/ research. There is hardly any opportunity/ provision under this system to enhance the entrepreneurship skills of those students who could start their own enterprise or have adequate skills to join the industry. Therefore, in order to overcome this gap, an optional internship/ in-plant training (called as IDEA) in lieu of thesis/ research work is recommended which will give the students an opportunity to have a real-time hands-on experience in the industry.

It is envisaged that the internship/ in-plant training would enhance the interactions between academic organizations and the relevant industry. It would not only enable the development of highly learned and skilled manpower to start their-own enterprises but also the industry would also be benefitted through this process. This pragmatic approach would definitely result in enhancedpartnerships between academia and industry.

The main objectives of the programme:

1. To promote the linkages between academia and industry
2. To establish newer University – Cooperative R&D together with industry for knowledge creation, research and commercialization
3. Collaboration between Universities and industries through pilot projects
4. To develop methods for knowledge transfer, innovation and networking potential
5. To enhance skill, career development and employability

Following criteria for IDEA will be taken into consideration:

- At any point of time there will not be more than 50% of students who can opt under IDEA
- Major Advisor will be from Academia and Co-advisor (or Advisory Committee member) from industry
- Total credits (30) will be divided into 20 for internship/ in-plant training and10 for writing the report followed by viva-voce similar to dissertation
- Work place will be industry; however, academic/ research support would be provided by the University or both. MoU may be developed accordingly
- The IPR, if any, would be as per the University policy

9. Teaching assistantship

- Teaching assistantship shall be encouraged. This will give the required experience to the students on how to conduct courses, practical classes, evaluation and other related academic matters. This is an important part of Ph.D. training all over the world and it is expected to address the shortage of faculty in many institutions/ universities.
- The fulltime doctoral students of the University with or without fellowship may be considered for award of Teaching Assistantships in their respective Departments. The Teaching Assistantship shall be offered only to those doctoral students who have successfully finished their course work. Any consideration for award of Teaching Assistantships must have the consent ofthe supervisor concerned.
- Teaching Assistantships shall be awarded on semester to semester basis on the recommendation of a screening/ selection committee to be constituted by the ViceChancellor. All classes and assignments given to the Teaching Assistants, including tutorials, practicals and evaluation work shall be under the supervision of a faculty member who would have otherwise handled the course/ assignment.
- Each Ph.D. student may be allowed to take a maximum of 16 classes in a month to UG/ Masters students.
- No additional remuneration shall be paid to the students who are awarded ICAR JRF/ SRF. The amount of fellowship to be paid as remuneration to other students (who are receiving any other fellowship or without any fellowships) may be decided by the concerned universities as per the rules in force.However, the total amount of remuneration/ and fellowship shall not exceed the amount being paid as JRF/ SRF of ICAR.
- At the end of each term, Teaching Assistants shall be given a certificate by the concerned Head of the Department, countersigned by the School Dean, specifying the nature and load of assignments completed.

10. Registration of project personnel (SRF/ RA) for Ph.D.

- A provision may be made to enable the project personnel (SRF/ RA) to register for Ph.D. However, this can be done only if they are selected based on some selection process such as walk-in-interview. The prior approval of PI of the project is mandatory to consider the application of project personnel (SRF/ RA) for Ph.D. admission
- The candidates need to submit the declaration stating that the project work shall not be compromised because of Ph.D. programme. Further, in order to justify the project work and Ph.D. programme, the number of course credits should not be more than 8 in a semester for the project personnel (SRF/ RA) who intend to register for Ph.D.

11. Compliance with the National Education Policy-2020

- While implementing the course structure and contents recommended by the BSMA Committees, the Higher Education Institutions (HEIs) are required to comply with the provisions of National Education Policy-2020, especially the following aspects:
- Given the 21st century requirements, quality higher education must aim to develop good, thoughtful, well-rounded, and creative individuals. It must enable an individual to study one or more specialized areas of interest at a deep level, and also develop character, ethical and Constitutional values, intellectual curiosity, scientific temper, creativity, spirit of service, and 21st century capabilities across a range of disciplines including sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects. A quality higher education must enable personal accomplishment and enlightenment, constructive public engagement, and productive contribution to the society. It must

prepare students for more meaningful and satisfying lives and work roles and enable economic independence (9.1.1. of NEP-2020).

- At the societal level, higher education must enable the development of an enlightened, socially conscious, knowledgeable, and skilled nation that can find and implement robust solutions to its own problems. Higher education must form the basis for knowledge creation and innovation thereby contributing to a growing national economy. The purpose of quality higher education is, therefore, more than the creation of greater opportunities for individual employment. It represents the key to more vibrant, socially engaged, cooperative communities and a happier, cohesive, cultured, productive, innovative, progressive, and prosperous nation (9.1.3. of NEP-2020).
- Flexibility in curriculum and novel and engaging course options will be on offer to students, in addition to rigorous specialization in a subject or subjects. This will be encouraged by increased faculty and institutional autonomy in setting curricula. Pedagogy will have an increased emphasis on communication, discussion, debate, research, and opportunities for cross-disciplinary and interdisciplinary thinking (11.6 of NEP-2020).
- As part of a holistic education, students at all HEIs will be provided with opportunities for internships with local industry, businesses, artists, crafts persons, etc., as well as research internships with faculty and researchers at their own or other HEIs/ research institutions, so that students may actively engage with the practical side of their learning and, as a by-product, further improve their employability (11.8 of NEP-2020).
- HEIs will focus on research and innovation by setting up start-up incubation centres; technology development centres; centres in frontier areas of research; greater industry-academic linkages; and interdisciplinary research including humanities and social sciences research (11.12. of NEP-2020).
- Effective learning requires a comprehensive approach that involves appropriate curriculum, engaging pedagogy, continuous formative assessment, and adequate student support. The curriculum must be interesting and relevant, and updated regularly to align with the latest knowledge requirements and to meet specified learning outcomes. High-quality pedagogy is then necessary to successfully impart the curricular material to students; pedagogical practices determine the learning experiences that are provided to students, thus directly influencing learning outcomes. The assessment methods must be scientific, designed to continuously improve learning and test the application of knowledge. Last but not least, the development of capacities that promote student wellness such as fitness, good health, psycho-social well-being, and sound ethical grounding are also critical for high-quality learning (12.1. of NEP-2020).

Definitions of Academic Terms

Chairperson means a teacher of the major discipline proposed by the Head of Department through the Dean of the College and duly approved by the Director of Education/ Dean Post Graduate Studies (or as per the procedure laid down in the concerned University regulations) to act as the Chairperson of the Advisory Committee and also to guide the student on academic issues.

Course means a unit of instruction in a discipline carrying a specific number and credits to be covered in a semester as laid down in detail in the syllabus of a degree programme.

Credit means the unit of work load per week for a particular course in theory and/ or practical. One credit of theory means one class of one clock hour duration and one credit practical means one class of minimum two clock hoursof laboratory work per week.

Credit load of a student refers to the total number of credits of all the courses he/ she registers during a particular semester.

Grade Point (GP) of a course is a measure of performance. It is obtained by dividing the per cent mark secured by a student in a particular course by 10, expressed and rounded off to second decimal place.

Credit Point (CP) refers to the Grade point multiplied by the number of credits of the course, expressed and rounded off to second decimal place.

Grade Point Average (GPA) means the total credit point earned by a student divided by total number of credits of all the courses registered in a semester, expressed and rounded off to second decimal place.

Cumulative Grade Point Average (CGPA) means the total credit points earned by a student divided by the total number of credits registered by the student until the end of a semester (all completed semesters), expressed and rounded off to second decimal place.

Overall Grade Point Average (OGPA) means the total credit points earned by a student in the entire degree programme divided by the total number of credits required for the P.G. degree, expressed and rounded off to second decimal place.

Restructured and Revised
Syllabi of Post-graduate Programmes
Vol. 2

Physical Sciences

– Agricultural Meteorology
– Agronomy
– Soil Science
– Agricultural Physics
– Organic Farming

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Vol. 2

Physical Sciences
– Agronomy

Course Title with Credit Load
M.Sc. in Agronomy

Course Code	Course Title	Credit Hours	Semester
Agron 501*	Modern Concepts in Crop Production	3+0	I
Agron 502*	Principles and practices of soil fertility and nutrient management	2+1	I
Agron 503*	Principles and Practices of Weed Management	2+1	I
Agron 504*	Principles and Practices of Water Management	2+1	I
Agron 505	Conservation Agriculture	1+1	II
Agron 506	Agronomy of major Cereals and Pulses	2+0 2+1	I
Agron507	Agronomy of oilseed, fibre and sugar crops	2+1	II
Agron 508	Agronomy of medicinal, aromatic & underutilized crops	2+1	II
Agron 509	Agronomy of fodder and forage crops	2+1	I
Agron 510	Agrostology and Agro- Forestry	2+1	II
Agron 511	Cropping System and Sustainable Agriculture	2+0	II
Agron 512	Dryland Farming and Watershed Management	2+1	II
Agron 513	Principles and practices of organic farming	2+1	II
Agron-550	Master's Seminar	1+0	
Agron -560	Master's research	-30	

*Indicates core course which is Compulsory course for M Sc.(Agri)

Course Contents
M.Sc. in Agronomy

I. Course Title : Modern Concepts in Crop Production

II. Course Code : Agron 501

III. Credit Hours : 3+0

IV. Theory

Unit I

Crop growth analysis in relation to environment; geo-ecological zones of India.

Unit II

Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

Unit III

Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.

Unit IV

Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition.

Unit V

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture.Modern crop production concepts: soil less cultivation, Aeroponic, Hydroponic, Robotic and terrace farming. use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture.

V. Suggested Reading

- Balasubramaniyan P and Palaniappan SP. 2001. *Principles and Practices of Agronomy*. Agrobios.
- Fageria NK. 1992. *Maximizing Crop Yields*. Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers*. 7th Ed. Prentice Hall.
- Paroda R.S. 2003. *Sustaining our Food Security*. Konark Publ.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani Publ.
- Sankaran S and Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ.
- Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.
- Alvin PT and kozlowski TT (ed.). 1976. *Ecophysiology of Tropical Crops*. Academia Pul., New York.
- Gardner PP, Pearce GR and Mitchell RL. 1985. *Physiology of Crop Plants*. Scientific Pub. Jodhpur.
- Lal R. 1989. *Conservation tillage for sustainable agriculture: Tropics versus Temperate Environments. Advances in Agronomy* 42: 85-197.
- Wilsie CP. 1961. *Crop Adaptation and Distribution*. Euresia Pub., New Delhi.

I. Course Title : Principal and Practices of Soil Fertility and Nutrient Management

II. Course Code : Agron 502

III. Credit Hours : 2+1

IV. Theory

Unit I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

Unit II

Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Unit III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Soil less cultivation.

Unit IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions.

Unit V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermincompost and residue wastes in crops.

V.Practical

- Determination of soil pH and soil EC
- Determination of soil organic C
- Determination of available N, P, K and S of soil
- Determination of total N, P, K and S of soil
- Determination of total N, P, K, S in plant
- Computation of optimum and economic yield

VII. Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils.* 13th Ed. Pearson Edu.
- Fageria NK, Baligar VC and Jones CA. 1991. *Growth and Mineral Nutrition of Field Crops.* Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers.* 7th Ed. Prentice Hall.
- Prasad R and Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture.* CRC Press.
- Yawalkar KS, Agrawal JP and Bokde S. 2000. *Manures and Fertilizers.* Agri-Horti Publ.

I. Course Title : Principles and Practices of Weed Management

II. Course Code : Agron 503

III. Credit Hours : 2+1

IV. Theory

Weed biology, and ecology and classification, crop-weed competition including allelopathy; principles and methods of weed control and classification management; weed indices, weed shift in different eco-systems

Unit II

Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

Unit III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides, rotation; weed control through use ofnano-herbicides and bio-herbicides, myco-herbicides bio-agents, and allelochemicals; movement of herbicides in soil and plant, Degradation of herbicides in soil and plants; herbicide resistance, residue, persistence and management; development of herbicide resistance in weeds and crops and their management, herbicide combinationand rotation.

Unit IV

Weed management in major crops and cropping systems; alien, invasive and parasitic weeds and their management; weed shifts in cropping systems; aquatic and perennial weed control; weed control in non-crop area.

Unit V

Integrated weed management; recent development in weed management- robotics, use of drones and aeroplanes, organic etc., cost: benefit analysis of weed management.

V. Practical

- Identification of important weeds of different crops, Preparation of a weed herbarium, Weed survey in crops and cropping systems, Crop-weed competition studies, Weed indices calculation and interpretation with data, Preparation of spray solutions of herbicides for high and low-volume sprayers, Use of various types of spray pumps and nozzles and calculation of swath width, Economics of weed control, Herbicide resistance analysis in plant and soil,
- Bioassay of herbicide resistance residues,
- Calculation of herbicidal herbicide requirement

VI. Suggested Reading

- Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. *Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry*. Springer.
- Chauhan B and Mahajan G. 2014. *Recent Advances in Weed Management*. Springer.
- Das TK. 2008. *Weed Science: Basics and Applications*, Jain Brothers (New Delhi).
- Fennimore, Steven A and Bell, Carl. 2014. *Principles of Weed Control*, 4th Ed, California Weed Sci. Soc.
- Gupta OP. 2007. *Weed Management*: *Principles and Practices*, 2nd Ed.
- Jugulan, Mithila (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC Press
- Monaco TJ, Weller SC and Ashton FM. 2014. *Weed Science Principles and Practices*, Wiley
- Powles SB and Shaner DL. 2001. Herbicide Resistance and World Grains, CRC Press.
- Walia US. 2006. *Weed Management*, Kalyani.
- Zimdahl RL. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub.*

I. Course Title : Principles and Practices of Water Management

II. Course Code : Agron 504

III. Credit Hours : 2+1

IV. Theory

Unit I

Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in of India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

Unit II

Field water cycle, water movement in soil and plants; transpiration; soil-water-plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and loses.

Unit III

Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses. Irrigation efficiency and water use efficiency.

Unit IV

Water management of crop and cropping system, Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement- estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

Unit V

Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

Unit VI

Quality of irrigation water and management of saline water for irrigation, water management in problem soils

Unit VII

Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

Unit VIII

Hydroponics,

Unit IX

Water management of crops under climate change scenario.

V. Practical

- Determination of Field capacity by field method
- Determination of Permanent Wilting Point by sunflower pot culture technique
- Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
- Determination of Hygroscopic Coefficient
- Determination of maximum water holding capacity of soil
- Measurement of matric potential using gauge and mercury type tensiometer
- Determination of soil-moisture characteristics curves
- Determination of saturated hydraulic conductivity by constant and falling head

method

- Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
- Measurement of soil water diffusivity
- Estimation of unsaturated hydraulic conductivity
- Estimation of upward flux of water using tensiometer and from depth ground water table
- Determination of irrigation requirement of crops (calculations)
- Determination of effective rainfall (calculations)
- Determination of ET of crops by soil moisture depletion method16. Determination of water requirements of crops
- Measurement of irrigation water by volume and velocity-area method
- Measurement of irrigation water by measuring devices and calculation of irrigation efficiency
- Determination of infiltration rate by double ring infiltrometer

VI. Suggested Reading

- Majumdar DK. 2014. *Irrigation Water Management: Principles and Practice*. PHL Learning private publishers
- Mukund Joshi. 2013. *A Text Book of Irrigation and Water Management Hardcover*, Kalyani publishers
- Lenka D. 1999. *Irrigation and Drainage*. Kalyani.
- Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.
- Paliwal KV. 1972. *Irrigation with Saline Water*. IARI Monograph, New Delhi.
- Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.
- Prihar SS and Sandhu BS. 1987. *Irrigation of Food Crops - Principles and Practices*. ICAR.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani.
- Singh Pratap and Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture*. Agrotech Publ.

I. Course Title : Conservation Agriculture

II. Course Code : Agron 505

III. Credit Hours : 1+1

IV. Theory

Unit I

Conventional and conservation agriculture systems, sustainability concerns, conservation agriculture: Historical background and present concept, global experiences, present status in India.

Unit II

Nutrient management in CA, water management, weed management, energy use, insect-pest and disease management, farm machinery, crop residue management, cover crop management.

Unit III

Climate change mitigation and CA, C-sequestration, soil health management, soil microbes and CA.

Unit IV

CA in agroforestry systems, rainfed / dryland regions

Unit V

Economic considerations in CA, adoption and constraints, CA: The future of agriculture

V. Practicals

- Study of long-term experiments on CA,
- Evaluation of soil health parameters,
- Estimation of C-sequestration,
- Machinery calibration for sowing different crops, weed seedbank estimation under CA, energy requirements, economic analysis of CA.

VI. Suggested Reading

- Arakeri HR and Roy D. 1984. *Principles of Soil Conservation and Water Management*. Oxford & IBH.
- Bisht JK, Meena VS, Mishra PK and Pattanayak A. 2016. Conservation Agriculture-An approach to combat climate change in Indian Himalaya. Publisher: Springer Nature. Doi: 10/1007/978-981-10-2558-7.
- Dhruvanarayana VV. 1993. *Soil and Water Conservation Research in India*. ICAR.
- FAO. 2004. *Soil and Water Conservation in Semi-Arid Areas. Soils Bull.*, Paper 57.
- Gracia-Torres L, Benites J, Martinez-Vilela A and Holgado-Cabera A. 2003. Conservation Agriculture- Environment Farmers experiences, innovations Socio-economic policy.
- Muhammad F and Kamdambot HMS. 2014. Conservation Agriculture. Publisher: Springer Cham Heidelberg, New Yaork Dordrecht London. Doi: 10.1007/978-3-319-11620-4.
- Yellamanda Reddy T and Sankara Reddy GH. 1992. *Principles of Agronomy*. Kalyani.

I. Course Title : Agronomy of Major Cereals and Pulses

II. Course Code : Agron 506

III. Credit Hours : 2+0

IV. Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of:

Unit I: *Rabi* cereals.

Unit II: *Kharif* cereals.

Unit III: *Rabi* pulses.

Unit IV: *Kharif* pulses.

VI. Practical

- Phenological studies at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)
- Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)
- Estimation of protein content in pulses
- Planning and layout of field experiments
- Judging of physiological maturity in different crops
- Intercultural operations in different crops
- Determination of cost of cultivation of different crops
- Working out harvest index of various crops
- Study of seed production techniques in selected crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

VII. Resources

- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Hunsigi G and Krishna KR. 1998. *Science of Field Crop Production*. Oxford & IBH.
- Jeswani LM and Baldev B. 1997. *Advances in Pulse Production Technology*.ICAR.
- Khare D and Bhale MS. 2000. *Seed Technology*. Scientific Publ.
- Kumar Ranjeet and Singh NP. 2003. *Maize Production in India: Golden Grain in Transition*. IARI, New Delhi.
- Pal M, Deka J and Rai RK. 1996. *Fundamentals of Cereal Crop Production*.Tata McGraw Hill.
- Prasad Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.
- Singh C, Singh P and Singh R. 2003. *Modern Techniques of Raising FieldCrops*. Oxford & IBH.
- Singh SS. 1998. *Crop Management*. Kalyani.
- Yadav DS. 1992. *Pulse Crops*. Kalyani.

I. Course Title : Agronomy of Oilseed, Fibre and Sugar Crops

II. Course Code : Agron 507

III. Credit Hours : 2+1

IV. Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing of the produce for maximum production of:

Unit I

Rabi oilseeds – Rapeseed and mustard, Linseed and Niger

Unit II

Kharif oilseeds - Groundnut, Sesame, Castor, Sunflower, Soybean and Safflower

Unit III

Fiber crops - Cotton, Jute, Ramie and Mesta.

Unit IV

Sugar crops – Sugar-beet and Sugarcane.

V. Practical

- Planning and layout of field experiments
- Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop
- Intercultural operations in different crops
- Cotton seed treatment
- Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)
- Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Determination of oil content in oilseeds and computation of oil yield
- Estimation of quality of fibre of different fibre crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

VIII. Suggested Reading

- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Das PC. 1997. *Oilseed Crops of India*. Kalyani.
- Lakshmikantam N. 1983. *Technology in Sugarcane Growing*. 2nd Ed. Oxford & IBH.
- Prasad Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.
- Singh C, Singh P & Singh R. 2003. *Modern Techniques of Raising FieldCrops*. Oxford & IBH.
- Singh SS. 1998. *Crop Management*. Kalyani.

I. Course Title : **Agronomy of Medicinal, Aromatic and Under Utilized Crops**

II. Course Code : **Agron 508/PSMA 503**

III. Credit Hours : **2+1**

IV. Theory

Unit I

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge.

Unit II

Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Mulhati, Isabgol, Rauwolfia, Poppy, *Aloe vera*, Satavar, *Stevia*, Safed Musli, Kalmegh, Asaphoetida, *Nuxvomica*, Rosadle, etc).

Unit III

Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium).

Unit IV

Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, Sesbania, Clusterbean, French bean, Fenugreek, Grain Amaranth, Coffee, Tea and Tobacco).

Unit V

Post harvest handling –drawing, processing, grading, packing and storage, value addition and quality standards in herbal products.

V. Practical

- Identification of crops based on morphological and seed characteristics
- Raising of herbarium of medicinal, aromatic and under-utilized plants
- Quality characters in medicinal and aromatic plants
- Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants.

IX. Suggested Reading

- Chadha KL and Gupta R. 1995**.** *Advances in Horticulture*. Vol. II. *Medicinal and Aromatic Plants*. Malhotra Publ.
- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Handa SS. 1984. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.
- Hussain A. 1984. *Essential Oil Plants and their Cultivation*. CIMAP, Lucknow.
- Hussain A. 1993. *Medicinal Plants and their Cultivation*. CIMAP, Lucknow.
- ICAR 2006. *Hand Book of Agriculture.* ICAR, New Delhi.
- Kumar N, Khader Md. Abdul, Rangaswami JBM & Irulappan 1997. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants.* Oxford & IBH.
- Prajapati ND, Purohit SS, Sharma AK and Kumar T. 2003. *A Hand Book of Medicinal Plants: A Complete Source Book*. Agrobios.
- Sharma R. 2004. *Agro-Techniques of Medicinal Plants*. Daya Publ. House.

I. Course Title : Agronomy of Fodder and Forage Crops

II. Course Code : Agron 509

III. Credit Hours : 2+1

IV. Theory

Unit I

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like sorghum, maize, *bajra*, *guar*, cowpea, oats, barley, berseem, *senji*, lucerne, etc.

Unit II

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasseslime, Napier grass, *Panicum*, *Lasiuras*, *Cenchrus*, etc.

Unit III

Year-round fodder production and management, preservation and utilization of forage and pasture crops.

Unit IV

Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poorquality fodder. Fodder production through hydroponics. Azolla cultivation.

Unit V

Economics of forage cultivation uses and seed production techniques of important fodder crops.

V. Practical

- Practical training of farm operations in raising fodder crops;
- Canopy measurement, yield, Leaf: Stem ratio and quality estimation, viz. crude protein, NDF, ADF, lignin, silica, cellulose and IVDMD, etc. of various fodder and forage crops
- Anti-quality components like HCN in sorghum and such factors in other crops
- Hay and silage making and economics of their preparation.

VI. Suggested Reading

- Chatterjee BN. 1989. *Forage Crop Production - Principles and Practices*. OXford & IBH.
- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Narayanan TR and Dabadghao PM. 1972. *Forage Crops of India*. ICAR.
- Singh P and Srivastava AK. 1990. *Forage Production Technology*. IGFRI, Jhansi.
- Singh C, Singh P and Singh R. 2003. *Modern Techniques of Raising Field Crops*. OXford & IBH.
- Tejwani KG. 1994. *Agroforestry in India*. OXford & IBH.

I. Course Title : Agrostology and Agro-forestry
(To be taught jointly by Agronomy and Forestry)

II. Course Code : Agron 510

III. Credit Hours : 2+1

IV. Theory

Unit I

Agrostology: definition and importance; principles of grassland ecology: grassland ecology – community, climax, dominant species, succession, biotype, ecological status of grasslands in India, grass cover of India; problems and management of grasslands.

Unit II

Importance, classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses.

Unit III

Agroforestry: definition and importance; agroforestory systems, agrisilviculture, silvipasture, agrisilvipasture, agrihorticulture, aquasilviculture, alley cropping and energy plantation.

Unit IV

Crop production technology in agro-forestory and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation and manuring in agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in agro-forestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

VI.Practical

- Preparation of charts and maps of India showing different types of pastures and agro-forestry systems
- Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry
- Seed treatment for better germination of farm vegetation
- Methods of propagation/ planting of grasses and trees in silvipastoral system
- Fertilizer application in strip and silvipastroal systems
- After-care of plantation
- Estimation of protein content in loppings of important fodder trees
- Estimation of calorie value of wood of important fuel trees
- Estimation of total biomass and fuel wood
- Economics of agro-forestry
- Visit to important agro-forestry research stations

VII. Suggested Reading

- Chatterjee BN and Das PK. 1989. *Forage Crop Production. Principles and Practices.* OXford & IBH.
- Dabadghao PM and Shankaranarayan KA. 1973. *The Grass Cover in India*. ICAR.
- Dwivedi AP. 1992. *Agroforestry- Principles and Practices.* OXford & IBH.
- Indian Society of Agronomy. 1989. *Agroforestry System in India. Research and Development,* New Delhi.
- Narayan TR and Dabadghao PM. 1972. *Forage Crop of India*. ICAR, New Delhi.

I. Course Title : Cropping Systems and Sustainable Agriculture

II. Course Code : Agron 511

III. Credit Hours : 2+0

IV. Theory

Unit I

Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

Unit II

Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.

Unit III

Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; research need on sustainable agriculture.

Unit IV

Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system. Advanced nutritional tools for big data analysis and interpretation.

Unit V

Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

Unit VI

Artificial Intelligence- Concept and application.

VII. Suggested Reading

- Panda SC. 2017. *Cropping Systems and Sustainable Agriculture*. Agrobios (India)
- Panda SC. 2018. *Cropping and Farming Systems*. Agrobios.
- Palaniappan SP and Sivaraman K. 1996. *Cropping Systems in the Tropics; Principles and Management*. New Age.
- Panda SC. 2003. *Cropping and Farming Systems*. Agrobios.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani.
- Sankaran S and Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ. Co.
- Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.
- Tisdale SL, Nelson WL, Beaton JD and Havlin JL. 1997. *Soil Fertility and Fertilizers*. Prentice Hall.

I. Course Title : Dryland Farming and Watershed Management

II. Course Code. : Agron 512

III. Credit Hours : 2+1

IV. Theory

Unit I

Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.

Unit II

Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

Unit III

Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

Unit IV

Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; soil and crop management techniques, seeding and efficient fertilizer use.

Unit V

Concept of watershed resource management, problems, approach and components.

V. Practical

- Method of Seed Priming
- Determination of moisture content of germination of important dryland crops
- Determination of Relative Water Content and Saturation Deficit of Leaf
- Moisture stress effects and recovery behaviour of important crops
- Estimation of Potential ET by Thornthwaite method
- Estimation of Reference ET ny Penman Monteith Method
- Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index)
- Classification of climate by Koppen Method
- Estimation of water balance by Thornthwaite method
- Estimation of water balance by FAO method
- Assessment of drought
- Estimation of length of growing period
- Estimation of probability of rain and crop planning for different drought condition
- Spray of anti-transpirants and their effect on crops
- Water use efficiency
- Visit to dryland research stations and watershed projects

VI. Suggested Reading

- Reddy TY. 2018. *Dryland Agriculture Principles and Practices*, Kalyani publishers
- Das NR. 2007. *Tillage and Crop Production*. Scientific Publ.
- Dhopte AM. 2002. *Agrotechnology for Dryland Farming*. Scientific Publ.
- Dhruv Narayan VV. 2002. *Soil and Water Conservation Research in India*. ICAR.
- Gupta US. (Ed.). 1995. *Production and Improvements of Crops forDrylands*. Oxford & IBH.

- Katyal JC and Farrington J. 1995. *Research for Rainfed Farming*. CRIDA.
- Rao SC and Ryan J. 2007. *Challenges and Strategies of Dryland Agriculture*. Scientific Publ.
- Singh P and Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture.* Agrotech Publ. Company.
- Singh RP. 1988. *Improved Agronomic Practices for Dryland Crops*. CRIDA.
- Singh RP. 2005. *Sustainable Development of Dryland Agriculture in India*. Scientific Publ.
- Singh SD. 1998. *Arid Land Irrigation and Ecological Management*. Scientific Publ.
- Venkateshwarlu J. 2004. *Rainfed Agriculture in India. Research and Development Scenario*. ICAR.

I. Course Title : Principles and Practices of Organic Farming

II. Course Code : Agron 513

III. Credit Hours : 2+1

IV. Theory

Unit I

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; principles of organic agriculture; organics and farming standards; organic farming and sustainable agriculture; selection and conversion of land, soil and water management - land use, conservation tillage; shelter zones, hedges, pasture management, agro-forestry.

Unit II

Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures, bio-fertilizers and biogas technology.

Unit III

Farming systems, selection of crops andcrop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

Unit IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, bio-pesticides.

Unit V

Socio-economic impacts; marketing and eXport potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

V. Practical

- Method of making compost by aerobic method
- Method of making compost by anaerobic method
- Method of making vermicompost
- Identification and nursery raising of important agro-forestry tress and tress for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with *Rhizobium* cultures, use of *Azotobacter*, *Azospirillum*, and PSB cultures in field
- Visit to a biogas plant
- Visit to an organic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

VI. Suggested Reading

- Ananthakrishnan TN. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.
- Gaur AC. 1982. *A Manual of Rural Composting*, FAO/UNDP Regional Project Document, FAO.
- Joshi M. 2016. *New Vistas of Organic Farming*. Scientific Publishers
- Lampin N. 1990. *Organic Farming*. Press Books, lpswitch, UK.
- Palaniappan SP and Anandurai K. 1999. *Organic Farming – Theory and Practice*. Scientific Publ.
- Rao BV Venkata. 1995. *Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective*: Publ.3, ParisaraprajnaParishtana, Bangalore.

- Reddy MV. (Ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.
- Sharma A. 2002. *Hand Book of Organic Farming*. Agrobios.
- Singh SP. (Ed.). 1994. *Technology for Production of Natural Enemies.* PDBC, Bangalore.
- Subba Rao NS. 2002. *Soil Microbiology*. Oxford & IBH.
- Trivedi RN. 1993. *A Text Book of Environmental Sciences*, Anmol Publ.
- Veeresh GK, Shivashankar K and Suiglachar MA. 1997. *Organic Farming and Sustainable Agriculture.* Association for Promotion of Organic Farming, Bangalore.
- WHO. 1990. *Public Health Impact of Pesticides Used in Agriculture.* WHO.
- Woolmer PL and Swift MJ. 1994. *The Biological Management of Tropical Soil Fertility*. TSBF & Wiley.

Course Title with Credit Load
Ph.D. in Agronomy

Course Code	Course Title	Credit Hours	Semester
Agron 601*	Current trends in Agronomy	3+0	I
Agron 602	Recent trends in crop growth and productivity	2+1	I
Agron 603	Irrigation management	2+1	I
Agron 604	Recent trends in weed management	2+0	I
Agron 605	Integrated farming systems for sustainable Agriculture	2+0	I
Agron 606	Soil Conservation and Watershed Management	2+1	II
Agron 607	Stress Crop Production	2+1	II
Agron 608*	Research and Publication ethics	2+0	II
Agron-691	Doctoral Seminar	1+0	
Agron 692	Doctoral Seminar	1+0	
Agron 699	Doctoral Research	75	

*Indicates Core course for Ph.D.

Course Contents
Ph.D. in Agronomy

I. Course Title : Current Trends in Agronomy

II. Course Code : Agron 601

III. Credit Hours : 3+0

IV. Theory

Unit I

Agro-physiological basis of variation in yield, recent advances in soilplant-water relationship.

Unit II

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming.

Unit III

Crop residue management in multiple cropping systems; latest developments in plant managementMechanizationin crop production: modern agricultural precision tools and technilogies, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

Unit IV

GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc.

Unit V

Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy. Conservation agriculture, principles, prospects and importance, potential benefits of CA under climate change scenario, policy issues.

V. Suggested Reading

- Agarwal RL. 1995. *Seed Technology*. Oxford & IBH.
- Dahiya BS and Rai KN. 1997. *Seed Technology*. Kalyani.
- Govardhan V. 2000. *Remote Sensing and Water Management in Command Areas: Agroecological Prospectives*. IBDC.
- ICAR. 2006. *Hand Book of Agriculture*. ICAR.
- Narasaiah ML. 2004. *World Trade Organization and Agriculture*. Sonali Publ.
- Palaniappan SP and Annadurai K. 2006. *Organic Farming - Theory and Practice*. Scientific Publ.
- Sen S and Ghosh N. 1999. *Seed Science and Technology*. Kalyani.
- Tarafdar JC, Tripathi KP and Kumar M. 2007. *Organic Agriculture* Scientific Publ.
- Kumar, R, Swarnkar KS, Singh KS and Narayan S. 2016. *A Text Book of Seed Technology*. Kalyani Publication.
- Reddy SR and Prabhakara G. 2015. *Dryland Agriculture*. Kalyani Publishers.
- Gururajan B, Balasubhramanian R and Swaminath V. 2013. *Recent Strategies on Crop Production*. Kalyani Publishers.
- Venkateswarlu B and Shanker Arun K. 2009. *Climate change and agriculture: Adaptation and mitigation strategies. Indian Journal of Agronomy* **54**(2): 226-230.

I. Course Title : Recent Trends in Crop Growth and Productivity
II. Course Code : Agron 602
III. Credit Hours : 2+1
IV. Theory

Unit I

Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.

Unit II

Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and Limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

Unit III

Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; heat unit concept of crop maturity: concept and types of heat units.

Unit IV

Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.

V. Practical

- Field measurement of root-shoot relationship in crops at different growth stages
- Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth
- Computation of harvest index of various crops
- Assessment of crop yield on the basis of yield attributing characters
- Construction of crop growth curves based on growth analysis data
- Computation of competition functions, viz. LER, IER aggressivity competition index etc in intercropping
- Senescence and abscission indices
- Analysis of productivity trend in un-irrigated areas
- Analysis of productivity trend in irrigated areas

VI. Suggested Reading

- Chopra VL and Paroda RS. 1984. *Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants*. Oxford & IBH.
- Delvin RM and Vitham FH. 1986. *Plant Physiology*. CBS Publ.
- Evans LT. 1975. *Crop Physiology*. Cambridge Univ. Press.
- Evans LT. 1996. *Crop Evolution, Adaptation and Yield*. Cambridge Univ. Press.
- Gupta US. (Ed.). 1995. *Production and Improvement of Crops for Drylands*. Oxford & IBH.
- Gupta US. 1988. *Progress in Crop Physiology*. Oxford & IBH.
- Kramer PJ and Boyer JS. 1995. *Water Relations of Plant and Soils.* Academic Press.
- Mukherjee S and Ghosh AK. 1996. *Plant Physiology*. Tata McGraw Hill.
- Narwal SS, Politycka B and Goswami CL. 2007. *Plant Physiology: Research Methods.* Scientific Pub.
- Tiaz L. and Zeiger E. 2006. Plant Physiology. Sinauer Associates, Inc.

I. Course Title : Irrigation Management

II. Course Code : Agron 603

III. Credit Hours : 2+1

IV. Theory

Unit I

Global water resources; Water resources of India, irrigation projects during pre and post independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

Unit II

Movement of water in soil-water movement under saturated and unsaturated conditions, Poiseulle's and Darcy's law, general equation of saturated and unsaturated flow of water in soil.

Soil-plant-water relationships, evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

Unit III

Water requirement, irrigation needs, factors affecting irrigation need; water use efficiency, Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

Unit IV

Soil and plant water potential, SPAC, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, factors affecting ET, control of ET by mulching and use of anti-transpirents; fertilizer use in relation to irrigation.

Unit V

Crop water stress – water deficits and crop growth, adoptability to the crops. Water availability with relation to nutrient availability.

Unit VI

Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

Unit VII

Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

Unit VIII

Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation.

Unit IX

Economic analysis of irrigation and cop planning for optimum use of irrigation water

Unit X

Crop water production function

V. Practical

- Determination of water infiltration characteristics and water holding capacity of soil profiles.
- Determination Moisture extraction pattern of crops
- Determination of water balance component of transplanted rice by drum culture technique
- Determination of consumptive use and water requirement of a given cropping pattern
- Determination of crop efficient of one important crop
- Planning, designing and installation of drip irrigation system
- Planning, designing and installation of sprinkler irrigation system
- Designing of drainage channel
- Measurement of irrigation efficiencies
- Determination of irrigation timing under different methods of irrigation

VIII. Visit to irrigation command area Suggested Reading

- MP. Singh 2017. Recent advances in Irrigation water management. Kalyani Publishers
- FAO. 1984. *Irrigation Practice and Water Management*. Oxford & IBH.
- Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.
- Mishra RR and Ahmad M. 1987. *Manual on Irrigation and Agronomy*. Oxford & IBH.
- Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani.
- Sankara Reddy GH and Yellamananda Reddy. 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.
- Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US.(Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH

I. Course Title : Recent Trends in Weed Management

II. Course Code : Agron 604

III. Credit Hours : 2+0

IV. Theory

Unit I

Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management. Migration, introduction, adaptation of weeds, Invasive weeds – biology and management. Different mechanisms of invasion – present status and factors influencing weed invasion.

Unit II

Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

Unit III

Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, Degradation of herbicides in soil and plants- factors affecting it, primary and secondary metabolites, residue management of herbicides, adjuvants.

Unit IV

Advances in herbicide products and application techniques and methods; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.

Unit V

Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

Unit VI

Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelochemical and alleloherbicides, herbicide bioassays. Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film, etc.

V. Suggested Reading

- Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. *Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry*. Springer.
- Das TK. 2008. *Weed Science: Basics and Applications*, Jain Brothers (New Delhi)
- Fennimore, Steven A and Bell, Carl. 2014. *Principles of Weed Control*, 4th Ed, California Weed Sci. Soc.
- Gupta OP. 2007. *Weed Management: Principles and Practices*, 2nd Ed.
- Jugulan M, (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC Press
- Monaco TJ, Weller SC and Ashton FM. 2014. *Weed Science Principles and Practices*, Wiley
- Powles SB and Shaner DL. 2001. *Herbicide Resistance and World Grains*, CRC Press.
- Walia US. 2006. *Weed Management*, Kalyani.
- Zimdahl RL. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub*

I. Course Title : Integrated Farming Systems and Sustainable Agriculture

II. Course Code : Agron 605

III. Credit Hours : 2+0

IV. Theory

Unit I

Integrated Farming systems (IFS): definition, scope and importance; classification of IFS based on enterprises as well as under rainfed/irrigated condition in different land situation. farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

Unit II

Concept of sustainability in of Integrated farming systems; efficient Integrated farming systems based on economic viability and natural resources - identification and management.

Unit III

Production potential of different components of Integrated farming systems; interaction and mechanism of different production factors; stability of Integrated Farming system based on research/long term information. in different systems through research; eco-physiological approaches to intercropping. Integration of components and adaptability of different farming system based on land situations and climatic condition of a region; evaluation of IFS.

Unit IV

Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems. Formation of different Integrated Farming system Models; evaluation of different Integrated Farming system models. Recycling of organic waste in farming system, in IFS.

Unit V

New concepts and approaches of farming system and organic farming; value addition, waste recycling, quantification and mitigation of Green House gases; case studies/ success stories of different Integrated Farming systems. cropping systems and organic farming; case studies on different farming systems. Possible use of ITK in Integrated farming system.

V. Suggested Reading

- Ananthakrishnan TN. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. OXford & IBH.
- Baishya A, Borah M, Das AK, Hazarika J, Gogoi B and Borah AS 2017. *Waste Recycling Through Integrated Farming systems. An Assam Agriculture Experience.* Omni Scriptum Gmbh & Co. KG, Germany.
- Balasubramanian P and Palaniappan SP. 2006. *Principles and Practices of Agronomy*. Agrobios.
- Edens T. 1984. *Sustainable agriculture and integrated farming system*. Michigan State Univ. press.
- Jayanthi C. 2006. *Integrated Farming systems-A way to sustainable Agriculture*. Tamil Nadu Agricultural University, Coimbatore
- Joshi M and Parbhakarasetty TK. 2005. *Sustainability through Organic Farming*. Kalyani.
- Kolhapure A and Madhukar D. *A text book of farming system and sustainable agriculture.*
- Palaniappan SP and Anandurai K. 1999. *Organic Farming - Theory and Practice*. Scientific Publ.
- Panda SC. 2004. *Cropping systems and Farming Systems*. Agribios.
- Lampin N. 1990. *Organic Farming*. Farming Press Books.
- Ravisankar D and Jayanthi C. 2015. *Farming systems: concepts and approaches*. Agrobios,

I. Course Title : Soil Conservation and Watershed Management

II. Course Code : Agron 606

III. Credit Hours : 2+1

IV. Theory

Unit I

Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion.

Unit II

Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; mulching, tillage, cropping system vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

Unit III

Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.

Unit IV

Land use capability classification, alternate land use systems; agro-forestry; leyfarming; *jhum* management - basic concepts, socio-ethnic aspects, its layout.

Unit V

Drainage, methods of drainage, Drainage considerations and agronomic management; rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion.

V. Practical

- Study of different types of erosion
- Determination of dispersion ratio
- Estimation of soil loss by Universal Soil Loss Equation
- Estimation of soil loss by wind erosion
- Measurement of runoff and soil loss
- Field studies of different soil conservation measures
- Laying out run-off plot and deciding treatments
- Identification of different grasses and trees for soil conservation
- Visit to watershed areas
- Visit to a soil conservation research centre, demonstration and training centre

VI. Suggested Reading

- Arakeri HR and Roy D. 1984. *Principles of Soil Conservation and Water Management*. Oxford & IBH.
- Dhruvanarayana VV. 1993. *Soil and Water Conservation Research in India*. ICAR.
- FAO. 2004. *Soil and Water Conservation in Semi-Arid Areas. Soils Bull.*, Paper 57.
- Frederick RT, Hobbs J, Arthur D and Roy L. 1999. *Soil and Water Conservation: Productivity and Environment Protection.* 3rd Ed. Prentice Hall.
- Gurmel Singh, Venkataraman CG, Sastry B and Joshi P. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.
- Murthy VVN. 1995. *Land and Water Management Engineering.* Kalyani.
- Tripathi RP and Singh HP. 1993. *Soil Erosion and Conservation*. Wiley Eastern.
- Yellamanda Reddy T and Sankara Reddy GH. 1992. *Principles of Agronomy*. Kalyani.

I. Course Title : Stress Crop Production

II. Course Code : Agron 607

III. Credit Hours : 2+1

IV. Theory

Unit I

Stress and strain terminology; nature and stress injury and resistance; causes of stress.

Unit II

Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature tress through, soil and crop manipulations.

Unit III

High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

Unit IV

Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations.

Unit V

Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.

Unit VI

Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

Unit VII

Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.

Unit VIII

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

VI. Practical

- Determination of electrical conductivity of plant cell sap
- Determination of osmotic potential and tissue water potential
- Measurement of transpiration rate
- Measurement of stomatal frequency
- Measurement of Relative Water Content of leaf
- Measurement of electrolytic leakage
- Growing of plants in sand culture under salt stress for biochemical and physiological studies
- Studies on effect of osmotic and ionic stress on seed germination and seedling growth
- Measurement of low temperature injury under field conditions
- Studies on plant responses to excess water.

VIII. Suggested Reading

- Baker FWG.1989. *Drought Resistance in Cereals.* Oxon, UK.

- Gupta US. (Ed.). 1988. *Physiological Aspects of Dryland Farming*. Oxford & IBH.
- Kramer PJ.1983. *Water Relations of Plants*. Academic Press.
- Levitt J. 1980. *Response of Plants to Environmental Stresses*. Vols. I, II. Academic Press.
- Mavi HS.1978. *Introduction to Agro-meteorology*. Oxford & IBH.
- Michael AM and Ojha TP.1981. *Principles of Agricultural Engineering*. Vol II. Jain Bros.
- Nilsen ET and Orcut DM. 1996. *Physiology of Plants under Stress – Abiotic Factors*. John Wiley & Sons.
- Singh K. 2000. *Plant Productivity under Environmental Stress*. Agribios.
- Singh KN and Singh RP. 1990. *Agronomic Research Towards Sustainable Agriculture*. Indian Society of Agronomy, New Delhi.
- Somani LL and Totawat KL. 1992. *Management of Salt-affected Soils and Waters*. Agrotech Publ.
- Virmani SM, Katyal JC, Eswaran H and Abrol IP. 1994. *Stressed Ecosystem and Sustainable Agriculture*. Oxford & IBH.

I. Title : Research and Publication Ethics

II. Course Code : Agron 608

III. Credit Hours : 0+2

IV. Theory

Unit I

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II

Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit III

Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV

Publication ethics: Defination, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME, etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatorypublishers and journals

Unit V

Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to checkpublisher copy right and selfarchivingpolicies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools viz., JANE, Elsevier Journal Finder, Springer Journal Suggesteretc.

Unit VI

Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open sourcesoftware tools

Unit VII

Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10-index altmetrics.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 2

Physical Sciences

– Soil Science

Course Title with Credit Load
M.Sc. in Soil Science

Course Code	Course Title	Credit Hours	Semester
*Soil 501	Soil physics	(2+1)	I
*Soil 502	Soil fertility and fertilizer use	(2+1)	II
*Soil 503	Soil chemistry	(2+1)	I
*Soil 504	Soil mineralogy, genesis and classification	(2+1)	I
Soil 505	Soil erosion and conservation	(2+1)	II
Soil 506	Soil Biology and Biochemistry	(2+1)	I
Soil 507	Radioisotopes in soil and plant studies	(1+1)	I
Soil 508	Soil, water and air pollution	(2+1)	II
Soil 509	Remote sensing and GIS technique for soil and crop studies	(2+1)	II
Soil 510	Plant analysis: physical technique and instrumental methods in soil and	(0+2)	II
Soil 511	Management of problematic soils and water	(1+1) 2+1	I
Soil 512	Land degradation and restoration	(1+0)	I
Soil 513	Soil Survey and Land use Planning	(2+0) 2+1	II
Soil 514	Introduction to nanotechnology	(2+1)	II
Soil 591	Master's Seminar	(1+0)	
Soil 599	Master's Research	30	

*Indicates Core Courses which are Compulsory for Master Programme

Course contents
M.Sc. in Soil Science

I. Course Title : Soil Physics
II. Course Code : Soil 501
III. Credit Hours : 2+1

IV. Theory

Unit I

Basic principles of physics applied to soils, soil as a three phase system.

Unit II

Soil texture, textural classes, mechanical analysis, specific surface.

Unit III

Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts.Alleviation of soil physical constraints for crop production. Soil erosion and edibility

Unit IV

Soil structure - genesis, types, characterization and management soil structure; soil
aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting -mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

Unit V

Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

Unit VI

Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement ofhydraulic conductivity in saturated and unsaturated soils.

Unit VII

Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

Unit VIII

Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.
Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soiltemperature management.

V. Practical

- Determination of B.D, P.D and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method,
- Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement

of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore-size, distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

VI. Suggested Reading

- Baver LD, Gardner WH and Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
- Ghildyal BP and Tripathi RP. 2001. *Soil Physics*. New Age International.
- Hanks JR and Ashcroft GL. 1980. *Applied Soil Physics*. Springer Verlag.
- Hillel D. 1972. *Optimizing the Soil Physical Environment toward Greater Crop Yields*. Academic Press.
- Hillel D. 1980. *Applications of Soil Physics*. Academic Press.
- Hillel D. 1980. *Fundamentals of Soil Physics*. Academic Press.
- Hillel D. 1998. *Environmental Soil Physi*cs. Academic Press.
- Hillel D. 2003. *Introduction to Environmental Soil Physics*. Academic Press.
- Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Kirkham D and Powers WL. 1972. *Advanced Soil Physics*. Wiley-Interscience.
- Kohnke H. 1968. *Soil Physics*. McGraw Hill.
- Lal R and Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

I. Course Title : Soil Fertility and Fertilizer Use

II. Course Code : Soil 502

III. Credit Hours : 3+1

IV. Theory

Unit I

Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources – fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.

Unit II

Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

Unit III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid andalkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soilsand management under field conditions. Potassium - forms, equilibrium in soils and its agriculturalsignificance; mechanism of potassium fixation; management of potassium fertilizers under fieldconditions.

Unit V

Sulphur - source, forms, fertilizers and their behavior in soils; roleincropsandhuman health; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

Unit VI

Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

Unit VII

Common soil test methods for fertilizer recommendations; quantity–intensityrelationships; soil test crop response correlations and response functions.

Unit VIII

Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; specialityfertilizersconcept, needand category.CurrentstatusofspecialityfertilizersuseinsoilsandcropsofIndia;

Unit IX

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soilquality in relation to sustainable agriculture, Determination of critical limit, DRIS

Unit X

Definition and concepts of soil health and soil quality; Longterm effects of fertilizers and soil quality.

V. Practical

- Soil and plant sampling and processing for chemical analysis
- Determination of soil pH, total and organic carbon in soil

- Chemical analysis of soil for total and available nutrients(major and micro)
- Analysis of plants for essential elements(major and micro)

IX. Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Kabata-Pendias A and Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.
- Kannaiyan S, Kumar K and Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.
- Leigh J G. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.
- Mengel K and Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
- Mortvedt JJ, Shuman LM, Cox FR and Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.
- Pierzinsky GM, Sims TJ and Vance JF. 2002. *Soils and Environmental Quality*. 2nd Ed. CRC Press.
- Stevenson FJ and Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Tisdale SL, Nelson SL, Beaton JD and Havlin JL. 1999. *Soil Fertility and Fertilizers*. 5th Ed. Prentice Hall of India.
- Troeh FR and Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

I. Course Title : Soil Chemistry

II. Course Code : Soil 503

III. Credit Hours : 2+1

IV. Theory

Unit I

Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

Unit II

Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

Unit III

Soil colloids: inorganic and organic colloids - origin of charge, concept of point ofzero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions.

Unit IV

Ion exchange processes in soil; cation exchange- theories based on law of massaction (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorptionisotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionicactivity measurement, thermodynamics, statistical mechanics; anion and ligand exchange–innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresisin sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

Unit V

Potassium, phosphate and ammonium fixation in soils covering specificand non-specific sorption; precipitation-dissolution equilibria; Conceptof quantity/intensity(Q/I)relationship; step and constant-rate K; managementaspects.

Unit VI

Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

Unit VII

Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.

Unit VIII

Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry

V. Practical

Preparation of saturation extract, measurement of pH, EC, CO, HCO, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter andconductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6)

ratio of soil humic and fulvic acids by visible spectrophotometric studies and the D (E4/E6) values at two pH values, Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by BaCl2-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

VI. Suggested Reading

- Bear RE. 1964. *Chemistry of the Soil.* Oxford and IBH.
- Bolt GH and Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.
- Greenland DJ and Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.
- Greenland DJ and Hayes MHB. *Chemistry of Soil Constituents*. John Wiley & Sons.
- McBride MB. 1994. *Environmental Chemistry of Soils.* Oxford University Press.
- Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford University Press.
- Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford University Press.
- Sposito G. 1989. *The Chemistry of Soils*. Oxford University Press.
- Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley & Sons.
- Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

I. Course Title : Soil Mineralogy, Genesis and Classification

II. Course Code : Soil 504

III. Credit Hours : 2+1

IV. Theory

Unit I

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

Unit II

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystal line and non-crystal line clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

Unit III

Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

Unit IV

Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness.

V. Practical

- Separation of sand, silt and clay fraction from soil
- Determination of specific surface area and CEC of clay
- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different land forms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soil susing available database in terms of soil quality

IX. Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Buol EW, Hole ED, MacCracken RJ and Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.
- Dixon JB and Weed SB. 1989. *Minerals in Soil Environments*. 2nd Ed. Soil Science Society of America, Madison.
- Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi
- Sehgal J. 2002. *Pedology - Concepts and Applications*. Kalyani.
- USDA. 1999. *Soil Taxonomy*. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.
- Wade FA and Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.
- Wilding LP and Smeck NE. 1983. *Pedogenesis and Soil Taxonomy*: II. *The Soil Orders*. Elsevier.
- Wilding NE and Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy*. I.

I. Course Title : Soil Erosion and Conservation

II. Course Code : Soil 505

III. Credit Hours : 2+1

IV. Theory

Unit I

History, distribution, identification and description of soil erosionproblems in India.

Unit II

Forms of soil erosion; effects of soil erosion and factors affecting soilerosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity - estimation as EI30 index and kinetic energy; factors affectingwater erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties andprecipitation.

Unit III

Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

Unit IV

Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout.

Unit V

Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

Unit VI

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds, sediment measurement

V. Practical

- Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI30) using rain gauge data
- Land capability classification of a watershed
- Visits to a watersheds

VI. Suggested Reading

- Biswas TD and Narayanasamy G. (Eds.) 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No. 17.
- Doran JW and Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.
- Gurmal Singh, Venkataramanan C, Sastry G and Joshi BP. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.
- Hudson N. 1995. *Soil Conservation*. Iowa State University Press.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

I. Course Title : Soil Biology and Biochemistry

II. Course Code : Soil 506

III. Credit Hours : 2+1

IV. Theory

Unit I

Soilbiota, soil microbialecology, types of organisms indifferent soils; soil microbial biomass; microbial interactions; un-culturable soilbiota.

Unit II

Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora; Root rhizosphere and PGPR.

Unit III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, microbiology and biochemistry of decomposition of carbonaceous and protenaceous materials, cycles of important organic nutrients.

Unit IV

organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

Unit V

Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

Unit VI

Biofertilizers–definition, classification, specifications, method of production and role in crop production; FCO specifications and quality control of biofertilizers.

Unit VII

Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms inpedogenesis – important mechanisms and controlling factors; soil genomics and bioprospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil.

V. Practical

- Determination of soil microbial population
- Soil microbial biomass carbon
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil
- Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N_2 fixation, S oxidation, P solubilization and mineralization of other micronutrients

VI. Suggested Reading

- Paul EA and Clark FE. *Soil Microbiology and Biochemistry*.
- Lynch JM. *Soil Biotechnology*
- Willey JM, Linda M. Sherwood and Woolverton CJ. *Prescott's Microbiology*.
- Subba Rao NS. *Advances In Agricultural Microbiology*.

I. Course Title : Radioisotopes in Soil and Plant Studies

II. Course Code : Soil 507

III. Credit Hours : 1+1

IV. Theory

Unit I

Atomic structure, radio activity and units; radio isotopes-properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter, artificial radioactivity

Unit II

Principles and use of radiation monitoring instruments-proportional, Geiger Muller counter, solid and liquids cintillation counters; neutron moisture meter, mass spectrometry, autoradiography

Unit III

Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating

Unit IV

Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes

V. Practical

- Storage and handling of radioactive materials
- Determination of half-life and decay constant
- Preparation of soil and plant samples for radioactive measurements
- Settingup of experiment on fertilizer use efficiency and cation exchange equilibria using radio isotopes
- Determination of A, E and L values of soil using 32P/65Zn
- Use of neutron probe for moisture determination
- Sample preparation and measurement of 15N enrichment by mass spectro photometery/ emission spectrometry

VI. Suggested Reading

- Comer CL. 1955. *Radioisotopes in Biology and Agriculture: Principles and Practice*. Tata McGraw Hill.
- Glasstone S. 1967. *Source Book on Atomic Energy*. East West Press.
- Michael FL and Annunziata. 2003. *Handbook of Radioactivity Analysis*. Academic Press.

I. Course Title : Soil, Water and Air Pollution

II. Course Code : Soil 508

III. Credit Hours : 2+1

IV. Theory

Unit I

Soil, water and air pollution problems associated with agriculture, nature and extent.

Unit II

Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants- their CPC standards and effect on plants, animals and human beings.

Unit III

Sewage and industrial effluents–their composition and effecton soil properties/ health, and plant growth and humanbeings; soil as sink for waste disposal.

Unit IV

Pesticides–their classification, behaviour in soil and effecton soil microorganisms.

Unit V

Toxic elements–their sources, behaviour in soils, effect on nutrients availability, effect on plant and human health.

Unit VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of green house gases–carbondioxide, methane and nitrous oxide.

Unit VII

Risk assessment of polluted soil, Remediation/ amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

V. Practical

Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safe guard food safety, Air sampling and determination of particulate matter and oxides of sulphur, NO_2 and O_2 conc**.** Visit to various industrial sites to study the impact of pollutants on soil and plants.

VI. Suggested Reading

- Lal R, Kimble J, Levine E and Stewart BA. 1995. *Soil Management and Greenhouse Effect.* CRC Press.
- Middlebrooks EJ. 1979. *Industrial Pollution Control.* Vol. I. *Agro-Industries*. John Wiley Interscience.
- Ross SM. *Toxic Metals in Soil Plant Systems*. John Wiley & Sons.
- Vesilund PA and Pierce 1983. *Environmental Pollution and Control*. Ann Arbor Science Publ.

I. Course Title : Remote Sensing and GIS Technique for Soil, Water and Crop Studies

II. Course Code : Soil 509

III. Credit Hours : 2+1

Unit I

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter, basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS)

Unit II

Sensor systems-camera, microwave radio meters and scanners; fundamentals of aerial photographs and multispectral imaging, hyperspectral imaging, thermal imaging; image processing and interpretations.

Unit III

Application of remote sensing techniques-landuse soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, waste land identification and management.

Unit IV

Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

Unit V

Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).

IV. Practical

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photo graphs and satellite data for mapping of land resources, Analysis of variability of different soil properties with classical and geostatistical techniques, Creation of datafiles in a database programme, Use of GIS for soil spatial simulation and analysis, To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning.

IX. Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Elangovan K. 2006. *GIS Fundamentals, Applications and Implementations*. New India Publ. Agency.
- Lillesand TM and Kiefer RW. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.
- Nielsen DR and Wendroth O. 2003. *Spatial and Temporal Statis*tics. Catena Verloggmbh.
- Star J and Esles J. 1990. *Geographic Information System: An Introduction*. Prentice Hall.

I. Course Title : Analytical Technique and Instrumental Methods in Soil and Plant Analysis

II. Course Code : Soil 510

III. Credit Hours : 0+2

IV. Practical

Unit I

Preparation of solutions for standard curves, indicators and standard solutions foracid-base, oXidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

Unit II

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

Unit III

Principles of visible, ultra violet and infrared spectrophotometery, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometery; identification of minerals by X-ray by different methods, CHNS analyzer.

Unit IV

Electrochemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

Unit V

Wet digestion/fusion/extraction of soil with aquaregia with soil for elemental analysis; triacid/di-acid digestion of plant samples; determination of available and total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in soils; determination of total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in plants

Unit VI

Drawing normalized exchange isotherms; measurement of redox potential.

V. Teaching methods/activities

Classroom teaching and laboratory practicals

VIII. Suggested Reading

- Hesse P. 971. *Textbook of Soil Chemical Analysis*. William Clowes & Sons.
- Jackson ML. 1967. *Soil Chemical Analysis*. Prentice Hall of India.
- Keith A Smith 1991. *Soil Analysis; Modern Instrumental Techniques*. Marcel Dekker.
- Kenneth Helrich 1990. *Official Methods of Analysis*. Association of Official Analytical Chemists.
- Page AL, Miller RH and Keeney DR. 1982. *Methods of Soil Analysis*. Part II. SSSA, Madison.
- Piper CE. *Soil and Plant Analysis*. Hans Publ.
- Singh D, Chhonkar PK and Pandey RN. 1999. *Soil Plant Water Analysis - A Methods Manual*. IARI, New Delhi.
- Tan KH. 2003. *Soil Sampling, Preparation and Analysis*. CRC Press/Taylor & Francis.
- Tandon HLS. 1993. *Methods of Analysis of Soils, Fertilizers and Wat*ers. FDCO, New Delhi.
- Vogel AL. 1979. *A Textbook of Quantitative Inorganic Analysis*. ELBS Longman.

I. Course Title : Management of Problem Soils and Water

II. Course Code : Soil 511

III. Credit Hours : 2+1

IV. Theory

Unit I

Area and distribution of problem soils–acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.

Unit II

Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils-soluble salts, ESP, pH; physical, chemical and microbiological properties.

Unit III

Management of salt-affected soils; salt tolerance of crops- mechanism and ratings; salt stress meaning and its effect on crop growth, monitoring of soils alinity in the field; management principles for sandy, clayey, red lateritic and dryland soils.

Unit IV

Acid soils-nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management.

Unit V

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

Unit VI

Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality groundwaters.

V. Practical

Characterization of acid, acid sulfate, salt-affected and calcareous soils, Determination of cations (Na+, K+, Ca++ and Mg++) in groundwater and soil samples, Determination of an ions (Cl^-, SO_4^-, CO_3^- and HCO_{3-}) in ground watersand soil samples, Lime and gypsum requirements of acid and sodic soils.

VI. Resources

- Bear FE. 1964. *Chemistry of the Soil*. Oxford & IBH.
- Jurinak JJ. 1978. *Salt-affected Soils*. Department of Soil Science & Biometeorology. Utah State University
- USDA Handbook No. 60. 1954. *Diagnosis and improvement of Saline and Alkali Soils*. Oxford & IBH.

I. Course Title : Land Degradation and Restoration

II. Course Code : Soil 512

III. Credit Hours : 1+0

IV. Theory

Unit I

Type, factors and processes of soil/land degradation and its impact on soil productivity including soil fauna, biodegradation and environment.

Unit II

Land restoration and conservation techniques-erosion control, reclamation of salt-affectedsoils; minelandreclamation, afforestation, organic products.

Unit III

Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

VIII. Suggested Reading

- Biswas TD and Narayanasamy G. (Eds.). 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Soc. Soil Sci. 17, New Delhi.
- Doran JW and Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Madison.
- Greenland DJ and Szabolcs I. 1994. *Soil Resilience and Sustainable Land Use*. CABI.
- Lal R, Blum WEH, Vailentine C and Stewart BA. 1997. *Methods for Assessment of Soil Degradation*. CRC Press.
- Sehgal J and Abrol IP. 1994. *Soil Degradation in India - Status and Impact*. Oxford & IBH.

I. Course Title : Soil Survey and Land Use Planning

II. Course Code : Soil 513

III. Credit Hours : 2+0

IV. Theory

Unit I

Soil survey and its types; soil survey techniques- conventional and modern; soil series–characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; thematic soil maps, cartography, mapping units, techniques for gene ration of soil maps, application of remote sensing and GIS in soil survey and mapping of major soil group of India

Unit II

Landform–soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT)–concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Unit III

Concept and techniques of land use planning; factors governing present land use; Land evaluation method sand soil-site suitability evaluation for different crops; land capability classification and constraints in application.

Unit IV

Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production. Status of LUP in India.

V. Practical

- Aerial photo and satellite data interpretation for soil and land use
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in differentscales
- Land use planning exercises using conventional and RS tools

IX. Suggested Reading

- Boul SW, Hole ED, MacCraken RJ and Southard RJ. 1997. *Soil Genesis and Classification.* 4th Ed. Panima Publ.
- Brewer R. 1976. *Fabric and Mineral Analysis of Soils.* John Wiley & Sons.

I. Course Title : Introduction to Nanotechnology

II. Course Code : Soil 514

III. Credit Hours : 2+1

IV. Theory

Unit I

General introduction: Basics of quantum mechanics, harmonic oscillator, magnetic phenomena, band structure in solids, Mössbauer effect and spectroscopy, optical phenomena, bond in solids, an isotropy.

Unit II

Nanostructures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nano tubes and nanowires, fullerenes (buckballs, graphene). Nanofabrication and nano-patterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, process of synthesis of nanopowders, electrode position, important nanomaterials.

Unit III

Mechanical properties, magnetic properties, electrical properties, electronic conduction with nanoparticles, investigating and manipulating materials in the nanoscale: Electron microscopy

Unit IV

Nano-biology: Interaction between biomolecules and nano-particle surface, different types of in organic materials used for the synthesis of hybrid nano-bioassemblies, application of nano-inagriculture, current status of nano-biotechnology, future perspectives of nano-biology, nano-sensors.

V. Practical

- Sources of nanoparticles and its preparation by different approaches
- Electrospinning and its use in agriculture and allied sector.
- Equipments used in Nanotechnology: its principle and uses
- Acquaintances with different equipments used in nanotechnology.
- Synthesis and characterization of Ag and ZnO nanoparticles.
- Mode of action of ZnO nanoparticles against soil borne diseases
- Study on efficacy of ZnO nanoparticles as seed treating agent on plant growth parameters.

IX. Suggested Reading

- Balandin AA and Wang KL. 2006. *Handbook of semiconductor nano structures and nano devices*. California: American Scientific Publishers.
- Timp G. 1999. *Nanotechnology*. New York: Springer Verlag.
- Challa Kumar SSR. 2006. *Nanotechnologies for the life sciences*. Weinheim: Wiley-VCHGmbH.
- Kohler M and Frintzsche W. 2007. *Nanotechnology: Introduction to nanostructuring techniques* W Weinheim: Wiley-VCH Verlag GmbH.
- Kosal ME. 2009. *Nanotechnology for chemicao and biological defense*. Dordrecht: Stringer.

Course Title with Credit Load
Ph.D. in Soil Science

Course Code	Course Title	Credit Hours	Semester
Soil 601	Recent trends in soil physics	2+0	II
Soil 602	Modern concept in soil fertility	2+0	II
Soil 603*	Physical chemistry of soil	2+0	II
Soil 604*	Soil genesis and micromorphology	2+0	I
Soil 605	Bio-chemistry of soil organic matter	2+0	I
Soil 606	Soil resource management	3+0	I
Soil 607	Modelling of soil plant system	2+0	I
Soil 608	Clay Mineralogy	2+1	II
Soil 609	Recent trends in soil microbial biodiversity	2+1	I
Soil 691	Doctoral seminar	1+0	I
Soil 692	Doctoral seminar	1+0	II
Soil 699	Doctoral Research	-75	

*Indicates Core Courses which are Compulsory for PhD Programme

Course Contents
Ph.D. in Soil Science

I. Course Title : Recent Trends in Soil Physics

II. Course Code : Soil 601

III. Credit Hours : 2+0

IV. Theory

Unit I

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system, soil-plant-atmospheric continuum (SPAC).

Unit II

Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated waterflow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional waterflow.

Unit III

Theories of horizontal and vertical infiltration under different boundary conditions.

Unit IV

Movement of salts in soils, models formiscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.

Unit V

Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heatflow, measurement of thermal conductivity of soil; Soil, Plant, Water relations- Plant uptake of soil moisture, Water balance and energy balance in the field; irrigation and water use efficiency.

Unit VI

Soil crust and clod formation; structural management of puddled rice soils; soil conditioning-concept, soils conditioners-types, characteristics, working principles, significance in agriculture.

Unit VII

Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer.

VII. Suggested Reading

- Baver LD, Gardner WH and Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
- Hanks and Ascheroft. 1980. *Applied Soil Physics*. Springer Verlag.
- Hillel D. 1980. *Applications of Soil Physics*. Academic Press.
- Hillel D. 1980. *Environmental Soil Physi*cs. Academic Press.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Kirkham D and Powers WL. 1972. *Advanced Soil Physics*. Wiley Interscience.
- Lal R and Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

I. Course Title : Modern Concept in Soil Fertility

II. Course Code : Soil 602

III. Credit Hours : 2+0

IV. Theory

Unit I

Nutrient availability-concept and relationships, modern concepts of nutrient s availability; soil colloids and nutrient availability; soil amendments and availability maintenance of nutrients, soil solution and plant growth; nutrient response functions and availability indices.

Unit II

Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.

Unit III

Chemical equilibria (including solid-solution equilbria) involving nutrientions in soils, particularly in submerged soils; Kinetic studies of nutrients in soils.

Unit IV

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

Unit V

Modernconcepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

Unit VI

Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Unit VII

Carbon– a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes; greenhouse effect and climate change; carbon sequestration vis-à-vis sustenance of soil quality and crop productivity.

V. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VI. Learning outcome

Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

VII. Suggested Reading

- Barber SA. 1995. *Soil Nutrient Bioavailability*. John Wiley & Sons.
- Barker V Allen and Pilbeam David J. 2007. *Handbook of Plant Nutrition*. CRC / Taylor & Francis.
- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Educ.
- Cooke GW. 1979. *The Control of Soil Fertility*. Crossby Lockwood & Sons.
- Epstein E. 1987. *Mineral Nutrition of Plants - Principles and Perspectives*. International Potash Institute, Switzerland.
- Kabata- Pendias Alina 2001. *Trace Elements in Soils and Plants*. CRC / Taylor & Francis.
- Kannaiyan S, Kumar K and Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.
- Mortvedt JJ, Shuman LM, Cox FR and Welch RM. (Eds.). 1991. *Micronutrients in Agriculture*. 2nd Ed. Soil Science Society of America, Madison.
- Prasad R and Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.
- Stevenson FJ and Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Stevenson FJ. (Ed.). 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison.
- Tisdale SL, Nelson WL, Beaton JD and Havlin JL. 1990. *Soil Fertility and Fertilizers*. 5th Ed. Macmillan Publ.
- Wild A. (Ed.). 1988. *Russell's Soil Conditions and Plant Growth*. 11th Ed. Longman.

I. Course Title : Physical Chemistry of Soil

II. Course Code : Soil 603

III. Credit Hours : 2+0

IV. Theory

Unit I

Colloidal chemistry of in organic and organic components of soils–their formation, clay organic interaction.

Unit II

Predictive approaches for cation exchange equilibria- thermodynamics, empirical and diffuse double layer theory (DDL)- relationships among different selectivity coefficients; structure and properties of diffuse double layer.

Unit III

Thermodynamics of nutrient transformations in soils; Climate change effects on minerology and surface properties of variable charge; cationic and anionic exchange and their models, molecular interaction.

Unit IV

Adsorption/desorption isotherms-Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on in organic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).

Unit V

Common solubility equilibria-carbonates, ironoxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of

examples from agricultural use).

V. Suggested Reading

- Bear RE. 1964. *Chemistry of the Soil.* Oxford & IBH.
- Bolt GH and Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.
- Fried M and Broeshart H. 1967. *Soil Plant System in Relation to Inorganic Nutrition.* Academic Press.
- Greenland DJ and Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.
- Greenland DJ and Hayes MHB. 1978. *Chemistry of Soil Constituents.* John Wiley & Sons.
- Jurinak JJ. 1978. *Chemistry of Aquatic Systems*. Department of Soil Science and Biometeorology, Utah State University
- McBride MB. 1994. *Environmental Chemistry of Soils.* Oxford University Press.
- Sparks DL. 1999. *Soil Physical Chemistry*. 2nd Ed. CRC Press.
- Sposito G. 1981. *The Thermodynamics of Soil Solutions.* Oxford University Press.
- Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford University Press.
- Sposito G. 1989. *The Chemistry of Soils*. Oxford University Press.
- Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley.
- van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

I. Course Title : Soil Genesis and Micromorphology

II. Course Code : Soil 604

III. Credit Hours : 2+0

IV. Theory

Unit I

Pedogenic evolution of soils; soil composition and characterization.

Unit II

Weathering and soil formation–factors and pedogenic processes; stability and weathering sequences of minerals.

Unit III

Assessment of soil profile development by mineralogical and chemical analysis.

Unit IV

Micro-pedological features of soils–their structure, fabric analysis, role in genesis and classification.

V. Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.
- Dixon JB and Weed SB. 1989. *Minerals in Soil Environments*. 2nd Ed. Soil Science Society of America, Madison.
- Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science.* ISSS, New Delhi.
- Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi
- Sehgal J. 2002. *Pedology - Concepts and Applications*. Kalyani.
- USDA. 1999. *Soil Taxonomy*. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.

- Wade FA and Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.

I. Course Title : Biochemistry of Soil Organic Matter

II. Course Code : Soil 605

III. Credit Hours : 2+0

IV. Aim of the course

To impart knowledge related to chemistry and reactions of organic substances and their significance in soils.

V. Theory

Unit I

Organic matter in soils and its maintenance Role of organic matter in soil productivity; humus levels in soils; current thinking on the maintenance of organic matter in the soils. Carbon retention and sequestration.

Unit II

Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.

Unit III

Nutrient transformation–N, P, S; tracemetal interaction with humic substances, significance of chelation reactions in soils.

Unit IV

Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes.

Unit V

Humus-pesticide interactions in soil, mechanisms.

VI. Reading Materials

- Lynch JM, Willey JM. *Soil Biotechnology*.
- Paul EA and Clark FE. *Soil Microbiology and Biochemistry*
- Sherwood LM and Woolverton CJ. *Prescott's Microbiology*.
- Subba Rao NS. *Advances In Agricultural Microbiology*

I. Course Title : Soil Resource Management

II. Course Code : Soil 606

III. Credit Hours : 3+0

Unit I

Relevance of soil management to sustainable agriculture; soil as a natural resource for biomass production, filtering, buffering, transportation of solutes, genereserves, and geogenic source of raw materials; soil as a source and sink of greenhouse gases.

Unit II

Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilience and resistance.

Unit III

Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation; history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semiarid, coastal and diaralands. Management of forest, peat and muck soils.

Unit IV

Soil conservation planning; land capability classification; soil conservation in special problem are as such as hilly, arid and semi-arid regions, waterlogged and wetlands; land restoration and conservation techniques–erosion control, reclamation of salt affected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation.

Unit V

Watershed management-concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds.

Unit VI

Agro-ecological regions of India; potentials and constraints of soils of different regions; land evaluation and rationalizing land use, decision support system with relation to land management; national and international soil policy considerations.

IV. Suggested Reading

- Abrol IP and Dhruvanarayana VV. 1990. *Technology for Wasteland Development*. ICAR, New Delhi.
- Andriesse JP. 1988. *Nature and Management of Tropical Peat Soils*, Soil Resources, FAO Soils Bulletin 59, Management and Conservation Service, Land and Water Development Division, FAO, Rome
- Blackwell, Dent D and Young A. 1981. *Soil Survey and Land Evaluation*. George Allen and Unwin, London.
- Burrough A and McDonnell RK. 1998.*Principles of Geographical Information System*. OXford University Press.
- Dan Binkley D and Fisher R. 2012. *Ecology and Management of Forest Soils*,4th Edition, Wiley.
- FAO. 1996. *Land Quality Indicators and their Use in Sustainable Agriculture and Rural Development*. FAO Land and Water Bulletin.5. FAO, Rome.
- Faroq M and Siddique K. (Ed.). 2015. *Conservation Agriculture*, Springer Nature, Chennai,

India.
- FESL. 1993. *An International Framework for Evaluating Sustainable Land Management, FAO World Soil Resources Report No. 73*, Land Development Division, FAO, Rome.
- ISSS. 1994. *Management of Land and Water Resources for Sustainable Agriculture and Environment*. Diamond Jubilee Symposium Publication, Indian Society of Soil Science, New Delhi.
- Lal R, Blum WEH, Valentine C and Stewart BA. (Editors). 1988. *Methods for Assessment of Soil Degradation*. CRC Press, Boca Raton.
- Mulders MA. 1987. *Remote Sensing in Soil Science*. Elsevier Science Publishers, Amsterdam.
- Sehgal J. 2014. *A Text Book of Pedology Concepts and Application*. Kalyani publishers, New Delhi.
- SSSA 1996. *Methods for Assessing Soil Quality*. SSSA Publication Number 49, Madison, Wisconsin, USA.

I. Course Title : Modelling of Soil Plant System

II. Course Code : Soil 607

III. Credit Hours : 2+0

IV. Theory

Unit I

Introduction, terms and definitions; classification of models; Taylor series; numerical methods of differentiation and integration.

Unit II

High level computer language: FORTRAN-its commands and usage; testing and evaluation of model.

Unit III

Description of spatially homogeneous models; K transformation model; nitrogen and phosphorus dynamics in soil.

Unit IV

Spatially heterogeneous models; equation of continuity; Simulation of water flow through soil; Explicit and Explicit-Implicit method; simulation of solute movement through soil with variable moisture flux by explicit-implicit method.

Unit V

Nutrient uptake model: Integration of nutrient movement in soil (mass flow and diffusion) and uptake by plants (Michaelis-Menten kinetics); Nutrient uptake model: Solubility and free ion activity model.

IV. Suggested Reading

- Datta SC. 2008. *Theory and Principles of Simulation Modeling in Soil-Plant System*. Capital Publishing Company, New Delhi.
- Frame J and Thornley JHM. 1984. *Mathematical Models in Agriculture—A Quantitative approach to problems in agriculture and related science*. Butterworth and Co. Ltd.
- Freud PJ and Minton PD. 1979. *Regression Methods—A tool for data Analysis*. Marcel Dekker Inc., New York.
- Frissel MJ and Reinger P. 1974. *Simulation of Accumulation and Leaching in Sils*. Oxford and IBM Pub. Co., New Delhi.
- Hanks J and Richie JT. (Eds.). 1991. *Modeling Plant and Soil System*. Agronomy Bulletin No. 31, ASA, SSSA Madison, Wisconsin, USA.
- Lipschutz S and Poe A. 1978. *Schaum's Outline Series–Theory and Problems of programming with Fortran*. McGraw-Hill Book Co., Singapore.
- Penning de Vries FWT, Jansen DM, Ten Berge HFM and Baker A. 1989. *Simulation of ecophysiological processes of growth in several annual crops*. PUDOC, Wageningen.
- Shaffer MJ, Ma L and Hansen S. 2001. *Modeling Carbon and Nitrogen Dynamics for Soil Management*. Lewis Publishers, Boca Raton.

I. Course Title : Clay Mineralogy

II. Course Code : Soil 608

III. Credit Hours : 2+1

IV. Theory

Unit I

Definition and concepts of clays and clay minerals, Fundamentals of crystallography – unit cell, external characteristics of crystals, crystallographic notations, crystal systems.

Unit II

Structures and classification of silicate minerals, basics of phyllosilicates, laws governing structural characteristics of phyllosilicates, Goldschmitdt's laws – Laws I and Law II, Classification of Phyllosilicates.

Unit III

Kaolonite group of minerals, Dioctahedral kaolins and Trioctahedral kaolins.

Unit IV

Smectites; properties of smectites, Reference models of structure, principal types based on Hofmann-Marshal-Hendricks (H-M-H) models, occurrence of smectites, transformation and formation in soils.

Unit V

Micas: occurrence and origin in soils, polytypes of micas, structure and formation of muscovites and illite.

Unit VI

Vermicullites: structure, occurrence in soils, formation, relation between vermiculites and montmorillonite.

Unit VII

Chlorite: occurrence and structure of chlorites, "swelling chlorites", formation of chlorite.

Unit VIII

Non-crystalline clays (amorphous materials), subgroups and chemical composition, morphology and structure, physico-chemical properties, influence of non-crystalline clays on soil properties.

Unit IX

Interstratified clay minerals, occurrence and formation in soils, regularly interstratified and partially random interstratified minerals.

Unit X

Genesis and transformation of clay minerals, Generalized conditions for formation and persistence of common clay-size minerals in soils.

Unit XI

Surface chemistry of clay minerals, clay-organic complexes, nanoclay mineralogy.

Unit XII

Clay minerals in different soil orders, role of clay minerals in soil fertility management.

V. Practicals

- Separation of clay for mineralogical study
- X-ray diffraction analysis of clay
- Selective dissolution of clay minerals
- IR, DTA and SEM of clay minerals
- Identification and quantification of clay minerals
- Determination of surface charge of clay minerals
- Potentiometric titration of clay minerals.

VI. Suggested Reading

- Dixon JB and Weed SB (Co-editors). *Minerals in Soil Environment.*
- Gieseking JE (Ed). *Soil Component*, Vol. 2. Inorganic Components.
- Grim RE. *Clay Mineralogy*.
- Mukherjee SK and Biswas TD (Editors). *Mineralogy of Soil Clays and Clay Minerals.*
- Read HH. *Rutley's Elements of Mineralogy*.
- Wilding LP and Smeck NE. 1983. *Pedogenesis and Soil Taxonomy Part II – Soil Orders.*

I. Course Title : Recent Trends in Soil Microbial Biodiversity

II. Course Code : Soil 609

III. Credit Hours : 2+1

IV. Theory

Unit I

Microbial evaluation and biodiversity, Microbial communities in ecosystems, New insights in below ground diverse of plant performance.

Unit II

Qualitative ecology of microorganisms; Biomass and activities.

Unit III

Nitrogen fixing organisms, Trends in diversity of N fixing organisms. Molecular approaches in characterising N fixing microorganisms.

Unit IV

Serology and molecular characterization, ecological aspects of bio determination, soil waste and water management

Unit V

Biodegradability, testing and monitoring of the bioremediation of xerobiotic pollutants and bacterial fertilizers.

V. Practicals

- Determination of soil microbes using classical techniques.
- Determination of soil microbial diversity using molecular techniques.
- Estimation of soil microbial biomass carbon, nitrogen and phosphorus.
- Estimation of key soil enzyme activities.
- Community level physiological profiling of microbial diversity.

VII. Suggested Reading

- Lynch JM, Willey JM. *Soil Biotechnology*.
- Paul EA and Clark FE. *Soil Microbiology and Biochemistry*.
- Sherwood LM and Woolverton CJ. *Prescott's Microbiology*.
- Subba Rao NS. *Advances In Agricultural Microbiology*.

I. Course Title : Research and Publication Ethics

II. Course Code : Soil 610

III. Credit Hours : 2+0

IV. Theory

Unit I

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II

Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit III

Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV

Publication ethics: Defination, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME, *etc*., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals

Unit V

Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self archiving policies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools, viz., JANE, Elsevier Journal Finder, Springer Journal Suggester etc.

Unit VI

Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools

Unit VII

Database and Research metrics: Indexing data base, citation database, web of science, scopus, *etc*. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g index, i10 index altmetrics

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 2

Physical Sciences
– Organic Farming

Preamble

Although, India had been traditionally organic and its farmers are 40 century farmers with large pool of traditional wisdom on best practices in organic agriculture, the modern standards based organic agriculture started only recently with the growing demand for organic food and fiber in the western world. Movement got major push when civil society organizations and farmer association brought in the focus on sustainability and food safety in the wake of deteriorating soil health and fertility, depleting natural resources, diminishing returns to the farmers and growing chemical residues in food. Growing demand for organic food nationally and internationally with the increased awareness for safe and healthy food further added to the strength of organic farming and attracted the attention of agricultural scientists and planners to look for alternative environment friendly ways which are not only productive enough to meet our growing demands but are also resource conserving and continuously contributing to the improvement of soil health and fertility. Organic agriculture emerged as the viable alternative to all such concerns. Ardent promoters of organic farming consider that present day organic agriculture, which is a mix of traditional wisdom and modern science and technology, can meet all these demands and become the mean for complete development of rural areas, especially in the developing countries like India where large chunk of farmers are small, with limited resources and with limited access to water, mainly through seasonal rains.

Institutional development such as National Programme for Organic production (NPOP) launched during 2001, followed by setting up of National Centre of Organic Farming (NCOF) under Ministry of Agriculture and Farmers Welfare and initiation of Network Project on Organic Farming (NPOF) Research by ICAR during 2004 laid the foundation for systematic development of the sector in the country. Started with just 42,000 ha during 2003-04, it has now grown almost 39-fold, touching a figure of 1.64 million ha during 2017-18. India is now the ninth largest in terms of total arable land under organic farming and largest in terms of total number of organic producers. Market started with exports is also catching up domestically and is now a 5000 crore industry. Dedicated stores and retail chains catering to the demand of organic food can be seen in almost all tier I and tier II cities in the country.

But this growth story has also many shortcomings and weaknesses. In the absence of technology and continuous research support, farmers are struggling to maintain yields. Availability of organic seeds and quality inputs for nutrient and pest management is one of the major bottlenecks. Absence of knowledge for diversified cropping systems (a pre-requisite for organic farming) keeps farmers relying on mono-crops which often yields poorly. Absence of trained manpower for extension, certification management and value chain management is also widely experienced and industry make do with less competent experts and personals. To take the organic farming fast forward it is necessary that efforts are made in value chain mode with an aim to transform farmers into entrepreneurs and create an infrastructure that cater to the ever evolving technology needs through research, extension and education. Although a National Organic Farming Research Institute (NOFRI) at Sikkim and some Institutes of Organic Farming in SAUs has started functioning but still there is lacking of institutions that can cater to the need of trained manpower. ICARs proposal to launch postgraduate programme in organic farming is the first of the efforts to bridge that gap. This report summarizes the recommendations of the committee constituted by the ICAR for drafting the course curriculum for M.Sc. Agriculture in Organic farming:

By the end of March 2017, India has brought more than 3.42 million ha area under organic certification, comprising of 1.64 million ha (47.95%) under cultivation and 1.780 million ha (52.05%) under wild harvest collection. India is producing wide range of crops

under organic management with oilseeds, sugar crops, fiber crops, cereals and millets and pulses occupy the large chunk of the basket.

With mainstreaming of organic farming there is growing requirement for first generation extension personals trained in organic farming. Similarly, for research the country requires first generation scientists with actual organic farming background and passionate-will to work for the sector. As on March 2018 there are more than 3500 grower groups comprising of about 1 million farmers. These groups are known as ICS units and each group comprising of an average of 250-350 farmers and are managed by not less than 5-7 technical persons for documentation management, internal inspections, certification, collective input purchases and sales. Besides third-party certification another farmer group centric certification under PGS-India programme is also certifying farmers. To manage the certification of PGS there are more than 400 Regional Councils and all these require technical manpower, not only in organic crop and livestock management, but also in certification and quality assurance. As on March 2018, there are 28 certification bodies and another 10 are in the pipeline. Each certification body requires an average of 20-150 technical persons. Similarly, for PGS management there are more than 400 Regional Councils requiring more than 4000 technical staff. There are more than 950 organic food processors in the country. As organic system requires complete integrity, therefore processing needs to be dedicated, away from conventional processing units. This is a fast-growing sector and may require large number of organic food professionals in the years to come.Therefore, to feed to the existing and future requirement of technical manpower it is essential that a postgraduate course in organic farming is launched and state Agricultural Universities be encouraged to offer such course.

Minimum Requirements for starting postgraduate course in the University:

1. Faculty

University having Centre of Excellence in Organic farming or having dedicated Institutes for Organic farming are ideal for launching such programme. In cases, if there is no such existing infrastructure then the university must aim to start such Department with multidisciplinary faculty or must be in a position to spare competent faculty for undertaking such course. Initially it may be possible that the institute do not have faculty for each subject, then in such cases faculty may be contracted as visiting faculty for specific course content.

2. Land

As organic farming is a farming system approach, therefore, there is a needfor a dedicated organic farmof not less than 5 ha. This farm must be kept organic for long term as frequent switching of land under conventional and organic is not allowed and may not be advisable.

3. Laboratory

There must be fully equipped laboratory for the following:

(i) Soil testing laboratory having facilities for micronutrient analysis along with the usual soil test parameters. Facilities should also be available for estimation of soil microbial carbon, soil enzymatic analysis and soil respiration studies.
(ii) General microbiological laboratory
(iii) General entomology and plant pathology laboratory
(iv) Access to plant analysis equipment and residue analysis laboratories.

Course Title with Credit Load
M.Sc. (Ag) in Organic Farming

Course Code.	Course Title	Credit Hours
OF 501	Concepts and Principles of organic farming	2+0
OF 502	Soil fertility, Crop Nutrition and Nutrients input	3+1
OF 503	Organic Crop Production Systems	2+1
OF 504	Plant Health Management	2+1
OF 505	Post harvest handling of organic produce	1+1
OF 506	Farming systems suitable for organic managements	2+1
OF 507	Organic certification Standards and regulation	2+1
OF 508	Value Chain Management	2+2
OF 509	Marketing	2+0
OF 510	Research Methodology and Biostatistics	2+1
OF 511	Organic Input Management and Production Technologies	2+1
Soil 591	Masters Seminar	1+0
Soil 599	Masters Research/ Thesis	0+30

Course Contents
M.Sc. (Ag) in Organic Farming

I. Course Title : Concepts and Principles of Organic Farming

II. Course Code : OF 501

III. Credit Hours : 2+0

IV. Theory

Unit I: Concepts and principles of organic farming

History and evolution of organic farming in the world and India. Scenario of organic farming in India and world, global market for organic products, IFOAM's Guiding principles of organic farming, conversion to organic agriculture, advantages and limitations.

Unit II: Definitions and types of organic farming

Definitions of organic farming, types of organic farming such as natural farming, zero chemical natural farming, bio dynamic farming, biological farming, compost farming, Natueco culture, integrated farming, homa farming, permaculture etc, traditional farming systems in India and evolving indigenous knowledge systems

Unit III: Conventional *vs* Organic farming

Philosophy of two farming systems, fundamental differences, productivity issues, management protocols, food quality, nutritional differences and impact of conventional practices on soil fertility, natural resources, environment and overall social perception. Myths and realities about organic farming in addressing nutritional security and food safety need *vis-à-vis* national food security.

Unit IV: Advocacy, Ethics, health and social issues in organic farming

Advocacy for organic farming with sustainability, resource conservation and food safety issues. Advocacy through overall farm productivity under diversified cropping systems. Spirituality values and ethics in organic farming. Socio economic importance of organic farming: concept measurements and issues. Need for ethical practices and values across the organic agriculture value chain including trading and reaching to consumers.

Unit V: Organic farming for sustainability, resource conservation, climate change issues and safe and healthy food

General concerns on sustainability, climate change issues threatening sustainability, potential of organic farming practices in addressing sustainability and climate change. Resource conservation through organic farming, rainwater conservation and preservation of native seeds and germplasm an essential component of organic farming, Consumers concerns on food quality and safety, organic farming for safe and healthy food, ITKs potential and role in sustainability of modern organic farming practices

Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition.
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B.Singh. Published by Jain Brothers
- *Basics of Organic Farming:* Deshpande, WR, 2009, All India Biodynamic and Organic Farming Association, Indore, MP, India P-306.
- Eyhorn, F, Heeb M and Weidmann, Gilles IFOAM *Training Manual for Organic Agriculture in the Tropics*, FiBL and IFOAM.

I. Course Title : Soil Fertility, Crop Nutrition and Nutrient Inputs

II. Course Code : OF 502

III. Credit Hours : 3+1

IV. Theory

Unit I: Soil – Source of Infinite Life

Soil as source of life, fundamentals of soil structure and quality, soil fertility, physico-chemical parameters and soil as living entity in organic farming.

Unit II: Soil fertility and productivity

History of soil fertility and plant nutrition. Factors affecting; features of good management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Unit III: Soil fertility evaluation

Physico-chemical soil testing, biological methods for soil health evaluation, plant and tissue tests; soil quality in relation to sustainable agriculture. Nutrient requirement modeling based on soil health and resources availability.

Unit IV: Soil Conservation and Soil Water Management

Principles of soil and water conservation, general practices for soil and water conservation, soil carbon buildup and biomass recycling.

Unit V: Soil biology and role of microorganisms in soil fertility management

Soil as a habitat for microorganisms, Soil microorganisms, Soil microbial ecology, Soil microbial biomass, Soil enzymes – origin, activity and importance. Microbial management of agricultural, domestic and industrial wastes for potential application in organic farming. Microbiology of composting and bio-methanation. Biodegradation of xenobiotics. Bioremediation – principles and application.

Unit VI: Nutrient recycling

Nitrogen, phosphorus and potash cycles, management for nutrient recycling, methods for recycling and reducing nutrient losses.

Unit VII: Management practices

Management practices in organic agriculture (mulching, fallowing, intercropping, manuring, crop rotation, agro-forestry, mixed farming).

Unit VIII: Organic fertilizers and composting technology

Compositing principles and factors affecting composting, dynamics of compositing, methods of composting, different forms of composts with nutrient profiles, Rapid methods of composting, liquid manures, compost enrichment through concentrates, minerals and micronutrients. Field application of compost and their response to crops.

Unit IX: Vermicomposting technology

Earthworm biology, principles of vermicomposting, methods for vermicompost production, nutrient profiling, field application and its response to crop yields

Unit X: Biofertilizers

Different types of biofertilizers, their contribution to soil fertility and nutrient pool, factors affecting their application and response, assessment of biofertilizers application to crop yields.

Unit XI: Addressing nutrient deficiencies and mineral fortification of composts (P, K, S and micro nutrients)

Identification of deficiency, need assessment, identification of mineral resource, fortification of composts and impact assessment on application

Unit XII: Indigenous practices in soil fertility and nutrient management

Indigenous inputs such as liquid manures, Jivamrit, Panchgavya, on-farm protein hydrolysates, plant extracts, dung-urine slurries etc, their production methods and effect of their application on soil fertility and crop productivity.

V. Practical

- Introduction of analytical instruments and their principles, calibration and applications, Determination of soil pH, electrical conductivity, organic carbon, total and available nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and DTPA extractable micronutrients in soil and their interpretations.
- Biological health assessment through dehydrogenases, soil microbial carbon and soil respiration
- Making of composts through aerobic and anaerobic methods
- Making of vermicomost using earthworms
- Analysis of manures and composts for NPK and heavy metals
- Microbial profiling of Jivamrit/ panchgavya

Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B.Singh. Jain Brothers
- *Manufacture of Biofertilizer and Organic Farming.* AB publisher

I. Course Title : Organic Crop Production systems

II. Course Code : OF 503

III. Credit Hours : 2+1

IV. Theory

Unit I: Fundamentals of organic farm management and conversion

Salient features of organic farm management, strategies for conversion to organic, step-by-step planning, integration of contamination control measures, planning for on-farm input production and supplementary off-farm inputs, planning for rain water harvesting and water conservation approaches including efficient irrigation systems and moisture preservation techniques, visit to organic farms and study on farmer's best practices for conversion.

Unit II: Management of diversity and cropping systems

Importance of diversity, installation of diversity through plantation of utility trees, nitrogen fixing tree hedges, habitat management for friendly insects and birds and nitrogen fixing crops as intercrops. Importance of cropping systems management with long term planning, crop rotations, intercropping, multi cropping, relay cropping, multi-layered cropping.

Unit III: Nutrient management

Components of nutrient management in organic crop production, assessment of crop nutrient requirements, calculation of nutrient credits from on-farm practices and resources such as intercrops, cover crops, biomass mulching, calculating additional input requirements. Managing nutrient needs through use of organic manures, viz. FYM, compost, Vermicompost, oil cakes, *in-situ* and *ex-situ* green manuring, crop residue management, use of restricted organic nutrient sources, liquid organic manures and dung urine slurries, methods of manuring and biomass application, split application of manures, foliar feeding as replacement of top dressing, ITKs and farmers innovations in nutrient management

Unit IV: Integration of microbial and mineral inputs

Importance of bio fertilizers, types of biofertilizers, nutrient potential, methods of application, enriching manures/ composts with biofertilizers, identifying the need for use of supplementary mineral sources and their integration in nutrient management package.

Unit V: Weed management

Prevention of weeds through cropping systems management, crop geometry, stale seedbed technique, summer ploughing, soil solarisation, cover crops, mulching,flooding, biological weed management, selection of suitable physical and mechanical approaches and biological and plastic mulches.

Unit VI: Water and Irrigation Management

Soil-water relation, theories of water availability, water use efficiency management, methods of irrigation and automation in irrigation systems, irrigation scheduling in different crops.

Unit VII: Modeling of agronomic practices and nutrient management protocols for some important agricultural and horticultural crops

Identification of compatible associate and intercrops/ companion crops, placing trap crops and insectary plants in cropping geometry, making provisions for nutrient credits from biomass mulching, intercrops and green manures, making provisions for nutrient credits from microbial enrichment with microbial/ liquid manure inputs, balance nutrient requirement modeling and identification of inputs and planning

for quantity and time of application.

Unit VIII: Crop growth and yield analysis

Crop growth expressions in plants, growth measurements, important growth indices and forms of growth analysis in field crops. Factors determining yield. Use of growth analysis technique to study variation in yield due to planting season, planting density, fertilizer treatment, other agronomic practices, light, temperature, water, growth substances, varietal differences. Crop response curves. Dynamics of crop growth and modeling.

Unit IX: Success stories of effective crop management with optimum yields of practicing organic farmers (one in irrigated systems and one in rainfed systems)

Field visit, documentation of farming system with inputs and outputs, identification of practices important for organic systems, nutrient management practices, pest management protocols, yields and economics. Salient features for success and for further replication in crop production modeling.

V. Practical

- Visit to organic farms and study general nutrient management practices, documentation of farming system with inputs and outputs and crop growth analysis using crop growth analysis techniques
- Getting acquainted with different tilling methods and rain water harvesting and water conservation techniques
- Production of liquid manures and dung-urine slurries
- Production of customized composts using FYM/ Compost, mineral nutrients and biofertilizers, assessment of nutrient profiles in enriched composts
- Methods of application for biofertilizers
- Weed management practices, tools and efficacy of different approaches
- Modelling of agronomic practices for a given cropping system with use of available resources.

XI Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B. Singh. Jain Brothers.

I. Course Title : Plant Health Management

II. Course Code : OF 504

III. Credit Hours : 2+1

IV. Theory

Unit I: Classification of pest organisms

Classification of pests, viz. weeds, bacteria, nematodes, fungi, insects, viruses, vertebrates, *etc*, identification of pests and beneficial organisms.

Unit II: General principles of plant health management in organic farming

Principles of pest management in organic crop production; Pest surveillance and pest population estimation; concept of economic injury levels (EILs) and economic threshold levels (ETLs), principles of Agro Eco-System Analysis (AESA) based pest management, estimation of Pest: Defender (P: D) ratio, understanding AESA methodology.

Unit III: Biology of pests and population dynamics

Population dynamics in relation to environment, distribution, identification; Life cycle of key pests of cereals, pulses, vegetables, stored grains, fruit crops and protected cultivation.

Unit IV: Ecological strategies for pest management

Proper sanitation, appropriate fertilization, necessary pruning, timing of planting to escape infection, crop rotation, avoidance of endemic sites, space management for sunlight and air, plant quarantine, *etc.*

Unit V: Cultural and physical control strategies

Importance and use of traps, coloured plates, pheromones, use of insectary plants, trap crops and planning for diversity plant integration as border crops, hedge rows, intercrops, *etc.*

Unit VI: Biological control

Conservation of natural enemies, classical biological control systems, important beneficial insects and their integration and use in different cropping systems.

Unit VII: Biopesticides

Biopesticides, types, mode of action, production, methods of application and impact assessment on crops and pest load.

Unit VIII: Botanical pest management

Using different plants for management of different pests, methods for using such plants and active ingredient extraction methodologies, formulation of usable solutions and methodologies for application. Integrated strategies, development of crop specific integrated management modules, importance and need for chemical alternatives permitted in organic farming, methods for use and application.

Unit IX: Indigenous practices and their importance in plant protection

Indigenous practices of avoiding pests, managing pests, important plants being used since ages and innovative botanical and fermentation inputs developed by farmers for pest management.

Unit X: Pest control of produce in storage

Physical, mechanical and biological approaches, modified environment, management of hygiene and phyto-sanitary approaches, use of organically acceptable fumigants such as carbon dioxide and nitrogen.

V. Practical

- Collection and Identification of major/ key pests and plant diseases,
- Estimation of pest population, nature of damage, assessment of crop losses,
- Familiarization with important crop pests & diseases and their biological control agents,
- Demonstration/ familiarization with various tools of insect-pest & disease management,
- Mass rearing techniques of important biological control agents,
- Preparation of organic/ natural formulations for insect-pest & disease management,
- Evaluation of organic formulations for determining their pesticidal properties and field efficacy.
- Preparation and validation of traditional formulations.

VI. Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B. Singh. Jain Brothers
- *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher

I. Course Title : Post Harvest-handling of Organic Produce

II. Course Code : OF 505

III. Credit Hours : 1+1

IV. Theory

Unit I: Pre/Postharvest Factors for Post-harvest Losses of Organic Produce

Pre and post-harvest factors responsible for causing organic produce losses. Principles and practices responsible for losses of organic agricultural produce. Qualitative, quantitative, nutritional and socioeconomic losses. Loss assessment and estimation techniques and their limitations and methods for reducing postharvest losses.

Unit II: Introduction to Value Chain and Handling of Fresh Organic Products for Processing

Management of hygiene and phyto-sanitary measures, measures to reduce field heat, cleaning and washing, control of enzymatic and non-enzymatic changes, transportation, sorting, grading, peeling, sampling and size reduction, packaging, labelling; handling methods for fresh fruits, vegetables and flowers.

Unit III: Organic Food Processing and Preservation

Fundamental principles for food processing in organic farming, acceptable processing techniques, use of preservatives, processing aids, flavouring agents and nutrient supplement in organic food and feed processing.

Unit IV: Food Standards and Residue Analysis/ Toxicology

Fundamental principles of food standards, HACCP system, US and European Export/ Import standards for different crops, MRLs, sources of contamination, assessment and management of residues and toxins in food, critical control points, heavy metals and pesticide residue analysis, analytical methods and tools. Interpretation of residue analysis reports, analysis protocols and GMO report analysis.

Unit V: Principles of Packaging

Characteristics of packaging materials for organic food, packaging requirements for fresh and processed organic food for local and international markets, labelling requirements for fresh and processed organic food for local and international markets, labelling requirements and management integrity.

V. Practicals

- Study of maturity indices for harvest of organic fruits, vegetables, spices and plantation crops.
- Determination of physiological loss in weight and respiration rate in fruits and vegetables.
- Determination of chemical constituents like sugar, starch, pigments, vitamin C, carotenes, acidity during maturation and ripening in fruits/ vegetables.
- Protective skin coating with organic wax emulsion to extend the shelf life of fruits and vegetables.
- Study of effect of precooling on shelf-life and quality of fresh fruits, vegetables and flowers.
- Study of packages-bulk and consumer packs for different fruits, vegetables, flowers and spices.
- Study of construction and working of zero energy cool chamber. Study of storage behaviour of different fruits and vegetables in zero energy cool chamber.
- Preparation and preservation of fruit-based beverages and blended products from fruits and vegetables.

- HACCP analysis, residue analysis in organic products. Visit to packaging centres, local markets, cooperative organisations, super markets dealing with marketing of organic perishables.

VII. Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B. Singh. Jain Brothers.

I. Course Title : **Farming Systems Concepts and Practices for Organic Farming**

II. Course Code : **OF 506**

III. Credit Hours : **2+1**

IV. Theory

Unit I: Introduction

Farming systems: Definition, importance, classification and scope, Classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises, Concept of sustainability in farming systems, role of integrated farming systems in agriculture, approaches

Unit II: Agro-ecology

Concepts and practices, Agro-ecology and the design of Sustainable Agro-ecosystems, Ecological processes to optimize in agro-ecosystems, Sustainable Agriculture: Basic Definitions and Concepts, Alternative Sustainable Farming Systems, Low external input sustainable agriculture

Unit III: Enterprises selection and Integration

Natural Farming Systems, Intentional Integrated Farming Systems, Pre-dominant farming systems in various regions, Eco-physiological approaches component selection and integration, Complementary and competitive interaction, Primary, Secondary, Complimentary and Supplementary enterprises for organic farming, livestock based systems, vertical farming, Principles and Practices of organic livestock production, Principles of organic aquaculture, Organic fruit and vegetable production practices, Models of integrated farming systems for irrigated ecosystems and rainfed ecosystems

Unit IV: Modeling of farming systems

Simulation models for intercropping, farming system design using farm design for various resource conditions, Linear programming, Multi-objective criteria decision making, Fuzzy logic analysis, Artificial Neural Network (ANN) based modeling, DSSAT, Infocrop, Cropsyst, Livesim

Unit V: Integrated Organic Farming Systems

Concepts, Principles, Strategies, Diversity plantations, Diversified cropping systems, crop rotations, soil fertility management, Selection of seeds, varieties and planting material, nutrient management, weed and pest management, integration of livestock, breeds and allied activities, *In-situ* recycling of Organic Wastes, Products and processes of composting, Component optimization, Market input chain, family employment generation, case studies, supplementary, Complimentary and substitution effects under dry-land, irrigated, wetland and hill-zone eco systems

Unit VI: Soil-crop-livestock-human chain

Bio-nutrition concepts, design of farming systems for nutrition, Household level production of food, feed, fodder, fertilizer, fuel and fibre from farming systems

Unit VII: Secondary Agriculture

Product diversification, Process diversification, processing of marketable surplus produces, packaging, branding and marketing

Unit VIII: Contract Farming

Farming system based cluster formation, production, processing and marketing, legal aspects of contract farming

Unit IX: Specialized farming systems

Protected cultivation, high value crops based systems, water based farming systems, region specific integrated farming systems, medicinal herb based systems

Unit X: Farming System diversification

Existing scenario of farming systems, need for diversification, methods of diversification, horizontal and vertical diversification

Unit XI: Four P Model of organic farming system

4P (Planning, Production, Processing and Promotion) model of organic farming systems

Unit XII: Ecological Engineering

Principles and Practices, Ecological engineering approach of soil fertility and pest management, examples of ecological engineering in traditional farming systems, case studies

V. Practical

- Agro-ecosystem analysis: Field study of farming systems in the context of production flows, energy flows and pest dynamics using quantitative tools
- Farming System typology analysis and clustering of group of farmers
- Synthesis of organic farming system model for a given region using primary and secondary data
- Estimation of ecological, economic, social and sustainable livelihood indicators for a given farming system
- Design of alternative farming systems using Farm Design and other available modelling tools
- Experiential learning on different enterprises
- Documentation of farming system case studies

VI. Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B.Singh. Jain Brothers.
- *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher.

I. Course Title : Organic Certification, Standards and Regulations

II. Course Code : OF 507

III. Credit Hours : 2+1

IV. Theory

Unit I

National and international regulations on quality assurance and certification

National Programme for Organic Production (NPOP), National Standards for Organic Production (NSOP), USDA NOP Programme and standards, EU Organic standards, Codex Alimentarius, Canada Organic regulation and important differences between NPOP and international standards. FSS Act 2006 for organic food, basic requirements, enforcement, standard operating procedures and verification in value chain

Unit II

ISO systems for quality assurance (ISO 17065, ISO 17011, ISO 19011 etc) and accreditation processes

What is ISO, salient features and functions of ISO, ISO systems for auditing, ISO 17065 for auditing and certification agencies, ISO 19011 Inspection protocols, ISO17011 Accreditation requirements, ISO 17025 Accreditation of quality analysis laboratories. Accreditation procedure and policies under NPOP, Essential requirements and competence for making an organic certification body, Conflict of interest management

Unit III

Types of certification systems (NPOP and PGS), standards and procedures

NPOP - A third party certification systems, Certification bodies operational policies and functions, National standards for crop production, livestock, Aquaculture, Processing and handling and other miscellaneous systems. Tracenet the online data management tool and traceability management

PGS – Participatory Guarantee Systems **–** Evolution of PGS Systems, Guiding principles, PGS Standards, International scenario on PGS development Procedure for organic guarantee under PGS systems, PGS-India programme, operation of PGS-India programme, institutional structure, PGS-India Data management platform, management of traceability.

Unit IV

On-field management of standard compliance and documentation

Issues for implementation of standards on field such as conversion period, contamination control, fertility management, living condition requirement for livestock, management of integrity in processing and handling, Fundamental policy for inspections, step-by-step inspection protocols, Development of inspection formats and inspection checklists. Documentation requirements such as organic system plan, field operation register, input and cultural practices record, processing record, purchase and sales records and product flow in processing.

Unit V

Individual and grower group certification management

Basic requirements for certification management by (a) Individual producer and (b) Grower/ producer groups. Applicability and types of systems covered

Unit VI

Inspection (under NPOP) and peer review (under PGS) systems

Fundamental principles of inspection, checklists and inspection parameters, general policy frame work

NPOP – Third party inspection procedure, risk assessment, documentation and record keeping review, physical verification of facilities, fields and stables, production facilities, estimated yield/production assessment, tracking the product flow throughout the process, chain of custody. Review of inspection forms and checklists and certification decisions.

PGS-India – Peer review principles, making of peer review committees and peer review checklists, analysis of peer review checklists and certification decisions. Submission of summary sheets to Regional councils and assessment and endorsement of certification decisions.

Unit VII

Certification of crop, livestock, aquaculture and other systems

Standards, their implementation in production systems, measures for contamination control, integrity management, sanitation and hygiene, input evaluation procedures, development of process tracking checklists

Unit VIII

Certification of processing, handling, trading and management of traceability

Standards, their implementation in production/ processing and handling systems, measures for contamination control, integrity management, sanitation and hygiene, packaging and labelling, development of process tracking checklists

Unit IX

Internal control system management in large farmer groupsunder NPOP

Large farmer groups, essential requirements, internal control systems, development of ICS operating manual, management of ICS, internal inspections, risk assessment, assessment of internal inspections and certification decisions, additional documentation for groups, produce/ output management and sale record management

Unit X

PGS Group development and PGS certification management

Essential requirements for local groups, development of local group operating manuals, requirements of group meetings and trainings, decision making by farmers, operational policies for Regional Councils, developing operating manual for Regional councils, assessment of summary sheets and decisions of local groups, procedure for decision endorsement and certification granting

VI. Practical

- Documentation of certification procedures, acquaintance with record keeping, handling, labeling and preparation of farmers IDs for developing ICS.
- Visit to certification bodies, certified farms, certified processing and handling operations
- Development of organic system plan for specific production system
- Development of inspection format and checklists for specific production system
- Development of operating procedures on specific aspects
- Risk assessment on organic farms and possible mitigating measures

- Running of audit trails in certified operations
- Mock inspections of different production systems
- Exercise on inspection report/ peer evaluation checklist review and certification decision
- Exercise on methods of yield assessment

VII. Suggested Reading

- *Basics of Organic Farming:* Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B.Singh. Jain Brothers.
- *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher.

I. Course Title : Value Chain Management

II. Course Code : OF 508

III. Credit Hours : 2+2

IV. Theory

Unit I: Introduction

What is value chain? Defining value chain and its finance (Internal value chain finance, External value chain finance, Interest around value chain finance in agriculture, interest in value chain finance in agriculture); Overview of value chain management.

Unit II: Understanding agricultural value chain finance

Context, the concept of agricultural value chain finance, Agricultural value chain finance as an approach, Enabling environment (standards and certification, regulation and enforcement, macro-economic and social context), and Value chains and diversified livelihoods.

Unit III: Value chain business models

Producer-driven value chain models, Buyer-driven value chain models, Facilitated value chain models, and Integrated value chain models. Case Study 1. On commercial village approach.

Unit IV: Agricultural value chain finance instruments

Product overview, Product financing (trader credit, input supplier credit, marketing company credit, lead firm financing), Receivables financing (Trade receivables finance, factoring and forfeiting), Physical asset collateralization (warehouse receipts, repurchase agreements, financial lease), Risk mitigation products (crop/ weather insurance, forward contracting, futures), Financial enhancements (securitization, loan guarantees, joint ventures). Case Study 2. Producer-driven financing of farm inputs: informal inventory credit; Case Study 3. Integrated financial instruments and value chain services.

Unit V: Innovations

Value chain innovations, Financial innovations, Technological innovations (management systems, networks and exchanges, mobile phones and mobile banking), Infrastructural innovations, Policy and public sector innovations. Case Study 4. Technological innovations; Case Study 5. Avenues for sustainable agricultural development.

Unit VI: Leadership Approaches for Successful Food Value Chains

Values-Based Leadership, Values-Based Leadership in Practice, Leadership in succession.

Unit VII: Organic food value chain management

V. Practicals

- Collection, aggregation and value addition
- Maintain quality and integrity of the product - practices and procedures, monitoring practices and procedures followed, record keeping systems, management practices and separation measures, handling and processing of organic products
- Pest control - Treatments with pest regulating agents – permitted [physical barriers, sound, ultra-sound, light and UV-light, traps (incl. pheromone traps and static bait traps), temperature control, controlled atmosphere and diatomaceousearth] and prohibited
- Ingredients - approved and prohibited ingredients (microorganisms, minerals,

gases)

- Processingmethods - permitted and prohibited mechanical, physical and biological
- Packaging - permissible biodegradable, recyclable, reusable systems and eco-friendly packaging
- Labeling - labeling requirements for agricultural commodities and processed food
- Storage and Transport - permitted conditions of storage to maintain productintegrity
- Food additives including carriers for use in production of processed organic food
- Processing aids and other products for use for processing of ingredients of agricultural origin from organic production flavouring agents, Preparations of Micro-organisms, Ingredients
- Approved products for packaging of organic foodstuffs incl. Permissible packaging material for aquaculture

IX. Suggested Reading

- *Basics of Organic Farming:* Mamta Bansal. Kindle Edition.
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B. Singh. Jain Brothers.
- *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher.

I. Course Title : Marketing

II. Course Code : OF 509

III. Credit Hours : 2+0

IV. Theory

Unit I: What is Marketing?
Facets of marketing, Facilitating functions of a market, What's special about agricultural markets? Pricing policy and Role of prices.

Unit II: Basics of Supply and Demand–
Demand, Aggregate demand, Supply and Aggregate supply.

Unit III: Food Marketing Channel–
Understanding the food marketing channel, Scenario Analysis.

Unit IV: Market intelligence–
Marketresearch, Production cost assessment, Projecting Revenues, Accounting,Market Selection.

Unit V
Organic production and domestic market size, Institutional context and regulations (such as NPOP, NSOP, APGMC Act, PGS, FSSAI, Jaivik Bharat).

Unit VI: Organic Food Distribution System–
Domestic market structures, and classification framework, urban organic retail models, Organic specialty stores, markets and health food stores. Direct marketing and Community Supported Agriculture.

Unit VII: Market Potential for Organic Foods–
Consumer preferences and perceptions (organic sensitivity, building awareness on organic foods and consumer needs, shopping Behavior, factors influencing purchases of new foods), general trade and organized retail.

Unit VIII: e-Marketing and e-Consumer Perceptions and Behaviour–
Why organic food, source and perception of organic foods, uses of organic food, resistance to use organic products, source of awareness, organic food-is it a fad?, On-line retail and home delivery services, role of advertising and choice of media,understanding the role of quality in marketing, perception of health benefits and assurance/certification.

Unit IX
Accessibility of organic foods, premiums and willingness to pay premiums, role of retailer

Unit X
Efficient supply chains and retail channels, sustainability of supply chain.

Unit XI: Consumer purchase Behavior and habits–
Shopping Behavior, role of influencer in decision making, concern over adulteration, chemicals, loss of nutrients and vitamins during processing and manufacturingand its impact on marketing and sale.

Unit XII: Challenges and success stories–
Success stories in organic marketing, organizational models, their advantages, challenges, limitations and legal context.

V. Suggested Reading

- *Basics of Organic Farming:* Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B. Singh. Jain Brothers
- *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher.

I. Course Title : Research Methodology and Biostatistics

II. Course Code : OF 510

III. Credit Hours : 2 + 1

IV. Theory

Unit I

Experimental techniques: Research design, sampling, data collection, On-station experimentation, On-Farm experimentation, tabulation, Statistical tools and analysis techniques for interpretation of data.

Unit II

Geo-referenced characterization: Questionnaire design principles, Questionnaire design for consumers of organic products, Questionnaire design for farmers and producers of organic products, Questionnaire design for processors/ traders/ exporters, Geo-spatial analysis and mapping of organic farms/ producers/ traders/ consumers.

Unit III

Meta data analysis: Concepts, statistical methods, clustering research results, Holism, Positivism, Objectivism, Reductionism, Constructivism, Subjectivism, data source, Variable coding and analysis, interpretation.

Unit IV

Niche area and crops for organic farming: Parameters for niche area and crop, Different scales of niche area, Tools and steps in Niche area and crop identification, Parameterization and classification based on macro, regional and micro level.

Unit V

Climate resilience of organic farming: Methodology for identification of climate resilient production systems, GHG's estimation using IPCC, GHG's measurement using instrumentation, Global Warming Potential, Energy & Carbon budgeting.

Unit VI

Breeding for organic production system: Conventional breeding strategies for organic production, participatory plant breeding, Marker aided selection, Stability analysis, Molecular characterization of indigenous organic inputs, Bio-chemical and molecular signature of organic produces.

Unit VII

Commercial Project Formulation on Organic Farming: Internal rate of return, Pay Back period, B: C ratio, Net Present Value, Model project formulation for organic farming, Impact analysis tools and methods.

Unit VIII

Farming System model development: Synthesis of IFS models using primary and secondary data, classification, validation of farming systems.

Unit IX

Notations in statistics: Basics of statistical notation, Algebric rules, designing a variable, standard notation for statistics.

Unit X

Descriptive statistics: Measures of central tendency, measures of variability, relative scores, measures of relationship, skewness, kurtosis.

Unit XI

Introduction to statistical inference and testing of hypothesis: Statistical model, point estimation, confidence intervals, hypothesis testing, t-test, non-parametric alternative sign test.

V. Practical

- Synthesis of farming system model
- Estimation of GHG emission from IPCC tool
- Meta data analysis using published papers
- Identification and niche area and crops for a district or block
- Identification of Climate resilient production system using long term meteorological data
- Commercial project formulation
- Geo-spatial analysis using GIS platform
- Carbon and energy budgeting of an organic farm

I. Course Title : Organic Input Management and Production Technologies

II. Course Code : OF 511

III. Credit Hours : 2+1

Theory

Unit I: Introduction

Need for on-farm and off-farm (external) organic inputs, types of organic inputs allowed under organic farming, regulatory scenarios and standards. Status of organic and biological input industry in the country.

Unit II: On-farm inputs soil fertility and nutrient management

Types of on-farm inputs for soil fertility and nutrient management, their need assessment under specific cropping systems *vis-à-vis* soil test reports, methodologies for recycling of on-farm biomass and crop residue, innovative traditional inputs such as jivamrit, beejamrit, panchgavya etc. their microbial profiling and nutrient mobilization potential and standardized production methods, Oil cakes and their applications.

Unit III: On-farm inputs, plant health management and pest control

Types of plant protection inputs and intervention approaches, use of biological and ecological approaches, preventive practices, Types of plants used in plant protection and their biological characterization for pest control, basic methodologies for active ingredient extraction and on-farm formulations.

Unit IV: Composts and their value added products

Types of composts, their characters, nutrient potential, composting methodologies (aerobic, anaerobic, NADEP, *etc*), value added composts, quality control parameters, commercial production methodologies for city waste compost, Phosphate Rich Organic manure (PROM), bio-organic manure, technologies for product formulations such as enrichment and granulations, *etc.*

Unit V: Biofertilizers

Types of biofertilizers, standards for commercial products, testing methodologies, characterization and efficiency parameters, management of microorganisms in laboratory, production methodologies such as mother culture development, mass production through fermentation and fermentation parameters, mass scale culture techniques, product formulations, carrier-based inoculants, liquid inoculants and lyophilized inoculants.

Unit VI: Microbial Biopesticides

Types of biopesticides, standards for commercial products, testing methodologies, characterization and efficiency parameters, management of microorganisms in laboratory, production methodologies such as mother culture development, mass production through fermentation and fermentation parameters, mass scale culture techniques, product formulations, carrier based inoculants, liquid inoculants and lyophilized inoculants. Types of polyhedrosis and granulosis viruses and their production methodologies.

Unit VII: Mass rearing of beneficial insects

Introduction to beneficial insects such as pest predators and parasites, classification and identification, mass rearing technologies including rearing of host insects, Production of egg cards of beneficial insects and their release in the field.

Unit VIII: Botanical pesticides and other non-chemical pest protectants

Type of non-chemical plant protection options, importance of soaps and oils, important plants having pesticidal properties, plant parts having pesticidal active ingredient and their extraction methodologies, product formulation and stabilization for increased shelf life, field assessment of efficacy. Regulatory scenario and quality parameters.

IV. Practical

- Getting familiarized with on-farm soil fertility management inputs (such as beejamrit, jivamrit, panchgavyaetc), ingredients needed and production methodology. Preparation and quality assessment
- Application of such inputs in small plots on selected crops and observation on growth
- Production of different composts including vermicompost
- Quality analysis of composts for nutrients and heavy metals
- Biofertilizer organisms, their laboratory characterization, sub-culturing and mother culture development
- Fermentation technology demonstration, production of bacterial broth in pilot scale fermenters
- Biofertilizer product formulations and quality analysis methods
- Study biopesticide organisms, laboratory culturing, mass cultivation using solid state fermentation, liquid fermentation and spore harvesting methods and product formulations
- Visit to beneficial insect rearing laboratory and handling of insects including demonstration on tricho-cards production
- Extraction of neem seed kernel extracts and neem oil. Production of botanical extracts and product formulation using emulsifiers
- Study effect of various botanical extracts on insect pests
- Preparation of Bordeaux mixtures and copper fungicides

V. Suggested Reading

- *The Complete Technology Book on Vermiculture and Vermicompost*, NPCS Board of consultants and Engineers, Asia Pacific Business Press
- *Training material on Composting and Vermicomposting*, Published by Ecosan Services Foundation
- *Biofertilizers and Biopesticides*, A, Channabasava and H.C. Lakshman
- *Handbook of Biofertilizers and Biopesticides*, by AM Deshmukh, RM Khobrgade and PP Dixit
- *Mass Production of Beneficial Organisms*, by J. Morales-Ramos, M. Guadalupe and DS Ilan, Academic Press, 2013.

Restructured and Revised
Syllabi of Post-graduate Programmes
Vol. 2

Social Sciences

– Agricultural Economics
– Agricultural Extension Education
– Agri-Business Management

Contents

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Syllabi of Post-graduate Programmes

Vol. 2

Social Sciences
– Agricultural Economics

Course Title with Credit load
M.Sc. (Ag) in Agricultural Economics

Major Courses: 20 credits

Course Code	Course Title	Credit Hours	Semester
AEC-501*	Micro Economic Theory And Applications	3 (3+0)	I
AEC-502*	Agricultural Production Economics	2 (1+1)	II
AEC-503*	Agricultural Marketing and Price Analysis	3 (2+1)	I
AEC-504*	Macro Economics And Policy	2 (2+0)	I
AEC-505*	Econometrics	3 (2+1)	II
AEC- 506	Agricultural Development and Policy Analysis	2 (2+0)	II
AEC-507*	Agricultural Finance and Project Management	3 (2+1)	II
AEC-508*	Linear Programming	2 (1+1)	II
AEC-509*	Research Methodology for Social Sciences	2 (1+1)	I
AEC-510	Indian Economy: History and Contemporary Issues	2 (2+0)	I
AEC-511	International Economics	2 (1+1)	II

*courses to be taken compulsorily

Minor Courses: 08 credits

a. It is suggested the student may choose at least two out of three courses listed above as part of minor courses as these are related to policy advocacy and aim to build larger understanding of the subject.
b. Further, it is suggested that the student may also opt to choose the remaining Courses from any other discipline including the disciplines of Agrl. Extensions/ ABM and are related to the research prob.lem selected by the student.
c. The final choice of the minor courses should be mandatorily approved by the Student Advisory committee/ HOD.

Course Code	Course Title	Credit Hours	Semester
AEC-512	Institutional Economics	1(1+0)	II
AEC-513	Natural Resource and Environmental Economics	2 (1+1)	II
AEC-514	Commodity Future Trading	2 (2+0)	I
AEC-515	Development Economics	2 (2+0)	II
AEC-516	Rural Marketing	2 (2+0)	II
AEC-517	Evolution of Economic Thought	1 (1+0)	I

Minor courses may be taken from above list or subjects closely related to a student's major subject.

Supporting Courses: 6 credits

STAT-501	Statistical Methods For Applied/ Social Sciences	3 (2+1)
STAT-502	Mathematics For Applied Sciences/ Agricultural Economics	3 (2+1)
STAT/COMP	Computer Applications For Agri-Business & Economics	3 (2+1)

Common Courses: 05 credits

1. Technical Writing and Communications Skills
2. Intellectual Property and its management in Agriculture
3. Agricultural Research, Research Ethics and Rural Development Programmes

Further, the subcommittee attempted to oversee the design of the entire course is such a way that students may opt to take extra courses to compete with MA Economics stream and Universities may consider to issue a certificate that the degree of M.Sc.(Ag) Agricultural Economics with special mention of extra credits in core Economics.

Course Contents
M.Sc. (Ag) in Agricultural Economics

I. Course Title : Micro Economic Theory and Applications
II. Course Code : AEC-501
III. Credit Hours : 3+0

IV. Theory

Block 1: Introduction to micro-economics

Unit 1: Basic Concepts: A review

Scarcity and Choice; Production possibility frontier, Positive and normative economics; concepts of opportunity cost, Demand and Supply: determinants of individual demand/supply; demand/ supply schedule and demand/ supply curve; market versus individual demand/ supply; shifts in the demand/ supply curve

Block 2- Insight of consumer, production and cost involved

Unit 1: Consumer Choice

Cardinal Utility Approach – Ordinal Utility Approach -Budget sets and Preferences under different situations – Hicks and Slutsky income and substitution effects – Applications of Indifference curve approach – Revealed Preference Hypothesis – Consumer surplus – Derivation of Demand curve – Elasticity of demand – Demand and supply together; how prices allocate resources; controls on prices – price floor and price ceiling – applications in agriculture.

Unit 2: Production and Cost

Production functions: single variable - average and marginal product, variable proportions, stages of production. Two variables - isoquants, returns to scale and to a factor; factor prices; Technical progress; cost minimization and output maximization; Elasticity of substitution. Expansion path and the cost function

Concept of economic cost; Short run and long run cost curves; increasing and decreasing cost industries; envelope curve; L-shaped cost curves; economies of scale; revenue and expenditure, elasticity and marginal revenue; Firm equilibrium and profit.

Block 3: Overview of market

Unit 1: Market Forms

Behaviour of profit maximizing firms and the production process- Perfect competition: Equilibrium of the market. Long run industry supply, applications: effects of taxes and subsidies; Monopoly: Equilibrium; supply; multiplant firm; monopoly power; deadweight loss; price discrimination; Monopolistic Competition: Product differentiation; equilibrium of the firm in the industry-with entry of new firms and with price competition. Comparison with pure competition. Duoploy: Cournot model and reaction curves; Stackelberg's model, Bertrand model; Oligopoly.

Unit 2: Factor Markets

Labour and land markets - basic concepts (derived demand, productivity of an input, marginal productivity of labour, marginal revenue product); demand for

labour; input demand curves; shifts in input demand curves; competitive labour markets; Economic rent and quasi rent.

V. Suggested Reading

- Koutsoyiannis A. *Modern Micro Economics.* Macmillan Press Ltd
- Ferguson and Gould. *Micro Economic Theory*. Richard D Erwin Inc., USA
- Richard A. Bilas, *Micro Economic Theory*.
- Leftwich Richard H. *The Price System and Resources Allocation*
- Allen CL. *A Frame Work of Price Theory*.

I. Course Title : Agricultural Production Economics

II. Course Code : AEC-502

III. Credit Hours : 1+1

IV. Theory

Block 1: Introduction to Production Economics

Unit 1: Concepts of production economics

Nature, scope and significance of agricultural production economics- Agricultural Production processes, character and dimensions-spatial, temporal - Centrality of production functions, assumptions of production functions, commonly used forms - Properties, limitations, specification, estimation and interpretation of commonly used production functions.

Block 2: Factors and costs

Unit 1: Factors and theory of production

Factors of production, classification, interdependence, and factor substitution -Determination of optimal levels of production and factor application -Optimal factor combination and least cost combination of production - Theory of product choice; selection of optimal product combination.

Unit 2: Concepts of cost

Cost functions and cost curves, components, and cost minimization -Duality theory – cost and production functions and its applications -Derivation of firm's input demand and output supply functions -Economies and diseconomies of scale.

Block 3: Assessment

Unit 1: Dynamics of economic assessment

Technology in agricultural production, nature and effects and measurement - Measuring efficiency in agricultural production; technical, allocative and economic efficiencies - Yield gap analysis-concepts-types and measurement - Nature and sources of risk, modeling and coping strategies.

V. Practical

- Different forms of production functions
- Specification, estimation and interpretation of production functions
- Returns to scale, factor shares, elasticity of production
- Physical optima-economic optima
- Least cost combination
- Optimal product choice
- Cost function estimation, interpretation
- Estimation of yield gap
- Incorporation of technology in production functions
- Measuring returns to scale-risk analysis.

VI. Suggested Reading

- EO Heady. *Economics of Agricultural Production and resources use.*
- John P Doll and Frank Orazem. *Production Economics: Theory with application*
- Heady EO & Dillon JL. 1961. *Agricultural Production functions.* Kalyani Publishers, Ludhiana, India. 667 p.
- Baumol WG. 1973. *Economic theory and operations analysis.* Practice Hall of India Private Limited, New Dehli.626 p.
- Gardner BL & Rausser GC. 2001. *Handbook of Agricultural Economics* Vol. I Agricultural Production. Elsevier.

I. Course Title : Agricultural Marketing and Price Analysis

II. Course Code : AEC 503

III. Credit Hours : 2+1

IV. Theory

Block 1: Introduction to Agricultural Marketing

Unit 1: Introduction to agricultural marketing

New Concepts in Agricultural Marketing - Characteristic of Agricultural product and Production – Problems in Agricultural Marketing from Demand and Supply and Institutions sides. Market intermediaries and their role - Need for regulation in the present context - Marketable & Marketed surplus estimation. Marketing Efficiency - Structure Conduct and Performance analysis - Vertical and Horizontal integration - Integration over space, time and form-Vertical co-ordination.

Block 2: Agricultural Markets

Unit 1: Aspects of agricultural marketing

Different Forms of marketing: Co-operatives Marketing – APMC Regulated Marketing - Direct marketing, Farmer Producer Companies, e-NAM and marketing under e-NAM, e-marketing Contract farming and Retailing, Organized retailing - Supply Chain Management - State trading, Warehousing and other Government agencies -Performance and Strategies -Market infrastructure needs, performance and Government role - Value Chain Finance.

Unit 2: Future marketing and government

Introduction to Commodities markets and future trading - Basics of commodity futures - Operation Mechanism of Commodity markets – Price discovery - Hedging and Basis - Fundamental analysis - Technical Analysis – Role of Government/SEBI in promoting commodity trading and regulatory measures.

Block 3: Advances in Agricultural Marketing

Unit 1: Use of Information Technology

Role of Information Technology and Market Intelligence in marketing of agricultural commodities, -electronic auctions (e-bay), e-Chaupals, Agmarknet and Domestic and Export market Intelligence Cell (DEMIC).

Unit 2: Dynamics of price

Price forecasting – time series analysis – time series models – spectral analysis. Price policy and economic development – non-price instruments.

V. Practical

- Supply and demand elasticities in relation to problems in agricultural marketing.
- Price spread and marketing efficiency analysis.
- Marketing structure analysis through concentration ratios.
- Performance analysis of Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products.
- Supply Chain Analysis - quantitative estimation of supply chain efficiency.
- Market Intelligence – Characters, Accessibility, and Availability Price forecasting.
- Online searches for market information sources and interpretation of market intelligence reports – commodity outlook.
- Technical Analysis for important agricultural commodities.
- Fundamental Analysis for important agricultural commodities.
- Presentation of the survey results and wrap-up discussion.

VI. Suggested Reading

- Acharya SS & Agarawal NL. 2004. *Agricultural Marketing in India*. Oxford and IBH Publishing company Pvt. Ltd. New Delhi.
- Acharya SS & Agarawal NL. 1994. *Agricultural Prices-Analysis and Policy*. Oxford and IBH Publishing company Pvt. Ltd. New Delhi.
- Richard H Kohls and Joseph N. Uhl: *Marketing of Agricultural products* by Collier MacMillan International.

I. Course Title : Macro Economics and Policy

II. Course Code : AEC-504

III. Credit Hours : 2+0

IV. Theory

Block 1: Conceptualising Macro Economics

Unit 1: Introduction: Measurement and Concepts

Basic concepts and scope of Macro-economics, National Income Accounting: Methods of measurement of key macro-economic aggregates, relationship of national income and other aggregates (with numerical exercises), real and nominal income

Block 2: Theories of macroeconomics

Unit 1: Classical Macroeconomics

Say's Law, Quantity Theory of Money, aggregate labour supply and demand of labour, Classical theory of determining output, wages and prices.

Unit 2. Income And Spending: Keynesian Framework

Simple Keynesian model of income determination; Keynesian Multiplier- aggregate spending, taxation, transfer payments, foreign spending, balanced budget; budget surplus (with numerical exercises).

Block 3- Money, Consumption and Inflation

Unit 1: Money, Interest and Income

Goods market equilibrium-IS curve; Demand for Money, the Liquidity Preference Theory – Liquidity Trap; asset market equilibrium- LM curve; simultaneous equilibrium in goods and asset market- effect of fiscal and monetary policy

Unit 2: Theories of Aggregarte Consumption and Investment

Absolute Income Hypothesis, Relative Income Hypothesis, Fisher's Inter-temporal Choice Model, Life-Cycle and Permanent Income Hypotheses; Profits and Accelerator Theory.

Unit 3: Inflation and Unemployment

Inflation: Nature, Effects and control; Types of inflation – demand pull, cost push-stagflation, core inflation, hyperinflation; Phillips curve.

V. Suggested Reading

- Stonier & Hegue. *A Text Book of Economic Theory*
- Samuelson PA. 1948. *Foundation of Economic Analysis*. Harvard University Press
- MC Vaish Allid. 1983. *Macro–Economics Theory*
- Gardner Ackley. 1961. *Macro–Economics Theory*: Macmillan, New York.
- TF Dernburg & DM Mcdougali-*Macro Economics*
- G. Sirkin – *Introduction to Macro–Economics Theory*
- RL Heibroker-*Understanding Macro–Economics*
- JK Mehta –*Macro Economics*
- Michael R Edgemand – *Macro-Economics: Theory & Policy*
- David' W Pearce –*The dictionary of modern Economics*

I. Course Title : Econometrics

II. Course Code : AEC 505

III. Credit Hours : 2+1

VII. Theory

Block 1: Introduction to Econometrics

Unit 1: Introduction

Relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics-regression analysis.

Block 2: Classical Regression

Unit 1: Classical Linear Regression

Basic two variable regression – assumptions estimation and interpretation approaches to estimation – OLS and their properties – extensions to multi-variable models-multiple regression estimation and interpretation.

Unit 2: Breaking down of Classical assumptions

Violation of assumptions – identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches – model misspecification.

Block 3: Qualitative Variables

Unit 1: Qualitative variables and simultaneous equation models

Use of dummy variables- Introduction to simultaneous equations- identification problem

VIII. Practical

- Single equation two variable model specification and estimation
- Hypothesis testing transformations of functional forms and OLS application
- Estimation of multiple regression model
- Testing and correcting specification errors
- Testing and managing Multicollinearity
- Estimation of regressions with dummy variables

X. Suggested Reading

- Dorfman R. 1996. *Linear Programming and Economic Analysis*. McGraw Hill.
- Greene WH. 2002. *Econometric Analysis*. Pearson Education.
- Johnston J and Dinardo J. 2000. *Econometric Methods*. Mc Graw-Hill.
- Koutseyianis, A. 1997. *Theory of Econometrics*. Barner & Noble.
- Maddala GS. 2002. *Econometrics*. Mc Graw-Hill.
- Pinndyck RS and Rubinfeld DL. 1990. *Econometric Models and Econometric Forecasts*. McGraw Hill.

I. Course Title : Agricultural Development and Policy Analysis

II. Course Code : AEC-506

III. Credit Hours : 2+0

IV. Theory

Block 1: Introduction

Unit 1: Introduction

Role of agriculture in economic/ rural development – Evolution of thinking on agriculture and development; Agricultural development – meaning, stages and determinants – Population and food supply – need for sound agricultural policies

Block 2: Theoretical Concepts

Unit 1: Theories of Agricultural Development

Resource exploitation model- Conservation model- Location (Urban impact) model- Diffusion model- High pay-off input model-Induced Innovation Model- Agricultural R&D and Linkages

Block 3: Performance and policies

Unit 1: Performance of Indian Agriculture

Agrarian structure and land relations; trends in performance and productivity; agrarian structure and technology; credit, commerce and technology; capital formation; subsidies; pricing and procurement; Post Green Revolution agriculture; Production and productivity crisis in agriculture; Regional differences; Food Security, PDS system and Malnutrition.

Unit 2: Agricultural Policy: Process and Implementation

Instruments of Agricultural Policy; Process of agricultural policy formulation, implementation, Monitoring and Evaluation in India; Global experiences in participatory approach to Agricultural policy process; critical review of various elements of Indian agricultural policy-resource policies – credit policies – input and product marketing policies – price policies; WTO – Agreement on Agriculture; Planning models. Planning for utilization of resources and Indian Five Year Plans.

V. Suggested Reading

- Albert O. Hirschman 1958. *Strategy of Economic Development*. New Man Yale University
- Simon Kuznets 1965. *Economic Growth and Structures.* Oxford New Delhi.
- Das Gupta AK. 1965. *Planning and Economic Growth.* George Allen and Unwin London
- Robert E. Baldwin 1966. *Economic Development and Growth.* John Willey, New York

I. Course Title : Agricultural Finance and Project Management

II. Course Code : AEC 507

III. Credit Hours : 2+1

VII. Theory

Block 1: Introduction to Agricultural Finance

Unit 1: Basic concepts: A Review

Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing - Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's - NGO's, and SHG's.

Block 2: Credit and Financial Analysis

Unit 1: Credit and its aspects

Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening.

Unit 2: Financial analysis

Financial Decisions – Investment, Financing, Liquidity and Solvency. Preparation of financial statements - Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and Assessing the performance of farm/ firm.

Block 3- Project and Risk Management

Unit 1: Project Overview

Project Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques – Undiscounted measures. Time value of money – Use of discounted measures - B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Net work Techniques – PERT and CPM.

Unit 2: Risk and its Management

Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes - yield loss and weather based insurance and their applications.

VIII. Practical

- Development of Rural Institutional Lending;
- Branch expansion, demand and supply of institutional agricultural credit and Over dues and Loan waiving;
- An overview, Rural Lending Programmes of Commercial Banks, Lead Bank Scheme;
- Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions;
- Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through financial statements;
- Performance of Micro Financing Institutions;
- NGO's and Self-Help Groups, Identification and formulation of investment projects;

- Project appraisal techniques – Undiscounted Measures and their limitations;
- Project appraisal techniques – Discounted Measures;
- Network techniques – PERT and CPM for project management;
- Case Study Analysis of an Agricultural project;
- Financial Risk and risk management strategies – crop insurance schemes;
- Financial instruments and methods – E banking, Kisan Cards and core banking.

IX. Suggested Reading

- E Die Sollem H and Heady EO. (Ed.). *Capital and Credit Needs in Changing Agriculture*, Bauman.
- Hopkins A Barry, Peter Jo and Baker CB. *Financial Management in Agriculture*.
- Murray WG and Nelson AG. 1960. *Agricultural Finance*. Iowa State University
- Chanona C. 1969. *Agricultural Finance in India: Role of Commercial Banks*. Marketing and Economics Research Bureau, New Delhi.
- Gittinger JP. 1972. *Economic analysis of agricultural projects*, John Hopkins Univ. Press, Baltimore.
- Little IMD and JA Mirrless. 1974, *Project appraisal and planning for developing countries*, Oxford and IBH publishing Co. New Delhi.
- Arnold CH. 1972. *Project Evaluation, collected papers*, Macmillan.

I. Course Title : Linear Programming

II. Course Code : AEC-508

III. Credit Hours : 1+1

IV. Theory

Unit I

Decision Making- Concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.

UnitII

Simplex Method: Concept of simplex Method, solving profit maximization and cost minimizations problems. Formulation of farms and non farm problems as linear programming models and solutions.

Unit III

Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.

Unit IV

Game Theory- Concepts of game theory, two person constant sum, zero sum game, saddle point, solution mixed strategies, the rectangular game as Linear toProgramming.

V. Practical

I. Course Title : Research Methodology for Social Sciences

II. Course Code : AEC 509

III. Credit Hours : 1+1

IV. Theory

Block 1: Concepts of research methodology

Unit 1: Concepts of research methodology

Importance and scope of research in agricultural economics. Types of research – Fundamental vs. Applied. Concept of researchable problem – research prioritization – selection of research problem. Approach to research – research process.

Block 2- Building up hypothesis and sample selection

Unit 1: Hypothesis: Framing and Testing

Hypothesis – meaning – characteristics – types of hypothesis – review of literature – setting of Course Objective and hypotheses – testing of hypothesis.

Unit 2: Sampling

Sampling theory and sampling design – sampling error - methods of sampling – probability and non-probability sampling methods - criteria to choose. Project proposals – contents and scope – different types of projects to meet different needs – trade-off between scope and cost of the study. Research design and techniques – Types of research design.

Block 3- Data Collection and Analysis

Unit 1: Data Collection

Data collection – assessment of data needs – sources of data collection – discussion of different situations. Mailed questionnaire and interview schedule – structured, unstructured, open ended and closed-ended questions. Scaling Techniques. Preparation of schedule – problems in measurement of variables in agriculture. Interviewing techniques and field problems - methods of conducting survey – Reconnaissance survey and Pre testing.

Unit 2: Data Analysis

Data coding, tabulation, cleaning. –Multivariate analysis –factor analysis' PCA' cluster analysis. Universal procedures for preparation of bibliography – writing of research articles.

V. Practical

- Exercises in problem identification.
- Project proposals – contents and scope.
- Formulation of Objective and hypotheses.
- Assessment of data needs – sources of data – methods of collection of data.
- Methods of sampling – criteria to choose – discussion on sampling under different situations.
- Scaling Techniques – measurement of scales.
- Preparation of interview schedule.
- Field testing. Method of conducting survey.
- Exercise on coding, editing, tabulation and validation of data.
- Preparing for data entry into computer.
- Hypothesis testing – Parametric and Non-Parametric Tests.
- Exercises on format for Thesis/ Report writing.

- Presentation of the results.

XI. Suggested Reading

- Baker CB. *Research Methodology in Agricultural Economics*
- Cohen MR and Nagel R. *An Introduction to Logic and Scientific Method*
- Devey J Logic. *The Theory of Enquiry*
- Dhondhyal SP. *Social Science Research and Thesis Writing*
- Ezekiel M. *Correlation Analysis*
- Heady EO. *Linear Programming Methods*
- Willson ER. *An Introduction to Scientific Research*
- Kumar A. 2008. *Research Methodology: A Survey*. Alts, New Delhi,

I. Course Title : Indian Economy: History and Contemporary Issues
Credit

II. Course Code : AEC-510

III. Credit Hours : 2+0

IV. Theory

Block 1- History of Indian Economy

Unit 1: India from Independence to Liberalization

An overview of the economic developments during the period 1947-1980; Objectives and strategies of planned economic development and the role of the State; Sectoral growth performance; savings and investment; Demographic trends and issues; education; health and malnutrition; Trends and policies in poverty; inequality and unemployment.

Unit 2: India Since 1980's (Liberalization And Beyond): Overview

Policy Changes since 1980s. The 1990 Crisis. Causes and Effects of liberalization. Regional differences: infrastructure, primary, secondary and tertiary sector.

Unit 3: Macro Trends Since 1990

Growth; Savings and Investment, Employment; productivity; diversification; Agro-based industries; competition policy; foreign investment, Regional differences.

Block 2- Contemporary Issues

Unit 1: Contemporary Issues

Monetary and Financial trends- areas of government spending in India, Capital expenditure, revenue expenditure, plan expenditure, non plan expenditure, Deficits (fiscal, primary, revenue), impact of fiscal deficit on economy, Capital receipts, revenue receipts, tax and non tax revenue, direct and indirect taxes, need to rationalize tax structure. Goods and Services Tax (GST). Union Budget, Zero base budgeting, Gender budgeting, Fiscal devolution and centre state financial relations in India, WPI, CPI implicit deflators. Foreign Trade policy.

V. Suggested Reading

- Dutt and Sundaram. *Indian Economy*

I. Course Title : International Economics

II. Course Code : AEC 511

III. Credit Hours : 2+1

VII. Theory

Block 1- Introduction

Unit 1: Concepts of International Economics

Scope and Significance of International Economics – The role of trade- General Equilibrium in a Closed Economy (Autarky Equilibrium) – Equilibrium in a Simple Open Economy - Possibility of World Trade - Trade gains and Trade Equilibrium.

Block 2- Models, Rate and Terms of Trade

Unit 1: Barriers to trade

Tariff, Producer Subsidy, Export Subsidy, Import Quota and Export Voluntary Restraints- The Case of Small Country and Large Country Case.

Unit 2: Models of trade

Ricardian Model of Trade- Specific Factors Model- Heckscher - Ohlin Model - Trade Creation and Trade Diversion – Offer Curve - Export Supply Elasticity and Import Demand Elasticity – Comparative Advantage and Absolute Advantage.

Unit 3: Rates and Terms of trade

Official Exchange Rate and Shadow Exchange Rate - Walra's Law and Terms of Trade – Trade Blocks.

Block 3- Institutions

Unit 1: Trades Institutions

IMF, World Bank, IDA, IFC, ADB – International Trade agreements – Uruguay Round – GATT – WTO.

VIII. Practical

- Producer's Surplus, Consumer's Surplus, National Welfare under Autarky and Free Trade Equilibrium with small and large country assumption.
- Estimation of Trade Gains
- Estimation of competitive and comparative measures like NPC, EPC, ERP and DRC
- Estimation of Offer Curve Elasticity
- Estimation of Effect of Tariff, Export Subsidy, Producer Subsidy, Import Quota and Export Voluntary Restraints on National Welfare
- Estimation of Ricardian Model
- Estimation of Effect of Trade under Specific Factor Model
- Estimation of trade Equilibrium under Heckscher -Ohlin model

IX. Suggested Reading

- Kindelberger and Joshi PK. 2016. *International Economics* AITBS Delhi-110051
- Brouwer F. *International Trade and Food Security*. LEI - Wageningen UR, The Netherlands.

I. Course Title : Institutional Economics

II. Course Code : AEC 512

III. Credit Hours : 1+0

IV. Theory

Block 1: Introduction

Unit 1: Basics of Institutional Economics

Old and New Institutional Economics – Institutional Economics vs Neo-classical Economics. Definition of institutions – Distinction between institutions and organizations – Institutional evolution.

Block 2: Approaches

Unit 1: Institutional changes & Resource allocation

Institutional change and economic performance - national and international economic institutions. Transaction cost economics – Transaction costs and the allocation of resources. Transaction costs and efficiency. Asymmetric information - Moral hazard and Principal-Agent problem.

Unit 2: Group and collective Approach

Free rider problem – path dependency – Interlinked transactions. Collective action and the elimination of free-rider problem - The logic of collective action and its role in reducing free rider problem – theory of Groups. Rent seeking – interest groups and policy formulation.

Block 3: Law Protection and Institutions

Unit 1: Property rights

Economic analysis of property rights- property rights regimes – private property – State Property - Common property Resources (CPRs) – public goods and club goods.

Unit 2: Agrarian Institutions

Special features of institutional arrangements in agriculture – Transaction costs in agriculture - Case Studies - Theories of agrarian institutions - tenancy institutions.

V. Suggested Reading

- Pearce DW –*The dictionary of modern Economics*

I. Course Title : Natural Resource and Environmental Economics

II. Course Code : AEC 513

III. Credit Hours : 1+1

VII. Theory

Block 1- Introduction to natural resource and environmental economics

Unit 1: Basic Foundation

Concepts, Classification and Problems of Natural Resource Economics – Economy Environment interaction – The Material Balance principle, Entropy law-Resources Scarcity - Limits to Growth - Measuring and mitigating natural resource scarcity – Malthusian and Recardian scarcity – scarcity indices - Resource Scarcity and Technical Change.

Block 2- Insights of the subject

Unit 1: Theories and economics of natural resources

Theory of optimal extraction renewable resources –economic models of oil extraction-efficiency - time path of prices and extraction - Hotelling's rule, Solow-Harwick's Rule. Theory of optimal extraction exhaustible resources – economic models of forestry and fishery.

Unit 2: Functioning of Market

Efficiency and markets – market failures - externalities – types - property rights – transaction costs – Coase's theorem and its critique - public goods - common property and open access resource management - Collective action.

Block 3- Dealing with the issues and sustainability

Unit 1: Environmental Issues

Environmental perspectives - biocentrism, sustainability, anthropocentrism - Environmental problems and quality of environment - Sources and types of pollution -air, water, solid waste, land degradation – environmental and economic impacts - Economics of pollution control - efficient reduction in environmental pollution.

Unit 2: Regulations

Environmental regulation – economic instruments - pollution charges – Pigovian tax - tradable permits – indirect instruments – environmental legislations in India.

Unit 3: Sustainability aspects

Concept of sustainable development – Economic Perspective – Indicators of sustainability Relation between development and environment stress-Environmental Kuznet's curve Environmental Accounting – resource accounting methods – International Environmental Issues – climate change – likely impacts – mitigation efforts and international treaties.

VIII. Practical

- Exhaustible resource management – optimum rate of oil extraction.
- Renewable resource management – optimum harvest of Forestry/fishery.
- Exercise on pollution abatement-I.
- Exercise on pollution abatement-II.
- Concepts in valuing the environment.
- Taxonomy of valuation techniques.
- Productivity change method – substitute cost method – Hedonic price method – Travel cost method – Contingent valuation methods.

- Discount rate in natural resource management.
- Environment impact assessment
- Visit to Pollution Control Board.

IX. Suggested Reading

- Pearce DW and Turner RK. *Economics of Natural Resource and Environment*
- Kwak J. *Economism: Bad Economics and the Rise of Inequality*
- Tietenberg T and Lewis L. *Environmental and Natural Resource Economics*
- Schwarz PM. *Energy Economics*

I. Course Title : Commodity Future Trading Credits

II. Course Code : AEC 514

III. Credit Hours : 2+0

Theory

Block 1- Introduction to commodity market

Unit 1: Concepts of commodity future trading

History and Evolution of commodity markets – Terms and concepts: spot, forward and futures Markets – factors influencing spot and future markets. Speculatory mechanism in commodity futures.

Block 2- Techniques and Risks in Commodity Market

Unit 1: Technical aspects

Transaction and settlement – delivery mechanism - role of different agents - trading strategies -potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets.

Unit 2: Risk and its Management

Risk in commodity trading, importance and need for risk management measures - managing market price risk: hedging, speculation, arbitrage, swaps - pricing and their features.

Block 3- Commodity exchange and market analysis

Unit 1: Commodity Exchange – A review

Important global and Indian commodity exchanges - contracts traded – special features -Regulation of Indian commodity exchanges - FMC and its role.

Unit 2: Analysis of commodity market

Fundamental Vs Technical analysis – construction and interpretation of charts and chart patterns for analyzing the market trend – Market indicators – back testing. Introduction to technical analysis software – analyzing trading pattern of different commodity groups.

IX. Suggested Reading

- Kaufman PJ. *The Concise Handbook of Futures Markets*: Jhon Wiley & Sons
- Purcell WD. *Agricultural Futures and Options: Principles and Strategies*: MacMillan Publications
- Wasendorf RR & McCaffery *All About Commodities from the Inside Out*. McGraw Hill

I. Course Title : Development Economics Credit

II. Course Code : AEC-515

III. Credit Hours : 2+0

IV. Theory

Block 1- Introduction to Development Economics

Unit 1: Conceptions of Development

Development Economics – Scope and Importance - Economic development and economic growth - divergence in concept and approach - Indicators and Measurement of Economic Development –GNP as a measure of economic growth – New Measures of Welfare – NEW and MEW – PQLI – HDI – Green GNP - Criteria for under development – Obstacles to economic development –Economic and Non-Economic factors of economic growth- Development issues, poverty, inequality, unemployment and environmental degradation.

Block 2- Theories and comparison

Unit 1: Theories of Economic growth and development

Classical theories- Adam smith - Ricardo- Malthus, Marx's theory of economic development; Schumpeter's theory, Approaches to development- low income equilibrium trap - critical minimum effort- The Strategy of economic development- Balanced vs. Unbalanced growth, choice of technique, investment criteria, big push theory, Rostow's stages of Economic Growth, unlimited supply of labour; social and technological dualisms; roles of capital accumulation, human capital and technological change in economic development, Models of economic growth Harrod-Domar, Kaldor, Mahalanobis, Lewis, FeiRanis, Input-Output, multisectoral models.

Unit 2: Comparative Economic Development

Countries selected for case studies -USA, Japan, China and India; Overview of economic development is selected countries; agrarian surplus and the role of the peasantry in economic development; industrial revolution; division of labour, organisation of work and industrial production, the role of the State in developmental transition

I. Course Title : Mathematics for Agricultural Economics

II. Course Code : STAT/AEC

III. Credit Hours : 3+0

Block 1- Introduction

Unit 1: Preliminaries

Logic and proof techniques; sets and set operations; relations; functions and their properties; number systems

Block 2- Variables and functions

Unit 1: Variables and functions

Specific functions is economic theory. Elementary analytical geometry-gradient and equation of straight line. Standard equations and simple properties of circle, parabola and rectangular hyperbola.

Unit 2: Differentiation of functions

Limit and continuity. Differentiation, theorems of differentiation, differentiation of logarithmic and exponential functions, function of a function, derivative of higher order, partial derivatives. Application of derivatives to determine average and marginal values in economic analysis; determination of elasticities; points of inflexion; linear homogenous production functions; derivation of average and marginal curves.

Block 3- Overview of Linear Algebra

Unit 1: Linear Algebra

Determinants, evaluation and properties of determinants, Vectors and vector spaces, Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; Solution of linear and quadratic equations involving one variable, simultaneous equations, application of determinants and matrices in solution of equation for economic analysis.

Unit 2: Optimization of functions

Optimization- unconstrained, maxima and minima, constrained optimization, Lagrange multiplier and their economic applications for optimization problems of cost, production, demand and supply.

Unit 3: Integration of functions

Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral, use of integration to determine relation between average and marginal value. Capitalization over time, estimation of returns from capital goods over time. Pareto distribution.

Course Title with Credit Load
Ph.D. in Agricultural Economics

Major Courses: 12 credits

Course Code	Course Title	Credit Hours	Semester
AEC-601*	Advanced Micro Economic Analysis	2 (1+1)	I
AEC-602	Advanced Macro Economic Analysis	2 (2+0)	II
AEC-603	Advanced Econometrics	3 (2+1)	I
AEC-604	Advanced Production Economics	3 (2+1)	II
AEC-610	Research and Publication Ethics	2(2+0)	I

Minor Courses: 06 credits

a. It is suggested the student may choose at least one out of three courses listed below as part of minor courses as these are related to policy advocacy and bring in global perspectives with an aim to build a larger understanding of the subject to the student.
b. Further, it is suggested that the student may choose the remaining Courses from any other discipline including the disciplines of Agril. Economics/ ABM and are related to the research problem selected by the student.
c. The final choice of the minor courses should be mandatorily approved by the Student Advisory committee/ HoD.

AEC-606	Advanced Agricultural Marketing and Price Analysis	3 (2+1)	
AEC-607	Quantitative Development Policy Analysis	2 (1+1)	
AEC-608	Natural Resource Management	3 (2+1)	
AEC-609	Environmental Economics	3(2+1)	

Minor courses may be taken from above list or subjects closely related to a student's major subject

Supporting Courses: 05 credits

AEC-605 Operations Research 3 (2+1)

One course of 600 series of 2 credits from Statistics or computer discipline may be taken depending upon availability.

- Some of these courses are available in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform.
- If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approval of the HoD/ BoS.
- It is also suggested that the student may choose the Supporting Courses other than the listed courses, provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory committee/HoD".

AEC-691	Doctoral Seminar -I	1(1+0)	I
AEC-692	Doctoral Seminar -II	1(1+0)	II
AEC-693	Special Problem in Ph.D.	1(0+1)	I
	RESEARCH	75	
	Total	100	

There will be two Doctoral Seminar and a research scholar has to published one review paper as output of these seminar. At Ph.D. level, Research Plan Proposal (RPP) be

delivered by the end of SEM II

Course Contents
Ph.D. in Agricultural Economics

I. Course Title : Advanced Micro Economic Analysis

II. Course Code : AEC 601

III. Credit Hours : 1+1

IV. Theory

Block 1- Consumer Theory Unit

1: Consumer Theory

Theory of consumer behavior – Duality in consumer theory - expenditure function and indirect utility function - Measurement of Income Effect and Substitution Effect. Measurement of Changes in Consumers' Welfare – Consumer's Surplus, Compensating Variation and Equivalent Variation - Dynamic versions of demand functions – Integrability of demand functions. Demand Models – Linear Expenditure System, Almost Ideal Demand System. Applications of consumer theory – Household model and time allocation – Labour supply decisions by households.

Block 2- Market and General Equilibrium

Unit 1: Market

Perfect competition – Monopoly, monopolistic competition and oligopoly. Oligopoly models – collusive and non-collusive models of oligopoly - Cournot model, Chamberlin model, Stackleberg solution.

Unit 2: General Equilibrium

General equilibrium theory – Conceptual overview - General equilibrium conditions with Production and Consumption. Existence, Uniqueness and Stability of general competitive equilibrium. Walrasian general equilibrium – Mathematical derivation of conditions for general equilibrium.

Block 3- Market Failure and Welfare

Unit 1: Market failure

Market failure - Incomplete markets - Asymmetric information – Principal-Agent problem, adverse selection and moral hazard. Externalities – Network externalities, Public goods – Optimal provision of public goods.

Unit 2: Welfare Economics

Welfare Economics - Concepts, problems, approaches and limitations of Welfare Economics, Pareto conditions of maximum welfare – Criteria for social welfare - Social Welfare functions, Social versus Private costs and benefits.

V. Practical

- Problems in consumer utility maximization
- Estimation of income and substitution effects;
- Estimation and comparison of Consumer's surplus, equivalent variation andcompensating variation.
- Estimation of demand models – Derivation and estimation of labour supply equations from household models comparative static analysis in consumption.
- Advanced problem solving in price determination under perfect competition,monopoly, oligopoly and monopolistic competition.
- Game theory models.
- Problems solving in General Equilibrium Theory and Welfare Economics.
- Problems in public goods provision.

VI. Suggested Reading

- Henderson JM and Quandt RE. *Microeconomic Theory: A Mathematical Approach* Tata McGraw Hill Publishing Co Ltd
- Koutsoyiannis A. *Modern Micro Economics.* Macmillan Press Ltd
- Ferguson and Gould. *Micro Economic Theory*. Richard D Erwin Inc USA
-

I. Course Title : Advanced Macro Economics

II. Course Code : AEC-602

III. Credit Hours : 2+0

IV. Theory

Block 1- Introduction

Unit 1: Overview

Conceptual framework - Classical, Keynesian, Neo-Classical, and Neo-Keynesian macroeconomics; Review of Keynes-Classical Synthesis; Aggregate Demand and Supply in the closed economy with fixed and variable price level- determination of wage, prices, output and employment

Block 2- Economic Models

Unit 1: Open Economy Models

Exchange rate determination; purchasing power parity; asset market approach; Short-run open economy models; Mundell-Fleming model- exchange rate regime: perfect capital mobility under fixed and flexible exchange rate; effectiveness of fiscal policy and monetary policy; Dornbusch's overshooting model; monetary approach to balance of payments; international financial markets

Unit 2: Dynamic Macroeconomic Models

Introduction to dynamic macroeconomic Models; Dynamic aggregate demand and supply – short and long term equilibrium- rational expectations approach

Block 3: Business Cycle and Policies

Unit 1: Business Cycles

Business cycle and its alternative equilibrium model, Stability analysis Economics of Great Events-Depression, Hyperinflation and Deficits; Advances in Business Cycle Theory; Real Business Cycles & Neo-Keynesian Economics

Unit 2: Macroeconomic Polices

Monetary policy - Design of Monetary Policy; Inflation Targeting, Fiscal Policy - Government Budget Constraint: The Arithmetic of Deficits and Debt, Current versus Future Taxes, the Evolution of Debt-to-GDP Ratio; Public Borrowing-Internal and external aid, Deficit financing, Development Financing; BOP & Adjustment Policies - Foreign Exchange Policy -International macro-economic policies, IMF, IBRD, UNCTAD.

IX. Suggested Reading

- Heibroker RL. *Understanding Macro Economics.*
- Mehta JK. *Macro Economics.*
- Edgemand MR. *Macro-Economics: Theory & Policy.*
- David' W Pearce. *The dictionary of modern Economics.*
- Allen RGD. 1968. *Macro–Economic Theory: A Mathematical Treatment.* London: Macmillan.
- Stanlake GF. *Macro–Economics: An Introduction.* Longman, London.
- Mithai DM. 1981. *Macro–Economics: Analysis and Policy.* Oxford and IBH, New Delhi.
- Hicks JR *Critical Essays in Monetary Theory.*
- Nawiyn WT. *Theory of Money.*

I. Course Title : Advanced Econometrics

II. Course Code : AEC 603

III. Credit Hours : 2+1

IV. Theory

Block 1: Concepts

Unit 1: Review

Review of classical regression model – review of hypothesis testing – restrictions on parameters – single equation techniques.

Block 2: Least Squares and Dummy Variables

Unit 1: Concept of least squares

Ordinary least squares – weighted least squares - generalized least squares – method of principal components – instrumental variables method - maximum likelihood method - errors in variables, non-linearity and specification tests – non spherical error terms.

Unit 2: Dummy Variable

Dummy variables - Qualitative and truncated dependent variables - limited dependent variables –LPM, probit and logit models, their multinomial extensions.

Block 3: Econometric Models

Unit 1: Models and their extensions

Autoregressive distributed lag models – panel data fixed and random effects models and their extensions.

Unit 2: Simultaneous equation models

Simultaneous equation methods –identification – estimation by indirect least squares 2SLS, PIML, SURE, 3SLS

V. Practical

Estimation of multiple regression model - GLS estimation methods - testing misspecification errors – Testing and Managing multicollinearity, heteroscedasticity and autocorrelation - estimation of LPM, Logit and Probit models - comparing two regressions - Chow test - estimation of distributed lag models – panel data random and fixed effects models - Indirect least squares 2SLS, SURE, 3SLS, estimation of simultaneous equation models.

VI. Suggested Reading

- Greene WH. 2002. *Econometric Analysis*. Pearson Education.
- Johnston J and Dinardo J. 2000. *Econometric Methods*. Mc Graw-Hill.
- Koutseyianis A. 1997. *Theory of Econometrics*. Barner & Noble.

I. Course Title : Advanced Production Economics

II. Course Code : AEC 604

III. Credit Hours : 2+1

IV. Theory

Block 1: Production process

Unit 1: Production Process

Agricultural Production process – Relationship between farm planning and production economics-scope of agricultural production and planning-methods/ procedures in agro-economic research and planning.

Block 2: Production Function

Unit 1: Production Functions and characteristics

Production functions, components, assumptions, properties and their economic interpretation - Concepts of homogeneity, homotheticity,, APP, MPP, elasticities of substitution and their economic relevance – Production relations – optimality- Commonly used functional forms, nature, properties, limitations, estimation and interpretation - linear, Spillman - Cobb Douglas, quadratic, multiplicative (power) functional forms - Translog, and transcendental functional forms - CES, production functional forms-Conceptual and empirical issues in specification, estimation and application of production functions- Analytical approaches to economic optimum - Economic optimum – determination of economic optimum with constant and varying input and output prices - Economic optimum with production function analysis - input use behaviour.

Block 3: Dynamics of production process

Unit 1: Decision Making in Production

Decision making with multiple inputs and outputs – MRT and product relationship-cost of production and adjustment in output prices-single input and multiple product decisions- Multi input, and multi product production decisions - Decision making with no risk -Cost of wrong decisions - Cost curves – Principles and importance of duality theory - Correspondence of production, cost, and profit functions - Principles and derivation of demand and supply functions

Unit 2: Technology, Efficiency and Risk Management

Technology, input use and factor shares -effect of technology on input use-decomposition analysis-factor shares-estimation methods- Economic efficiency in agricultural production – technical, allocative and economic efficiency – measurement -Yield gaps analysis – concepts and measurement - Risk and uncertainty in agriculture – incorporation of risk and uncertainty in decision making – risk and uncertainty and input use level-risk programming.

Unit 3: Programming

Simulation and programming techniques in agricultural production-Multiple Objective Programming (MOP) – Goal programming, Weighted sum and Compromise programming – applications.

V. Practical

Estimation of different forms of production functions- Optimal input and product choice from estimated functions-Derivation of demand and supply functions and estimation-Estimation of cost function and interpretations-Optimal product and input choice under multi input and output system-Estimation of factor shares from

empirical functions estimated-Estimating production functions incorporating technology changes: Decomposition analysis and incorporation of technology-Estimation of efficiency measures – Stochastic, probabilistic and deterministic frontier production functions-Risk programming – MOTAD-Quadratic programming-Simulation models for agricultural production decisions-Goal programming – Weighted, lexicographic and fuzzy goal programming-Compromise programming.

VI. Suggested Reading

- Baumol WG. 1973. *Economic theory and operations analysis*. Practice Hall of India Private Limited, New Dehli. 626 p.
- Gardner BL and Rausser GC. 2001. *Handbook of Agricultural Economics* Vol. I Agricultural Production. Elsevier.
- Heady EO. 1952. *Economics of Agricultural Production and resources use*. Practice Hall of India.
- Heady EO and Dillon JL. 1961. *Agricultural Production functions*. Kalyani Publishers, Ludhiana, India. 667 p.

I. Course Title : Operations Research

II. Course Code : AEC-605

III. Credit Hours : 2+1

IV. Theory

Block 1: Concepts

Unit 1: Concepts

Elementary concepts and objectives of Operations Research, Review of Linear programming - Assumptions & Methods, Non-linear programming problem - Quadratic programming, Multi Objective Programming (MOP)

Block 2: Inventory and Models

Unit 1: Inventory- A Review

Inventory control models, costs involved in Inventory management, types of inventory, Economic order quantity model, Waiting line models: Waiting line problem, Characteristics of a waiting line system, Single channel model,

Unit 2: Modles

Markov Chains, Sequencing, Replacement models, Transportation and Assignment problems.

Block 3: Decision Making

Unit 1: Decision Making

Decision making under risk and uncertainties, decision problem, maximax criterion, maximin criterion, minimax regret criterion, Laplace criterion, Pay off tables, Decision trees, Expected value of perfect information.

Unit 2: Game Theory

Game Theory – Two-person Zero sum game, Simulation, Network Analysis- PERT & CPM.

V. Practical

- Linear and Non-linear programming problem,
- Quadratic programming, Multi-Objective Programming- Goal Programming,
- Lexicographic, Weighted Sum, Determining economic order quantity, reorder levels of EOQ model.
- Waiting line problem, Problems on Markov Chains, Sequencing and Replacement models.
- Formulating and solving transportation type problems, Assignment problems as a special type of transportation problem.
- Solving deterministic and probabilistic queuing models Structuring and solving decision trees for optimal decisions Game theory, Simulation, Developing network (PERT/CPM) diagrams and determining the critical path.

VI. Suggested Reading

- Taha HA. *Operations Research: An Introduction.*
- Veerabhadrappa H. *An Introduction to Operations Research.*
- Gupta PK and Hira DS. *Operations Research.*
- Sharma R. *Operations Research.*
- Sharma JK. *Operation Research.*
- Greene WH. 2002. *Econometric Analysis.* Pearson Education.
- Johnston J and Dinardo J. 2000. *Econometric Methods.* Mc Graw-Hill.
- Koutseyianis A. 1997. *Theory of Econometrics.* Barner & Noble.

I. Course Title : Advanced Agricultural Marketing And Price Analysis

II. Course Code : AEC 606

III. Credit Hours : 2+1

VII. Theory

Block 1: Concepts

Unit 1: Agricultural Marketing-

Insights Importance of market analysis in the agricultural system - types of marketing-advantages and disadvantages - quantitative estimation -the distinguishing characteristics and role of agricultural prices -data sources for agricultural products and prices - softwares used in market analysis.

Block 2: Marketing Institutions and Dynamics

Unit 1: Institutions and their functions

Role of various formal institutions in agricultural marketing - and functions - measuring their efficiency - public - private partnership - institutional arrangements. Successful case studies.

Unit 2: Market Dynamics

Multi market estimation, supply response models. Market integration and price transmission - supply / value chain management. GAP analysis. Current trends in information in the changing agrifood system.

Block 3: Techniques

Unit 1: Commodity Marketing

Agricultural commodity marketing -spot and futures- marketing of derivatives-speculation, hedging, swap, arbitrage etc. commodity exchanges - price discovery and risk management in commodity markets-Regulatory mechanism of futures trading.

Unit 2: Models for Analysis

Lag operators and difference equations; stationary and stochastic processes; Unit roots and cointegration; conditional heteroscedasticity: ARCH and GARCH models -forecast evaluation; methods of forecasting. price indices and econometric estimation and simulation.

VIII. Practical

- Estimation of demand/ supply forecasting,
- Supply chain/ value chain analysis for different commodities
- Commodity models- multi market estimation- time series analysis
- Market integration studies- price discovery price volatility estimation

X. Commodity price forecasting using econometric softwares.

XI. Suggested Reading

- Acharya SS and Agarawal NL. 1994. *Agricultural Prices-Analysis and Policy*. Oxford and IBH Publishing company Pvt. Ltd, New Delhi.
- Acharya SS and Agarawal NL. 2004. *Agricultural Marketing in India*. Oxford and IBH Publishing company Pvt. Ltd, New Delhi.
- Kohls RH and Joseph N. Uhl: *Marketing of Agricultural products* by Collier MacMillan International.
- Rhodes VJ. 1978. *The Agricultural Marketing System*. Grid Pub. Ohio.

I. Course Title : Quantitative Development Policy Analysis

II. Course Code : AEC 607

III. Credit Hours : 1+1

Theory

Block 1: Concepts

Unit 1: Policy Framework

olicy framework – goals, value, beliefs and welfare maximization. Market – Policy and State – State vs. Market – Failure of Policy – Failure of Markets - Rationale for Government Intervention. Role of Quantitative Policy Analysis.

Block 2: Demand-supply and household behaviour

Unit 1: Demand- Supply Analysis

Demand analysis for policymaking – Alternative approaches to demand analysis – Policy implications. Supply response – Alternative approaches to measurement of supply response – Nerlovian models of supply response – Policy implications.

Unit 2: Household Behaviour and models

Household behaviour and policy analysis – Household models.

Block 3: Approaches to review policy and welfare

Unit 1: Multi-Pronged approach to policy review

Partial equilibrium analysis – Concept of reference prices – Price distortions – indicators and impact. Transaction costs – Implications for efficiency and productivity – Institutional solutions - Multi market approach to policy analysis.

Unit 2: General equilibrium and programming

Social Accounting Matrices and multipliers -– Computable General Equilibrium models to assess economy wide impact of policy changes. fuzzy goal programming-Compromise programming.

IV. Practical

- Review of criteria for policy evaluation
- Estimation of price elasticities
- Review of estimation of complete demand systems
- Estimation of Nerlovian supply Response model
- Review of Household models
- Specification and estimation of household models
- Partial equilibrium analysis
- Input–output table
- Social Accounting Matrix
- Construction of a SAM
- Computation of Multipliers
- Multi Market Analysis
- Review of Computable General Equilibrium Models.

I. Course Title : Natural Resource Management

II. Course Code : AEC 608

III. Credit Hours : 1+1

VI. Theory

Block 1: Concepts

Unit 1: Concepts

Natural resources - definition - characteristics and classification. Stock dynamics of renewable and non-renewable resources. Equation of motion for renewable and non-renewable resources. Fundamental equation of renewable resources.

Block 2: Models and Management

Unit 1: Models for economic view of natural resources

Growth curves of fishery and forest resources. The role of time preference in natural resource use. Simple two-period model of optimal use of renewable and non-renewable resources. Advanced models of optimal resource use – Static Vs. dynamic efficiency in natural resource use Applications of dynamic programming and optimal control.

Unit 2: Management of water resources

Economics of groundwater use - optimal extraction of groundwater. Analytical and numerical solutions for optimal inter-temporal allocation of natural resources. Optimal harvesting of single rotation and multiple rotation forests. Optimal management of fishery.

Block 3: Regulations and planning

Unit 1: Property Rights

Property rights in natural resources and their implication for conservation and management of natural resources. Management of common property natural resources – Institutional arrangements for conservation and management of common pool fishery, groundwater and forestry resource.

Unit 2: Dynamics of resource economics

Resource scarcity – Natural resource degradation – Poverty and resource degradation – Natural resource accounting - Pricing and valuation of natural resources – Natural resources policy. Practical Derivation of the fundamental equation of renewable resources-Estimation of growth curves and stock dynamics for fishery and forestry resources. Simple two period problem of optimal resource use – Numerical solution for simple two-period model of dynamic efficiency in natural resource extraction. Multi-period dynamic efficiency – Using Excel Solver in solving dynamic natural resource harvesting problems. Using analytical solution procedures for solving natural resource management problems – Optimal control.

VII. Suggested Reading

- Hackett SC. 2001. *Environmental and Natural Resource Economics: Theory, Policy and the Sustainable Society*. M.E. Sharpe, Armonk, NY.
- Hartwick JM and Olewiler ND. 1998. *The Economics of Natural Resource Use*. 2nd Ed. Addison-Wesley Educational Publ.
- Kerr JM, Marothia DK, Katar Singh, Ramasamy C and Bentley WR. 1997. *Natural Resource Economics: Theory and Applications in India*. Oxford & IBH.
- Pearce DW and Turner K. 1990. *Economics of Natural Resources and the Environment*.John Hopkins Univ. Press.
- Prato T. 1998. *Natural Resource and Environmental Economics*. Iowa State Univ. Press.
- Sengupta R. 2000. *Ecology and Economy, an Indian Perspective*. Oxford Univ. Press.
- Tietenberg T. 2003. *Environment and Natural Resource Economics*. 6th Ed. Addison Wesley.

I. Course Title : Environmental Economics

II. Course Code : AEC 609

III. Credit Hours : 2+1

IV. Theory

Block 1: Overview

Unit 1: Overview of Environmental Economics

Environmental pollution as a consequence of market failure - Causes and consequences of market failure - Externalities - Public goods and externalities -Economics of pollution – Private vs. Social cost of environmental pollution – Property rights, environment and development – Theory of environmental policy.

Block 2: Assessment and Development Dynamics

Unit 1: Economic assessment

Environmental cost benefit analysis - Environmental impact assessment techniques Non-market valuation of environmental resources (WTP / WTA) - Environment, market and social welfare.

Unit 2: Developmental aspects

Economic growth and environmental cost - Growth oriented economic policies and their environmental impacts - Population and environmental quality - poverty and environmental degradation – Sustainable development – Indicators of sustainable development – Issues in sustainable development.

Block 3: Regulations and Issues

Unit 1: Accounting, Policies and Regulation

Environment, ecology and environmental accounting - Environmental pollution with respect to water and air - Land and forest resources related environmental pollution - Coastal externalities - Urbanization and environment - Basic approaches to environmental policy (Tax, subsidy, pollution permits, *etc*.) Green taxes - Political economy of environmental regulation and management.

Unit 2: Environmental Issues

Transboundary environmental problems - Economics of global warming, climate change and emission trading - Environment, international trade and development.

V. Practical

- Contemporary global environmental global environmental issues, movement, policies, programmes, laws and other regulatory mechanisms
- Criteria for evaluating the environment related projects and review of Environmental Impact Assessment (EIA) techniques
- Recreation demand models of environmental valuation
- Contingent valuation techniques
- Environmental Resource Accounting Techniques
- Discussion on the techniques dealing with air pollution and review of case studies on air pollution and its impacts - forest environment and wild life conservation
- Green GDP and Green house insurance
- Practical considerations and comparison of instruments of environmental policy
- Non-point source pollution control methodologies
- Environment in macroeconomic modeling
- Meta-analysis, economic valuation and environmental economics

- Multi-criteria methods for quantitative, qualitative and fuzzy evaluation problems related to environment
- Input output analysis, technology and the environment
- Computable general equilibrium models for environmental economics and policy analysis.

VI. Suggested Reading

- Hackett SC. 2001. *Environmental and Natural Resource Economics: Theory, Policy and the Sustainable Society*. ME. Sharpe, Armonk, NY.
- Hartwick JM and Olewiler ND. 1998. The Economics of Natural Resource Use. 2nd Ed. Addison-Wesley Educational Publ.
- Kerr JM, Marothia DK, Katar Singh, Ramasamy C and Bentley WR. 1997. *Natural Resource Economics: Theory and Applications in India.* Oxford & IBH.
- Pearce DW and Turner K. 1990. *Economics of Natural Resources and the Environment.* John Hopkins Univ. Press.
- Prato T. 1998. *Natural Resource and Environmental Economics.* Iowa State University Press.
- Sengupta R. 2000. *Ecology and Economy, an Indian Perspective.* Oxford University Press.
- Tietenberg T. 2003. *Environment and Natural Resource Economics*. 6th Ed. Addison Wesley.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 2

Social Sciences

– Agricultural Extension Education

Course Title with Credit Load
M.Sc. in Agricultural Extension Education

Major Courses 20

Course Code	Course Title	Credit Hours	Semester
EXT-501*	Extension Landscape	2(2+0)	I
EXT-502*	Applied Behaviour Change	3(2+1)	II
EXT-503*	Organisational Behaviour and Development	3(2+1)	I
EXT-504*	Research Methodology in Extension	3(2+1)	I
EXT-505*	Capacity Development	3(2+1)	I
EXT-506*	ICTs for Agricultural Extension and Advisory Services	3(2+1)	II
EXT-507*	Evaluation and Impact Assessment	3(2+1)	II

Minor Courses 08

a. It is suggested the student may choose at least two out of three courses listed below as part of minor courses as these are related to policy advocacy and aim to build larger understanding of the subject.
b. Further, it is suggested that the student may choose the remaining Courses from any other discipline including the disciplines of Agrl. Economics/ABM and are related to the research problem selected by the student.
c. The final choice of the minor courses should be mandatorily approved by the Student Advisory committee/HoD.

EXT-508	Managing Extension Organisations	3(2+1)
EXT-509	Enabling Innovation	2(1+1)
EXT-510	Gender Mainstreaming	3(2+1)

Supporting Courses 06

STAT	Statistical Methods for Applied/ Social Sciences	3(2+1)
STAT/COMP	Computer Applications for Agricultural Extension Research	3(2+1)

It is suggested that the student may choose the Supporting Courses other than the listed courses, provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory committee/HoD".

Common Courses 05

1. Technical Writing and Communications Skills
2. Intellectual Property and its management in Agriculture
3. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approval of the HoD/BoS.

EXT-591	Master's Seminar	**01**
	Thesis/Research	30

Total	70

Course Contents
M.Sc. in Agricultural Extension Education

I. Course Title : Extension Landscape

II. Course Code : EXT 501

III. Credit Hours : 2+0

Theory

Block 1: Globally, What Is New In Extension?

Unit 1: Challenges before Extension and Advisory Services (EAS)

Extension and Advisory Services (EAS)- Meaning (embracing pluralism and new functions) New Challenges before farmers and extension professionals: Natural Resource Management-Supporting farmers to manage the declining/deteriorating water and soil for farming; Gender Mainstreaming- How extension can enhance access to new knowledge among women farmers; Nutrition- Role of extension in supporting communities with growing nutritious crop and eating healthy food; Linking farmers to markets- Value chain extension including organizing farmers, strengthen value chain and supporting farmers to respond to new standards and regulations in agri-food systems; Adaptation to climate changes-How extension can contribute to up-scaling Climate Smart Agriculture; Supporting family farms-strengthening the capacities of family farms; Migration-Advising farmers to better respond to opportunities that emerge from increasing mobility and also supporting migrants in enhancing their knowledge and skills; Attracting and Retaining Youth in Agriculture including promotion of agripreneurship and agri-tourism; Urban and peri-urban farming- How to support and address issues associated with urban and peri-urban agriculture; Farmer distress, suicides- Supporting farmers in tackling farm distress.

Unit 2: New Functions and New Capacities

Beyond transfer of technology: Performing new functions to deal with new challenges; Organising producers into groups-dealing with problems that need collective decision making such as Natural Resource Management (NRM) and access to markets; Mediating conflicts and building consensus to strengthen collective decision making; Facilitating access to credit, inputs and services-including development of service providers; Influencing policies to promote new knowledge at a scale Networking and partnership development including convening multi-stakeholder platforms/ innovation platforms.

New Capacities needed by extension and advisory services at different levels –at the individual (lower, middle management and senior management levels), organizational and enabling environment levels; –Core competencies at the individual level; Varied mechanisms for capacity development (beyond training).

Unit 3: Pluralism in EAS

Pluralism in Extension Delivery: Role of private sector (input firms, agri-business companies, consultant firms and individual consultants)- Trends in the development of private extension and advisory services in India and other countries; challenges faced by private extension providers; Role of Non-Governmental Organizations (National/international)/ Civil Society Organizations (CSOs) in providing extension-Experiences from India and other countries; Producer Organizations- Role in strengthening demand and supply of extension services; their strength and

weaknesses-experiences from different sectors; Role of Media and ICT advisory service providers; global experiences with use of media and ICTs in advisory services provision.

Block 2: Insights From Innovation Studies and New Extension Approaches

Unit 1: From the Linear Paradigm to Systems Paradigm

Diffusion of Innovations paradigm- strengths and limitations; multiple sources of innovation-farmer innovation, institutional innovation; farmer participation in technology generation and promotion; strength and limitations; Agricultural Knowledge and Information Systems (AKIS); strength and limitations; Agricultural Innovation Systems (AIS); Redefining Innovation- Role of Extension and Advisory Services in AIS-From information delivery to intermediation across multiple nodes; Role of brokering; Innovation Platforms, Innovation Management; Strength and weaknesses of AIS. Rethinking Communication in the Innovation Process – Network building, support social learning, dealing with dynamics of power and conflict.

Unit 2: Evolving Extension Approaches

Evolution and features of extension approaches: Transfer of technology approach; educational approach, farmer participatory extension approach, demand-driven extension, market led extension (value chain extension), extension for climate smart agriculture, gender sensitive extension, extension for entrepreneurship Extension systems in different regions: Asia-Pacific, Europe, Latin America, Australia, North America Networking for Strengthening EAS: GFRAS (Global Forum for Rural Advisory Services) and its regional networks.

Block 3: Extension Reforms and Policy Challenges

Unit 1: Changes in Governance, Funding and Delivery

Reduction in public funding: public withdrawal from extension provision (partial/ full); Examples/Cases; Privatization: Public funding and private delivery; cost sharing and cost recovery; Examples/Cases; Decentralisation of extension services; Examples/ Cases; Lessons from extension reforms in different countries; Extension and Sustainable Development Goals (SDGs).

Unit 2: Challenges in Managing Pluralistic Extension Systems

Pluralism: Managing pluralism and Co-ordination of pluralistic extension provision; Public private partnerships in extension (including the role of local governments/ panchayats and producer organisations); Examples, challenges in co-ordination; Achieving convergence in extension planning and delivery, Financing Extension: Mobilising resources for extension: public investments, donor support (grants/loans); Monitoring and Evaluation of Extension: Generating appropriate data for Assessment and Evaluation of pluralistic extension; Strengthening extension policy interface; generating evidence on impact of communication.

VIII. Suggested Reading

Adolph B. 2011. *Rural Advisory Services World wide: A Synthesis of Actors and Issues. GFRAS*: Lindau, Switzerland. https://www.g-fras.org/en/knowledge/gfras-publications.html?download=6: rural-advisory-services-worldwide&start=40

Ashok G, Sharma P, Anisha S and Prerna T. 2018. *Agriculture Extension System in India Review of Current Status, Trends and the Way Forward.* Indian Council for Research on International

Economic Relations (ICRIER). http://icrier.org/pdf/Agriculture-Extension- System-in-India-2018.pdf

Barber J, Mangnus E and Bitzer V. 2016. *Harnessing ICT for agricultural extension***.** KIT WorkingPaper 2016: 4.

https://213ou636sh0ptphd141fqei1-wpengine.netdna-ssl.com/sed/wp-content/uploads/sites/2/2016/11/KIT_WP2016- 4_Harnessing-ICT-for-agricultural-eXtension.pdf

Bentley J, Chowdhury A and David S. 2015. *Videos for Agricultural Extension.* Note 6. GFRAS Good Practice Notes for EXtension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/6-video-for-agricultural-eXtension.html #SNote1

Bingen RJ and Simpson BM. 2015. *Farmer Organizations and Modernizing Extension and Advisory Services*. MEAS Discussion Paper. http://meas.illinois.edu/wp-content/uploads/2015/04/Bingen-Simpson-2014-FarmerOrganizations-MEAS-Discussion-Paper.pdf

Bitzer V, Wennink B and de Steenhuijsen PB. 2016. *The governance of agricultural extension systems*. KIT Working Paper 2016: 1.http://213ou636sh0ptphd141fqei1.wpengine.netdna-cdn.com/sed/wpcontent/uploads/sites/2/2016/03/WPS_1-2016-web.pdf

Bitzer V, Wongtschowski M, Hani M and Blum M. 2016. *New directions for inclusive Pluralistic Service Systems.* In New Directions for Inclusive Pluralistic Service Systems Rome (Italy). FAO. http://www.fao.org/3/a-i6104e.pdf

Burton ES & Kristin D. 2014. *Status of Agricultural Extension and Rural Advisory Services Worldwide.* GFRAS: Lindau, Switzerland. http://www.g-fras.org/en/knowledge/gfras-publications.html?download=391: status-of-agricultural-eXtension-and-rural-advisory-services-worldwide

Christoplos I. 2010. *Mobilizing the potential of rural and agricultural extension*. Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/docrep/012/i1444e/i1444e.pdf

Colverson KE. 2015. *Integrating Gender into Rural Advisory Services.* Note 4. GFRAS Good Practice Notes for EXtension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/integrating-gender-into-rural-advisory-services.html#SNote1

David S. 2018. *Migration and rural advisory services.* GFRAS Issues Paper 2. Global Forum for Rural Advisory Services. https://www.g-fras.org/en/knowledge/gfras-publications/category/97-gfras-issues-papers.html?download=856: migration-and-rural-advisory-services

Davis K and Heemskerk W. 2012. *Coordination and Collective Action for Agricultural Innovation* Overview Module 1 Investment in EXtension and Advisory Services as Part of Agricultural Innovation Systems. In Agricultural Innovation Systems: An Investment Sourcebook. Agricultural and Rural Development. World Bank. © World Bank. http://siteresources.worldbank.org/INTARD/Resources/335807-1330620492317/9780821386842ch3.pdf

FAO. 2016. *New directions for inclusive Pluralistic Service Systems*. Report of FAO EXpert Consultation. Food and Agriculture Organization of the United Nations and Royal Tropical Institute, Rome. http://www.fao.org/3/ai6103e.pdf

FAO.2017. *Climate-Smart Agriculture Sourcebook.* Available at: http://www.fao.org/3/a-i3325e.pdf

Faure G, Pautrizel L, de Romémont A, Toillier A, Odru M and Havard M. 2015. *Management Advice for Family Farms to Strengthen Entrepreneurial Skills***.** Note 8. GFRAS Good Practice Notes for EXtension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/management-advice-for-family-farms-to-strengthen-entrepreneurial-skills.html#SNote8

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GFRAS. 2015. *Producer organisations in rural advisory services: Evidence and experiences.* Position Paper. Lindau: Global Forum for Rural Advisory Services. http://www.g-fras.org/en/593-producer-organisations-in-rural-advisory-servicesevidence-and-eXperiences.html

GFRAS. 2016. *Five Key Areas for Mobilising the Potential of Rural Advisory Services.* GFRAS Brief 1. Global Forum for Rural Advisory Services. https://www.g-fras.org/en/knowledge/

gfras-publications.html?download=4: five-key-areas-for-mobilising-the-potential-of-rural-advisory-services.
GFRAS.2016. *The New Extensionist Learning Kit*. http://g-fras.org/en/knowledge/new-extensionist-learningkit-nelk.html#module-1-introduction-to-the-new-extensionist
GRFAS. 2014. *Policy Compendium*. http://www.g-fras.org/en/policy-compendium.html
Gwyn EJ and Garforth C. nd. *The history, development, and future of agricultural extension*. FAO. Rome. http://www.fao.org/docrep/W5830E/w5830e03.htm
Jennings JR, Packham RG and Woodside D. 2011. *Shaping change: natural resource management, agriculture and the role of extension*. Australasia Pacific Extension Network. http://www.apen.org.au/shaping-change
Leeuwis C with A W van den Ban. 2004. *Communication for rural innovation: Rethinking agricultural extension*. John Wiley & Sons.
Magdalena Blum and Sanne Chipeta. 2016. *Innovative Financing Mechanisms for Demand-driven Agricultural Advisory Services*. Gfras good practice note for extension and advisory services 21. Global Forum for Rural Advisory Services. https://www.g-fras.org/en/good-practice-notes/20-innovative-financing-mechanisms.html#SNote8
Manfre C, Rubin D and Nordehn C. 2017. *Assessing How Agricultural Technologies can Change Gender Dynamics and Food Security Outcomes*. A three part toolkit. Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES). http://www.culturalpractice.com/wp-content/uploads/Introduction-to-the-Toolkit-Final-10_17.pdf
Mittal N, Sulaiman RV and Prasad RM. 2016. *Assessing capacity needs of Extension and Advisory Services: A Guide for Facilitators*. Agricultural Extension in South Asia (AESA). http://crispindia.org/wpcontent/uploads/2015/09/Facilitators-Guide-Final-LR.pdf
Posthumus H and Wongtschowski M. 2014. *Innovation Platforms*. Note 1. GFRAS good practice note for extension and advisory services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/innovation-platforms.html#SNote1
Rajalahti R, Janssen W and Pehu E. 2008. *Agricultural innovation systems: From diagnostics toward operational practices*. Agriculture & Rural Development Department, World Bank. https://agrilinks.org/sites/default/files/resource/files/ARDDiscussionPaper38.pdf
Rao S. 2015. *Using Radio in Agricultural Extension*. Note 18. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/using-radio-in-agricultural-extension.html#SNote8
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https://www.g-fras.org/en/good-practice-notes/mextension.html#SNote17
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Swanson BE. 2008. *Global Review of Good Agricultural Extension and Advisory Service Practices.* Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/docrep/pdf/011/i0261e/i0261e00.pdf

Terblanche S and H Ngwenya. 2017. *Professionalisation of Rural Advisory Services.* Note 27. GFRAS Global Good Practice Notes for Extension and Advisory Services. GFRAS: Lausanne, Switzerland.
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World Bank. 2006. *Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems.* Washington, DC: World Bank. © World Bank.
https://openknowledge.worldbank.org/handle/10986/7184

Websites

- **AESA**- Agricultural Extension in South Asia http://www.aesanetwork.org/
- **FAO**- Food and Agricultural Organisation (Research and Extension) http://www.fao.org/research-and-extension/en/
- **GFRAS**- Global Forum for Rural Advisory Services http://www.g-fras.org/en/
- **INGENEAS**- Integrating Gender and Nutrition within Agricultural Extension Services https://ingenaes.illinois.edu/
- **IFPRI**- International Food Policy Research Institute (Extension) http://www.ifpri.org/topic/agricultural-extension
- **KIT**- Royal Tropical Institute (KIT)-Sustainable Economic Development https://www.kit.nl/sed/
- **WUR**- Wageningen University and Research Research (Knowledge, Technology and Innovation Group (KTI)) https://www.wur.nl/en/Research-Results/Chair-groups/Social-Sciences/
- KnowledgeTechnology-and-Innovation-Group.htm

I. Course Title : Applied Behaviour Change

II. Course Code : EXT 502

III. Credit Hours : 2+1

IV. Theory

Block 1: Foundations of Behaviour Change

Unit 1: Foundations of Human Behaviour

Human behaviour – Meaning, importance and factors influencing human behaviour; Biological bases of human behaviour – Nervous system, brain, endocrine system and genes; Individual variations – intelligence, ability and creativity– foundations and theories, personality and temperament - foundations, approaches, theories of personality, measuring personality (traits, locus of control, self-efficacy; Personal, social and moral development – meaning, concepts – self-concept, self-esteem and self-worth and theories. Motivation – foundations, approaches, theories, managing human needs and motivations; perceiving others – impression, attitude, opinions; Emotions - foundations, types and functions, measuring emotional intelligence.

Block 2: Cognitive Processes And Learning

Unit 1: Cognitive Processes affecting Human Behaviour

Sensory organs and their role cognition; Cognitive processes – Attention, perception, remembering and forgetting, knowledge and expertise – foundations and theories; Principles and processes of perception; Consciousness – meaning, types, sleep and dreams; Learning and Memory – Memory - meaning, types and mechanisms of storage and retrieval of memories in the Human brain; Complex cognitive processes - Concept formation, Thinking, Problem solving and transfer – foundations, theories and approaches.

Unit 2: Information Processing

Information processing – meaning, principles; Models of information processing - Waugh and Norman model of primary and secondary memory; Atkinson and Shiffrin's stage model of memory; other models including blooms taxonomy and Sternberg's Information Processing Approach; Attention and perception – meaning, types, theories and models; Consciousness.

Unit 3: Learning

Learning – foundations, approaches and theories; Cognitive approaches of learning – meaning, principles theories and models; Memory – foundations, types; Behavioural approaches of learning – foundations and theories - classical conditioning, operant conditioning, applied behaviour analysis; Social cognitive and constructivist approaches to learning – foundations and theories – social cognitive theory, Self-regulated learning; learning styles – meaning, types and applications in learning.

Unit 4: Judgement, Choice and Decision-making

Human judgement – meaning, nature, randomness of situations, theories and models; Choice – meaning, criteria for evaluating options; theories and models of human choice; Choice architecture; Decision-making – Meaning, problem analysis; steps and techniques of decision-making under different contexts.

Block 3: Human Behaviour in the Society

Unit 1: Attitudes and Influence

Attitudes - meaning, assumptions, types, theories and models of attitude formation; methods of changing attitudes, Relating to others - liking, attraction, helping

behaviour, prejudice, discrimination and aggression; Liking/ affect – meaning, types and theories; Attraction – meaning, types and theories; Persuasion – meaning, theories and techniques; Social influence and groups – conformity, compliance and obedience.

Unit 2: Social Judgement, Social Identity and Inter-Group Relations

Social judgement – meaning, frame of reference, stereotyping; The judgement of attitude models; Attribution – meaning, theories; Rational decision making; Social identify – meaning, types; assessment; Groups – meaning, types, group processes; sustainability of groups; Inter group processes and theories social learning.

V. Practicals

- Understanding perception – Attentional Blink and Repetition Blindness exercise
- Understanding attention - Testing selective attention capacity and skills and processing speed ability through Stroop test
- Hands-on experience in the techniques for assessing creative thinking – divergent and convergent thinking
- Lab exercise in applying Maslow's need hierarchy to assess motivation
- Learning - Classical conditioning and operant conditioning
- Assessing learning styles through Barsch and Kolb inventories
- Practical experience in building self-esteem
- Assessment of emotional intelligence
- Exercises in problem solving
- Exercises in visual perception
- Measuring self-concept using psychometric tools
- Experiment on factors influencing information processing
- Assessment of attitudes
- Hands on experience in methods of persuasion
- Field experience in assessing social judgement
- Simulation exercise to understand decision-making under different situations
- Exercise in rational decision-making.

Suggested Reading

Eiser J, Richard. 2011. *Social Psychology: Attitudes, Cognition and Social Behaviour*. Cambridge: Cambridge University Press.(First Edition, 1986))

Eysenck MW and Keane M T. 2010. *Cognitive psychology: A student's handbook.* Sixth Edition, Hove: Psychology Press.

Feldman RS. 2008. *Essentials of understanding psychology* (7th ed.). Boston: McGraw-Hill.

Gilovich T, Keltner D, and Nisbett RE. 2011. *Social psychology*. New York: W.W. Norton & Co.

Moreno R. 2010. *Educational Psychology*. Hoboken, NJ: John Wiley & Sons Inc.

Nevid JS. 2012. *Essentials of psychology: Concepts and applications* Belmont, CA: Wadsworth, Cengage Learning.

Rachlin H. 1989. *Judgment, decision, and choice: A cognitive/behavioral synthesis.* New York: W.H. Freeman.

I. Course Title : Organisational Behavior and Development

II. Course Code : EXT 503

III. Credit Hours : 2+1

IV. Theory

Block 1: Organizational Behavior

Unit 1: Basics of Organization

Introduction to organizations-concept and characteristics of organizations; Typology of organizations; Theories of organizations: nature of organizational theory, Classical theories, Modern management theories, System Theory - Criticisms and lessons learnt/ analysis.

Unit 2: Basics of Organizational Behaviour

Concepts of Organisational Behaviour, Scope, Importance, Models of OB.

Unit 3: Individual Behaviour in Organizations

Introduction, Self-awareness, Perception and Attribution, Learning, Systems approach to studying organization needs and motives – attitude, values and ethical behavior, Personality, **Motivation**-Concept & Theories, Managing motivation in organizations.

Unit 4: Group Behaviour in Organization

Foundations of group, group behaviour and group dynamics, Group Development and Cohesiveness, Group Performance and Decision Making, Intergroup Relations; Teams in Organizations-Team building experiential exercises, Interpersonal Communication and Group; Leadership: Meaning, types, Theories and Perspectives on Effective Leadership, Power and Influence, managing Conflict and Negotiation skills, Job/ stress management, decision-making, problem-solving techniques.

Unit 5: Productive Behaviour and Occupational Stress

Productive behaviour - Meaning, dimension; Job analysis and Job performance – meaning, dimensions, determinants and measurement; Job satisfaction and organizational commitment - meaning, dimensions and measures roles and role clarity; Occupational stress – meaning, sources, theories and models, effects, coping mechanism, effects and management; Occupational stress in farming, farmer groups/ organizations, research and extension organizations.

Unit 6: Organizational System

Organizations Structure- Need and Types, Line & staff, functional, committee, project structure organizations, centralization &decentralization, Different stages of growth and designing the organizational structure; Organizational Design-Parameters of Organizational Design, Organization and Environment, Organizational Strategy, Organization and Technology, Power and Conflicts in Organizations, Organizational Decision-Making; Organizational Culture vs Climate; Organizational Change; Organizational Learning and Transformation.

Block 2: Organisational Development

Unit 1: Overview of Organizational Development

Concept of OD, Importance and Characteristics, Objectives of OD, History and Evolution of OD, Implications of OD Values.

Unit 2: Managing the Organizational Development Process

Basic Component of OD Program-Diagnosis-contracting and diagnosing the problem,

Diagnostic models, open systems, individual level group level and organizational level diagnosis; Action-collection and analysis for diagnostic information, feeding back the diagnosed information and interventions; Program Management- entering OD relationship, contracting, diagnosis, feedback, planned change, intervention, evaluation.

Unit 3: Organizational Development Interventions

Meaning, Importance, Characteristics of Organization development Interventions, Classification of OD Interventions-Interpersonal interventions, Team Interventions, Structural Interventions, Comprehensive Interventions.

Unit 4: Organizational Development Practitioner or Consultant

Who is OD consultant? Types of OD consultants and their advantages, qualifications, Comparison of traditional consultants Vs. OD consultants, Organizational Development process by the practitioners skills and activities.

V. Practicals

- Case Analysis of organization in terms of process – attitudes and values, motivation, leadership.
- Simulation exercises on problem-solving – study of organizational climate in different organizations.
- Study of organizational structure of development departments, study of departmentalization, span of control, delegation of authority, decision-making patterns.
- Study of individual and group behaviour at work in an organization.
- Conflicts and their management in an organization.
- Comparative study of functional and nonfunctional organizations and drawing factors for organizational effectiveness.
- Exercise on OD interventions (Interpersonal, Team, Structural, Comprehensive) with its procedure to conduct in an organization

VI. Suggested Reading

Bhattacharyya DK. 2011. *Organizational Change and Development*, Oxford University Press.

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I. Course Title : Research Methodology in Extension

II. Course Code : EXT 504

III. Credit Hours : 2+1

IV. Theory

Block 1: Introduction To Behavioural Research

Unit 1: Nature of Behavioural Research

Methods of knowing; Science and scientific method; Behavioural research – Concept, aim, goals and objectives; Characteristics and Paradigms of research; Types of behavioural research based on applications, objectives and inquiry; Types of knowledge generated through research – historical, axiological, theoretical and conceptual knowledge, prior research studies, reviews and academic debate; Role of behavioural research in extension; Careers in behavioural research.

Unit 2: The Behavioural Research Process

Basic steps in behavioural research – Formulating a Research Problem; Reviewing the Literature; Identifying the variables and hypotheses; Formulating research designs, methods and tools; Selecting sample; Collecting data; Analyzing and Interpreting the Data; Reporting and Evaluating Research; Skills needed to design and conduct research; Writing research proposals.

Block 2: Steps in Behavioural Research Process

Unit 1: Formulating a Research Problem

The research problem and research topic - definitions; Importance of formulating a research problem; Sources of research problems; Characteristics of a good research problem; Research problems in quantitative and qualitative research; Steps in formulating a research problem; Strategies for writing research problem statement; Research purpose statement; Research questions – Types, Criteria for selecting research questions, techniques for narrowing a problem into a research question; Objectives - Meaning, types and criteria for judging the objectives.

Unit 2: Reviewing the Literature

Review-meaning and importance; Types of literature review – Context, Historical, Integrative, methodological, self-study and theoretical; Literature review for quantitative and qualitative studies; Steps in conducting literature review – Identify key terms, locate literature, critical evaluation and selection; organising literature

Unit 3: Identifying Variables and Hypotheses

Developing theoretical, conceptual, empirical frameworks; Approaches for identifying concepts, constructs and variables; Role of theory in behavioural research; Steps in identifying variables – Domain, Concepts, Constructs, Dimensions; Indicators; Variables, Definitions, premises, propositions and hypotheses; Techniques of identifying concepts, constructs and variables - Types of concepts; Types of variables –causal relationship, the study design; and the unit of measurement; Types of definitions-Types of propositions and hypotheses. Characteristics of good hypotheses; Measurement – Meaning, levels of measurement – nominal, ordinal, interval and ratio; Criteria for choosing measurement levels for variables.

Unit 4: Formulating Research Designs, Methods and Tools

Research designs – Definition, purpose and functions; Research Design as Variance Control - MAXMINCON Principle; Criteria for selecting a suitable Research Design; Classification of research designs: Quantitative designs - experimental, descriptive, comparative, correlational, survey, ex-post facto and secondary data analysis;

Qualitative designs - ethnographic, grounded theory, phenomenological and Narrative research; Mixed method designs – Action research design; Translational research; Elements of research design - Research strategies, Extent of researcher interference, Study setting, Unit of analysis and Time horizon. Sources of errors while specifying research designs. Internal and external validity; Choosing right research design; Triangulation - Importance in behavioural research, Types of triangulation. Research methods: Designing research Instruments – questionnaires, interview schedules; tests – knowledge tests, behaviour performance tests; scales – scales and indexes, checklists, focus groups; Steps in developing and using research methods and tools; participatory rural appraisal.

Unit 5: Selecting Sample

Sampling - population, element, sample, sampling unit, and subject; Sampling strategies for quantitative and qualitative research; Principles of sampling; Factors affecting the inferences drawn from a sample; Types of sampling, Methods of drawing a random sample, Sampling with or without replacement, Types of sampling - Probability Sampling - Simple random sampling, Cluster sampling, Systematic sampling, Stratified random sampling and Unequal probability Sampling; Non-probability Sampling - Reliance of available subjects, Purposive or judgmental sampling, accidental sampling, expert sampling, Snowball sampling, and Quota sampling; Sample size requirements for quantitative and qualitative studies. Methods for estimating sample size; Generalisation – Importance, Types of generalisations.

Unit 6: Collecting Data

The process of collecting data – Selection, training, supervision, and evaluation of field investigators; Online data collection; Errors and biases during data collection. Testing goodness of measures through item analysis - Reliability and validity; Types of validity – Content validity: Face and content validity, Criterion-related validity: concurrent and predictive validity, Construct validity: convergent, and discriminant validity, factorial validity, and nomological validity; Types of reliability – Test-Retest, Parallel forms, Inter-item consistency reliability, Split-half reliability. Factors affecting the validity and reliability of research instruments, Strategies for enhancing validity and reliability of measures. Validity and reliability in qualitative research.

Unit 7: Analyzing and Interpreting the Data

Data coding, exploration and editing; Methods of data processing in quantitative and qualitative studies; Quantitative data analysis - parametric and non-parametric statistical analyses; Parametric analysis – Descriptive and inferential statistics, Hypothesis testing - Type I and Type II errors. Concepts in hypothesis testing - Effect Size, á, â, and Power, P Value; Multivariate data analysis – regression, factor analysis, cluster analysis, logistic regression and structural equation modelling. Guidelines for choosing appropriate statistical analysis; Statistical packages for data analysis; Methods of interpreting data and drawing inferences - The Ladder of Inference; Methods of communicating and displaying analysed data.

Unit 8: Reporting and Evaluating Research

Writing reports and research publications; Evaluation Methodology

V. Practicals

- Selecting a research problem and writing problem statement
- Narrowing down research problem to purpose, research questions and objectives
- Choosing, evaluating and reviewing research literature

- Selection of variables through construct conceptualisation and defining variables
- Choosing research design based on research problem
- Choosing right sampling method and estimating sample size
- Developing research methods and tools – questionnaires, interview schedule, check lists and focus group guides
- Writing a research proposal
- Field data collection using research methods and tools
- Testing reliability and validity of research instruments
- Hands on experience in using SPSS for coding, data exploration, editing, analysis and interpretation Formulation of secondary tables based on objectives of research
- Writing report, writing of thesis and research articles
- Presentation of reports

VI. Suggested Reading

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Sivakumar PS and Sulaiman RV. 2015. *Extension Research in India-Current Status and Future Strategies*. AESA Working Paper 2. Agricultural Extension in South Asia.http:// www.aesanetwork.org/aesa-working-paper-2-on-extension-research-in-india-current-status-and-future-strategies-p-sethurman-sivakumar-and-rasheed-sulaiman-v-december-2015/

I. Course Title : Capacity Development

II. Course Code : EXT 505

III. Credit Hours : 2+1

VI. Theory

Block 1: Introduction to Capacity Development

Unit 1: Capacity Development–An Overview

Training, capacity building, capacity development and HRD-Meaning and differences; Need and principles of capacity development; Types and levels of capacities - Institutional capacities (include the rules, regulations and practices that set the overarching contextual environment), Organisational capacities (how various actors come together to perform given tasks), Individual capacities (technical, functional and leadership skills). Types of capacity building - Based on structure (structured, semi-structured &unstructured), Based on context (orientation, induction and refresher), and other categories (online, Webinar, distance etc.). Components of capacity development; Capacity development cycle.

Unit 2: Capacity Development- Approaches and Strategies

Capacity Development Dilemma- Theory versus Practice, Trainee versus Task, Structured versus Unstructured, Generic and Specific; Approaches in Capacity Development -Informative approach, Participatory approach, Experimental approach/ Experiential, Performance based approach; Capacity Development Strategies - Academic strategy, Laboratory strategy, Activity strategy, Action strategy, Personal development strategy, Organizational development strategy.

Unit 3: Planning and Organization of Capacity Development Programmes

Steps in Designing and Planning of Capacity Development- Step 1. Select the participants, Step 2. Determine the participants' needs, Step 3. Formulate goal and objectives, Step 4. Outline the content, Step 5. Develop instructional activities, Step 6. Prepare the design, Step 7. Prepare evaluation form, Step 8. Determine follow-up activities; Organising capacity development programme; Operational arrangements at different stages- Before the programme, During the programme, Middle of the programme, At the end of the programme, After the programme, Follow up; Stakeholders' responsibilities.

Block 2: Capacity Development Needs Assessment

Unit 1: Planning and Organization of Capacity Development Programmes

Concept of Need Assessment; Approaches in Need Analysis- Performance Analysis, Task Analysis, Competency Study; Needs Survey.

Unit 2: Capacity Development Needs Assessment Methods

Data Collection Methods in Identifying Needs - Rational Methods (Observation, Informal talks, Complaints, Comparison, Analysis of report, Opinion poll, Buzz session, Analysis of the new programme), Empirical Methods (Job analysis, Performance evaluation, Checklist or Questionnaire Method, Tests, Critical Incident Technique, Card Sort Method, Focus Group Discussion, Interview, SWOT Analysis); Information and Skills required in Need Analysis; Identification of Needs through Task Analysis - Task identification, Task Analysis, Gap Analysis.

Block 3: Capacity Development Institutions and Management

Unit 1: Capacity Development Institutions

Capacity Developer (Trainer): Meaning and concept; Types of Capacity Developers (regular, *ad-hoc*, part time, guest and consultants); Roles of Capacity Developer

(explainer, clarifier, supporter, confronter, role model, linker, motivator, translator/ interpreter, change agent); Good Capacity Developer – Qualities, skills and roles Qualities, Skills (Intrapersonal & Inter personal), Roles (Manager, Strategist, Task Analyst, Media Specialist, Instructional Writer, Marketer, Facilitator, Instructor, Counsellor, Transfer Agent, Evaluator); Capacity Development Centres and Locations; Organisation's Role in Capacity Development.

Unit 2: Capacity Development Project Formulation

Project Proposal: Concept and Meaning; Steps in Project Formulation- Review of past proposals, Consulting experts, consultants, and previous organizers, Review past project evaluation reports, Interact with the prospective beneficiaries; Format for Writing Project Proposal (LFA).

Block 4: Capacity Development Process and HRD

Unit 1: Capacity Development Methods and Tools

Capacity Development Methods –Lecture, Discussion, Syndicate, Seminars, Conference, Symposium, Role Play, Case study, Programmed Instruction, T - group/ Laboratory methods; Factors Determining Selection of Methods - Capacity development objectives, subject matter, categories of participants, and the available resources like time, location, budget; Capacity Development Aids.

Capacity Development Programme Evaluation - Meaning & Importance; Purpose of Evaluation; Principles of Evaluation; Types of Evaluation – Formative, Summative, Kirkpatrick's four levels of evaluation; Process of Evaluation- Evaluation at the beginning, Evaluation during the programme, Evaluation at the end; Use of evaluation findings; Statistical Tools for evaluation.

Unit 3: Impact Assessment

Impact Assessment- Meaning, Need, Features, Benefits, Concepts; Indicators for Impact Assessment - Direct indicators, Indirect or proxy indicators, Quantitative indicators, Qualitative indicators, Result chain / hierarchy of indicators; Methods of Impact Evaluation- Learning retention of participants (KOSA), Impact on the job performance, Impact on organizational effectiveness, Impact on stakeholder's competency.

Unit 4: Human Resource Development

HRD: Meaning, Importance and Benefits; Types of HRD Systems & Sub-systems Career system (Manpower planning, Recruitment, Career planning, Succession planning, Retention), Work system (Role analysis, Role efficacy, Performance plan, Performance feedback and guidance, Performance appraisal, Promotion, Job rotation, Reward), Development system (Induction, Training, Job enrichment, Self-learning mechanisms, Potential appraisal, Succession development, Counselling, Mentor system), Self-renewal system (Survey, Action research, Organisational development interventions), Culture system (Vision, mission and goals, Values, Communication, Get together and celebrations, Task force, Small groups); Components of HRD System - Performance Appraisal, Potential Appraisal, Task System, Development System, Socialisation System, Governance; Functions of HRD-Organisational Development, Career Development, Capacity Development.

VII. Practicals

- Capacity development needs assessment exercise
- Capacity development project formulation exercise
- Planning organizing and conducting an extension capacity development programme
- Designing a programme
- Writing learning objectives

- Developing objectives into curriculum
- Training plan
- Organizing capacity development workshop
- Evaluation with pre- and post-training tests
- Training methods – Practicing each method mentioned in contents as group exercise

X. Suggested Reading

ADB. 2009. *Training Needs Assessment and Strategic Training Plan.*

Bentaya GM, and Hoffmann V (Eds). 2011. *Rural Extension* Volume 3 -Training Concepts and Tools. Margraf Publishers GmbH, Scientific books, KanalstraBe 21; D-97990, Weikersheim, 191 pp.

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FAO .2010. *FAO Capacity Assessment Approach and Supporting Tools - Discussion Draft*, Food and Agriculture Organisation of the United Nations

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Swanson BE and Rajalahti R. 2010. *Strengthening Agricultural Extension and Advisory Services.* A Guide for Facilitators.
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TAP. 2016. *Common Framework on Capacity Development for Agricultural Innovation Systems*. Guidance Note on Operationalization, Tropical Agricultural Platform
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WAC. 2013. *Assessing Capacity Needs and Strategy Development for Grassroots Rural Institutions: A Guide for Facilitators*. World Agroforestry Centre (WAC)

Websites

TAP–Tropical Agriculture Platform for Capacity Development– https://www.tapipedia.org/FAO–FAO Capacity Development– http://www.fao.org/capacity-development/en/ GFRAS–Global Forum for Rural Advisory Services– http://www.g-fras.org/en/ AESA–Agricultural EXtension in South Asia– http://www.aesanetwork.org/

I. Course Title : ICTs for Agricultural Extension and Advisory Services

II. Course Code : EXT 506

III. Credit Hours : 2+1

IV. Theory

Block 1: Introduction to Information and Communication Technologies (ICTs) and E-extension

Unit 1: ICTs- Concepts and Status

ICTs- meaning, concepts, basics of ICTs, global and national status, types and functions of ICTs, innovations, meaning of e-Governance, e-learning, mLearning, advantages and limitations of ICTs.

Unit 2: ICTs in Knowledge Management

Knowledge management-meaning, approaches and tools. Role of ICTs in Agricultural Knowledge Management.

Unit 3: e-Extension initiatives in Agriculture and allied sectors

e-Extension, overview on Global and national e-extension initiatives, Inventory of e-Extension initiatives in Agriculture and allied sectors from Central and State governments, ICAR, SAUs, private sector and NGO initiatives in India.

Block 2: Application of ICTs in Extension and Advisory Services

Unit 1: ICT Applications

Knowledge centres (tele centres), digital kiosks, websites and web portals, community radio, farmers call centres, mobile phone based advisory services and mobile applications (mExtension, mLearning), Self-learning CDs on Package of practices, social media, digital videos, Market Intelligence and Information Systems- ICT enabled Supply-Chains and Value-Chains/ e-Marketing (e-NAM, Agmarknet, *etc*.).

Unit 2: ICT Expert Systems

Expert System/ Decision Support System/ Management Information Systems, Farm Health Management & Intelligence System for Plant Health, Animal Health, Soil Health, Fishery, Water, Weather, etc.

Unit 3: ICT Networks

Global and regional knowledge networks, international information management systems, e-Learning platforms (MOOCS, Course CCRA, EduEx, *etc*), e-Governance Systems; digital networks among extension personnel, Farmer Producers Organisations (FPOs)/ SHGs/ Farmers Groups.

Block 3: Knowledge Management and Standards

Unit 1: Policies in Knowledge Management

Global policy/ Standards on e-Governance, National policy on e-governance, Open Data / Open Gov Standards and Open Source etc; Language Technology Applications; National e-Agriculture policy/ Strategies/ guidelines.

Unit 2: Web Standards

Web standards, creating and writing for webportals, development of mobile applications, developing digital videos- story board- video recording- video editing, types of blogs and writing guidelines.

Unit 3: Social Media Applications to engage audience

Video conference, live streaming and webinars, types and functions of social media applications, guidelines for preparing social media content, engaging audience and data-analytics.

Block 4: Smart and Disruptive Technologies and Advanced Analytics for Agricultural Extension

Unit 1: Smart Technologies

Open technology computing facilities, System for data analytics/ mining/ modelling/ Development of Agricultural simulations; Remote Sensing, GIS, GPS, Information Utility (AIU); disruptive technologies- Analysis; Internet of Things (IoTs), Drones, Artificial intelligence (AI), block chain technology, social media and Big Data analytics for extension.

Unit 2: Human Computer Interactions

Human Centered Learning/Ergonomics/ Human Computer Interactions-Meaning; Theories of multimedia learning - Sweller's cognitive load theory, Mayer's cognitive theory of multimedia learning, Schnotz's integrative model of text and picture comprehension, van Merriënboer's four-component instructional design model for multimedia learning; Basic Principles of Multimedia Learning - Split-attention, Modality, Redundancy, Coherence, Signaling, segmenting, pre-training, personalisation, voice embodiment; Advanced principles - Guided discovery, worked examples, Self-explanation, drawing, feedback, multiple representation, Learner control, animation, collaboration, prior knowledge, and working memory. Designing ICT gadgets based on human interaction principles - Interactive design-Meaning, importance; Approaches of interactive design - user-centered design, activity-centered design, systems design, and genius design; Methods of interactive design - Usability testing methods.

V. Practicals

- Content and client engagement analysis
- Designing extension content for ICTs
- Creating and designing web portals, blogs, social media pages
- Developing digital videos
- Live streaming extension programmes and organising webinars
- Working with Farmers call centres
- Engaging with professional digital networks
- Writing for digital media

VI. Suggested Reading

Andres D and Woodard J. 2013. *Social media handbook for agricultural development practitioners.* Publication by FHI360 of USAID. http://ictforag.org/toolkits/ social/ SocialMedia4 AgHandbook.pdf

Barber J, Mangnus E and Bitzer V. 2016. *Harnessing ICT for agricultural extension.* KIT Working Paper 2016: 4. https://213ou636sh0ptphd141fqei1-wpengine.netdna-ssl.com/sed/wp-content/uploads/sites/2/2016/11/KIT_WP2016-4_Harnessing-ICT-for-agricultural-extension.pdf

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CTA–The Technical Centre for Agricultural and Rural Cooperation: Digitalization– https://www.cta.int/en/channel/digitalisation-sid05951b8c7-e611-4f34-9ae6-8c0fc0c822bc

GFRAS–Global Forum for Rural Advisory Services– http://www.g-fras.org/en/

AESA–Agricultural EXtension in South Asia– http://www.aesanetwork.org/

I. Course Title : Evaluation and Impact Assessment

II. Course Code : EXT 507

III. Credit Hours : 2+1

IV. Theory

Block 1: Programme Evaluation

Unit 1: Introduction to Evaluation

Concept of Evaluation: Meaning and concept in different contexts; Why Evaluation is Done and When? Programme planning, analyse programme effectiveness, decision making, accountability, impact assessment, policy advocacy; Objectives, types, criteria and approaches of programme evaluation, evaluation principles; the context of program evaluation in agricultural extension; Role and Credibility of Evaluator: Role as educator, facilitator, consultant, interpreter, mediator and change agent. Competency and credibility of evaluator.

Unit 2: Evaluation Theories

Evaluation theory vs. practice – synergistic role between practice and theory in evaluation; Evaluation theories - Three broad categories of theories that evaluators use in their works - programme theory, social science theory, and evaluation theory (other theories/ approaches - Utilization-Focused Evaluation & Utilization-Focused Evaluation (U-FE) Checklist, Values Engaged Evaluation, Empowerment Evaluation, Theory-Driven Evaluation). Integration between theory and practice of evaluation: –evaluation forums, workshops, conferences and apprenticeship/ internship.

Block 2: Evaluation Process

Unit 1: How to Conduct Evaluation

Ten Steps in programme evaluation: (1) Identify and describe programme you want to evaluate (2) Identify the phase of the programme(design, start-up, on-going, wrap-up, follow-up) and type of evaluation study needed (needs assessment, baseline, formative, summative, follow-up) (3) Assess the feasibility of implementing an evaluation (4) Identify and consult key stakeholders (5) Identify approaches to data collection (quantitative, qualitative, mixed) (6) Select data collection techniques (survey interviews and questionnaires with different types) (7) Identify population and select sample (sampling for evaluation, sample size, errors, sampling techniques (8) Collect, analyse and interpret data (qualitative and quantitative evaluation data analysis) (9) Communicate findings (reporting plan, evaluation report types, reporting results, reporting tips, reporting negative findings (10) Apply and use findings (programme continuation/ discontinuation, improve on-going programme, plan future programmes and inform programme stakeholders).

Unit 2: Evaluating the Evaluation

Evaluating the Evaluation - 10 Steps as above with focus on conceptual clarity, representation of programme components and stakeholders, sensitivity, representativeness of needs, sample and data, technical adequacy, methods used for data collection and analysis, costs, recommendations and reports.

Block 3: Programme Management Techniques

Unit 1: SWOT Analysis and Bar Charts

SWOT Analysis – Concept, origin and evolution; SWOT As a Programme Management Tool; Conducting SWOT Analysis - Common Questions in SWOT Analysis; Advantages and Disadvantages of SWOT; Bar Charts (Gantt Charts and Milestone Charts) - Characteristics, advantages and limitations.

Unit 2: Networks

Networks – Introduction, origin and widely used networks (Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM), differences between PERT and CPM, advantages and disadvantages. Networks Terminology – Activity, Dummy activity, Event (predecessor event, successor event, burst event, merge event, critical event), Earliest Start Time (EST), Latest Start Time (LST), Critical Path, Critical Activity, Optimistic time (T_o), Pessimistic time (P_o), Most likely time (T_M), Expected time (T_E), Float or Slack, Event Slack, Lead time, Lag time, Fast tracking, Crashing critical path, Acclivity Table, Danglers, Normal Time. Rules for Preparation of Networks and Steps in Network Preparation with example.

Block 4: Programme Evaluation Tools

Unit 1: Bennett's Hierarchy of Evaluation

Introduction to Bennett's hierarchy – Background and description; Relation between programme objectives & outcomes at 7 levels of Bennett's hierarchy – Inputs, activities, participation, reactions, KASA changes, practice and behaviour changes, end results. Advantages and Disadvantages of Bennett's hierarchy

Unit 2: Logic Framework Approach (LFA)

Introduction to LFA – Background and description; Variations of LFA - Goal Oriented Project Planning (GOPP) or Objectives Oriented Project Planning (OOPP); LFA Four-by-Four Grid – Rows from bottom to top (Activities, Outputs, Purpose and Goal & Columns representing types of information about the events (Narrative description, Objectively Verifiable Indicators (OVIs) of these events taking place, Means of Verification (MoV) where information will be available on the OVIs, and Assumptions). Advantages and Disadvantages of LFA.

Block 5: Impact Assessment

Unit 1: Introduction to Impact Assessment

Concept of Impact Assessment: Meaning, concept and purpose in different contexts; Impact Assessment Framework: Meaning of inputs, outputs, outcomes, impacts and their relation with monitoring, evaluation and impact assessment.

Unit 2: Impact Assessment Indicators

Indicators for impact assessment – meaning and concept; Selecting impact indicators; Types of impact indicators for technology and extension advisory services - social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.

Unit 3: Approaches for Impact Assessment

Impact assessment approaches – Quantitative, qualitative, participatory and mixed methods with their advantages and disadvantages; Quantitative Impact Assessment Types – Based on Time of Assessment (Ex-ante and ex-post), Based on Research Design (Experimental, quasi experimental, Non-experimental). Econometric Impact Assessment: - (Partial Budgeting Technique, Net Present Value, Benefit Cost Ratio, Internal Rate of Return, Adoption Quotient, *etc*). Qualitative and Participatory Impact Assessment Methods.

Unit 4: Environment Impact Assessment (EIA)

Concept of EIA – Introduction, What it is? Who does it? Why it is conducted? How it is done?; Benefits and important aspects of EIA-risk assessment, environmental management and post product monitoring. Environmental Components of EIA – air, noise, water, biological, land; Composition of the expert committees and Steps

in EIA process - screening, scoping, collection of baseline data, impact prediction, mitigation measures and EIA report, public hearing, decision making, monitoring and implementation of environmental management plan, assessment of alternatives, delineation of mitigation measures and EIA report; Salient Features of 2006 Amendment to EIA Notification - Environmental Clearance/Rejection, participants of EIA; Shortcomings of EIA and How to improve EIA process?

V. Practicals

- Search the literature using web / printed resources and identify evaluation indicators for the following:
  - Utilization-Focused Evaluation
  - Values Engaged Evaluation
  - Empowerment Evaluation
  - Theory-Driven Evaluation
- Visit Directorate of Extension in your university and enquire about extension programmes being implemented / coordinated by Directorate. Develop an evaluation proposal of any one programme using 'Ten Steps in Programme Evaluation' discussed in the theory class.
- Review any comprehensive programme evaluation report from published sources. Evaluate the report and write your observations following the 'Evaluating the Evaluation' approach.
- Identify at least four agriculture development programmes and their objectives being implemented in your state. Write two attributes each on Strengths, Weaknesses, Opportunities and Threats related to the identified programme objectives in the SWOT grid.
- Identify an on-going development programme and make-out 6 activities from the programme.
- Draw a Gantt chart for 12 months programme activities.
- Write a report on evaluation hierarchy levels and indicators as per Bennett's hierarchy of evaluation for any development programme or project.
- Develop LFA four-by-four grid for any development programme or project with activities, outputs, purpose and goal and objectively verifiable indicators, means of verification & assumptions.
- Visit a nearby KVKs / ATIC. Select any agriculture technology with package of practices and extension advisory services promoted by KVK / ATIC. Identify impact assessment indicators for social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.
- Refer any Environment Impact Assessment report and analyse steps in EIA. Write your observations.

VI. Suggested Reading

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Suvedi, M and Morford S. 2003. *Conducting Program and Project Evaluations: A Primer for Natural Resource Program Managers in British Columbia.* Forrex-Forest Research Extension Partnership, Kamloops, B.C. Forrex Series 6.
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TAP– Tropical Agriculture Platform: Monitoring and Evaluation - www.tapipedia.org
GFRAS– Global Forum for Rural Advisory Services http://www.g-fras.org/en/

AESA– Agricultural Extension in South Asia http://www.aesanetwork.org/
USAID– United States Agency for International Development: Evaluation https://www.usaid.gov/evaluation
https://education.illinois.edu/faculty/jennifer-greene

I. Course Title : Managing Extension Organizations

II. Course Code : EXT 508

III. Credit Hours : 2+1

IV. Theory

Block 1: Basics of Management

Unit 1: Management- An Over view

Management Extension managementandimportant- meaning concepts nature and theories of management. Management, administration and supervision - meaning, definition and scope; Approaches to management, Principles, functions and levels of management; Qualities and skills of a manager; Interpersonal relations in the organization; Reporting and budgeting

Block 2: Management in different types of Extension Organizations

Unit 1: Extension Management in public, private sector and other sectors

Extension management (POSDCORB) in public sector, Department of Agriculture, Agricultural Technology Management Agency (ATMA), Krishi Vigyan Kendra (KVK), SAUs, ICAR Institutes, Private sector, Cooperatives, NGOs, FPOs etc. Organisational Structure, Relations between different units- Challenges in management

Unit 2: Concepts in Management

Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions; Human Resource Management: Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development; Dealing with fund and staff shortages in different extension organizations (KVK, ATMA etc.); Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles; Authority and responsibility, Delegation and decentralization, line and staff relations; Challenges of co-ordination in extension organizations; Managing interdepartmental coordination and convergence between KVK, ATMA and line departments; Coordinating pluralism in extension services; Challenges in managing public-private partnerships (PPPs) at different levels in agricultural development in general and extension in particular; Performance appraisal – Meaning, Concept, Methods.

Block 3: Motivation and Organizational Communication

Unit 1: Motivation and Communication

Managing work motivation – Concept, Motivation and Performance, Approaches to motivation, team building; Organizational Communication – Concept, Process, Types, Networks, Barriers to Communication; Mentoring, Time management, Team work and team-building strategies; Modernization of information handling

Unit 2: Supervision and Control

Supervision – Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision; Managerial Control – Nature, Process, Types, Techniques of Control, Observation, PERT and CPM, Management Information Systems (MIS): Concept, tools and techniques, MIS in extension organizations.

V. Practicals

- Simulated exercises on techniques of decision making
- Study the structure and function of agro-enterprises, Designing organizational structure/ organograms.
- Group activity on leadership development skills
- Simulated exercise to understand management processes
- Field visit to extension organizations (ATARI, KVKs, NGOs), FPOs, dairycooperatives to understand the functions of management
- Practical exercises on PERT & CPM
- Group exercise on development of short term and long term plans for agro-enterprises
- Developing model agriculture-based projects including feasibility study, financial planning and cost-benefit analysis

X. Suggested Reading

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Van den Ban AW and Hawkins HS. 1998. *Agricultural extension- Chapter 10*, BSL, CBS Publishers and Distributors.

I. Course Title : Enabling Innovation
II. Course code : EXT 509
III. Credit Hours : 1+1
IV. Theory

Block 1: Agricultural Innovation Systems

Unit 1: Agricultural Innovation Systems: Concepts and Elements

Origins of the innovation systems concept-Innovation vs Invention; Agricultural Innovation System (AIS) -ToT, FSR, AKIS and AIS compared, Key insights from AIS: How Innovation takes place; Role of different actors in AIS; Importance of interaction and knowledge flows among different actors, Role of Communication in Innovation Process; Role of Extension in AIS, Different views to analyze AIS: structural view, functional view, process view and capacity view.

Unit 2: Enabling Innovation

Role of enabling environment: Policies and institutions in enabling innovation; Role of Government-Innovation Policy: Achieving coordination and policy coherence; Innovation Platforms; Role of Innovation Brokers, Methodologies for AIS Diagnosis: Typologies of existing methodologies-strengths and limitations; Assessing Extension and Advisory Services within AIS; Capacity Development in AIS: Strengthening capacities to innovate.

Block 2: Scaling Up Knowledge for Innovation

Unit 1: Scaling Up: Tools, Approaches and Pathways

Scaling Up: Definitions; Changing views on scaling up: Approaches to Scaling Up: Push, pull, plant, probe: Scaling up pathways: Drivers and spaces for scaling up; Framework and Tools for Scaling up: Planning and implementing a scaling up pathways; Scalability assessment tools; Role of policies in scaling up: Influencing policies for scaling up; Innovation Management for scaling up knowledge and implications for Extension and Advisory Services.

V. Practical

- Identify one crop/commodity sector and use AIS framework to diagnose actors and their roles, patterns of interaction, institutions determining interaction and the enabling policy environment and develop a AIS Diagnosis Report (Review and Key informant interviews)
- Undertake a case study on a successful case of scaling up knowledge and identify factors that contributed to its success
- Identify one specific knowledge (a technology, an approach) that has been recently introduced and develop an Up scaling Strategy

VI. Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Appreciate and apply AIS framework in different contexts
- Enhance their knowledge and skills related to enabling innovation
- Diagnose AIS and design interventions for improvement and
- Design scaling up strategies to achieve innovation and impact

VIII. Suggested Reading

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FAO- Food and Agricultural Organisation (Research and EXtension)– http://www.fao.org/research-and-eXtension/en/

GFRAS- Global Forum for Rural Advisory Services– http://www.g-fras.org/en/

KIT- Royal Tropical Institute (KIT)-Sustainable Economic Development– https://www.kit.nl/sed/

TAPipedia - Tropical Agriculture Platform– https://www.tapipedia.org/

WUR-Wageningen University and Research Research [Knowledge, Technology and Innovation Group (KTI)]– https://www.wur.nl/en/Research-Results/Chair-groups/Social-Sciences/ KnowledgeTechnology-and-Innovation-Group.htm

I. Course Title : Gender Mainstreaming

II. Course Code : EXT 510

III. Credit Hours : 2+1

IV. Theory

Block 1: Why Gender Matters?

Unit 1: Historical Perspective of Gender

Historical perspective of gender: Feminism and emergence of gender as a concept, Scope of gender studies in agriculture and rural development

Unit 2: Agrarian Importance of Gender

Agrarian Importance of Gender: Understanding the importance of gender in national and global agriculture-Key gender issues and challenges in agriculture - Gender and value chain- Global actions to address gender-needs and strategies to address gender and women empowerment.

Block 2: Gender Related Concepts, Analysis, Gender and Technology

Unit 1: Gender Related Concepts and Divides

Gender related concepts and divides: Understanding of the concepts of gender, gender equality and equity, gender balance, gender blindness, gender relations, gender neutrality, gender bias and discrimination, gender rights, gender roles and responsibilities. Gender budgeting, Gender divides and their implications such as gender digital divide, gender access to resources and inputs divide, gender mobility divide, gender wage divide, Gender needs: practical and strategic.

Unit 2: Gender Analysis

Gender analysis: Importance, usage, prerequisites, techniques of gender analysis-Tools for gender analysis.

Unit 3: Gender and Technology

Gender and technology: How gender and technology impact each other, Gender neutral technology, Gender sensitive technology, Gender supportive assistance in technology adoption-Gender in agricultural research and extension.

Block 3: Gender Mainstreaming and Women Empowerment

Unit 1: Gender Mainstreaming

Gender mainstreaming: Importance of gender mainstreaming in agriculture, Extension strategies to address gender issues such as gender and health, nutrition, gender in agricultural value chains, gender and climate change adaptation, gender and globalization& liberalization for mainstreaming gender concerns into the national programmes and policies.

Unit 2: Women Empowerment

Women Empowerment: Importance of women empowerment, Current national women empowerment and gender indices. Women empowerment approaches (technological, organizational, political, financial, social, legal and psychological), Case studies based on experiences and learning from various development and rural development programmes.

Unit 3: Global Best Practices, Policies and Frameworks

Global Best Practices, Policies and Frameworks: Global best practices, women

empowerment and gender mainstreaming models and frameworks for addressing gender concerns in agriculture, approaches of various organizations: gender mainstreaming and special women focused programmes in agriculture and rural development.

Unit 4: Entrepreneurship Development for Women

Entrepreneurship development for women: Women entrepreneurship development in agriculture and agro processing: current status, women led enterprises, supporting organizations and schemes, Govt. policies, entrepreneurship development programme and process for women in agriculture.

VII. Practicals

- t to a village for understanding rural gender roles and responsibilities as groups, followed by class presentation by groups
- Exercise for capturing shifts in gender roles and responsibilities
- Conducting gender analysis in a village using gender analysis techniques
- Visit to agencies supporting women empowerment followed by report presentation. Each student to visit a different organization such as State Rural Livelihood Mission, Women Development Corporation, Department of Agriculture, Important NGOs working for women empowerment
- Exercise for identification and prioritization of issues affecting/needs for women empowerment
- Interaction with a successful women entrepreneur/ SHG

VIII. Suggested Reading

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GFRAS- Global Forum for Rural Advisory Services– http://www.g-fras.org/en/
INGENAES- Integrating Gender and Nutrition within Agricultural Extension Services– https://www.agrilinks.org/activities/ingenaes-integrating-gender-and-nutrition-within-agricultural-extension-services
RRW- Reaching Rural Women– http://www.reachingruralwomen.org/
UN WOMEN– http://www.unwomen.org/en

Course Title with Credit Load
Ph.D. in Agricultural Extension Education

Major Courses 12

Course Code	Title of Course	Credit Hours	Semester
EXT-601*	Policy Engagement and Extension	2+1	I
EXT-602*	Methodologies for Social and Behavioural Sciences	2+1	I
EXT-603*	Technology Commercialization and Incubation	2+1	II
EXT-604*	Educational Technology and Instructional Design	2+1	I

Minor Courses 06

a. It is suggested the student may choose at least one out of three courses listed below as part of minor courses as these are related to policy advocacy and bring in global perspectives with an aim to build a larger understanding of the subject to the student.
b. Further, it is suggested that the student may choose the remaining Courses from any other discipline including the disciplines of Agrl. Economics/ABM and are related to the research problem selected by the student.
c. The final choice of the minor courses should be mandatorily approved by the Student Advisory committee/HOD.

EXT-605	Risk Management and Climate Change Adaptation	2+1
EXT-606	Livelihood Development	1+1
EXT-607	Facilitation for People centric Development	2+1

Supporting Courses 05

STAT	Multivariate Statistical Methods for Extension Research	2+1
COM	Multimedia and Applications	1+1

It is suggested that the student may choose the Supporting Courses other than the listed courses, provided the opted courses are related to the research problem selected by the student and be mandatorily approved by the Student Advisory committee/HOD".

Seminars 2

EXT-691	Doctoral Seminar-I	1+0
EXT-692	Doctoral Seminar-II	1+0
	ii. Thesis / Research	75
	Total	100

Course Contents
Ph.D. in Agricultural Extension Education

I. Course Title : Policy Engagement and Extension
II. Course Code : EXT 601
III. Credit Hours : 2+1

IV. Theory

Block 1: Why Policies Matter?

Unit 1: Understanding Policy

Why policies are important for extension? Role in providing structure, ensure funding and framework for providing functions-examples; Policy: definitions and types: Is policy a product or a process or both? Policies and institutions-How these influence defining organisational roles and performance in extension organizations-Role of policies in upscaling knowledge-Role of extension in influencing policies to enable innovation.

Unit 2: Policy Advocacy and Tools

Definition of advocacy, Approaches to policy advocacy-Advising, Media campaigning, Lobbying, Activism, Information Education Communication (IEC) and Behavior Change Communication (BCC); Advocacy for Rural Advisory Services (RAS); Policy advocacy strategy

Unit 3: Policy Analysis

Explain the meaning and use of policy analysis in decision- making; Describe different types of policy analysis- empirical, evaluative or normative policy analysis, retrospective/ prospective policy analysis, predictive/prescriptive/descriptive policy analysis; How to do policy analysis? - understand the process of policy analysis, highlight the different methods and techniques used in policy analysis, doing ethical policy analysis; Tools for policy impact- research tools, context assessment tools, communication tools, policy influence tools

Unit 4: Policy Development Process

Policy development process: Who drives policy change?: National Governments, Donors, Civil Society-varied experiences: Understanding the environment and key actors in policy space- problem identification-policy adoption, implementation and evaluation; stakeholder mapping, identifying opportunities and barriers, mobilising financial resources; Dealing with policy incoherence: identifying contradictions and challenges in policy implementation

Block 2: Using Evidence to Influence Policy Change

Unit 1: Influencing Policy Change

Generating evidence: Role of policy research; analyzing the usefulness and appropriateness of the evidence; Using evidence in policy advocacy; Understanding your audience: analyzing channels of influence; creating alliances; identifying policy champions; Defining goals and objectives; Developing advocacy messages: Policy papers, Policy briefs, good practice notes, *etc*.: Good practices in influencing policies Organising policy dialogues: Policy engagement strategy-Engaging with policy makers: GO and NGO experiences; Policy working groups; advisory panels; use of

committees: Use of media including ICTs and social media for influencing policies.

Unit 2: Global Experience with Extension Policy

Extension policy in different countries: Explicit extension policy Vs extension as part of Agriculture Policy, Challenges in policy implementation: lack of capacities, financial resources, ownership, lack of stakeholder consultations: Strengthening capacities in extension to influence policies: Global Forum for Rural Advisory Services (GFRAS)'s efforts in strengthening extension policy advocacy: policy compendium, training modules, training for strengthening capacities to influence policies.

V. Practicals

- Analysis of country/state level agricultural/extension policy to understand the policy intentions from strengthening EAS
- Analysis of extension policy of other countries: policy intentions, processes adopted in development of the policy and mechanisms of policy implementation
- Interview key policy actors in EAS arena at the state/national level (eg: Director of Agriculture, Director of Extension in SAU, Chairman/Managing Director of Commodity Board. Member Agriculture, State Planning Board) to explore policy level challenges in EAS
- Identify what evidence policy makers look for from extension research? Is the evidence available? If so what form? (Reports, Briefs etc), If not, develop a plan
- Explore how different stakeholders influence policies (eg: policy advocacy of prominent NGOs, private sector and public sector) -What mechanisms and tools they use
- Identify policy level bottlenecks that constrain effective EAS delivery at the district level- Eg: Issues around linkages between KVK and ATMA; inter-departmental collaboration; public private partnerships; joint action etc.

VI. Suggested Reading

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Sulaiman RV. 2014. *How to Develop and Implement Extension Policies? Lessons from Four Australasian Countries*. Global Forum for Rural Advisory Services, Switzerland
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I. Course Title : Methodologies for Social and Behavioural Research

II. Course Code : EXT 602

III. Credit Hours : 2+1

IV. Theory

Block 1: Advanced Methods for Improving Quality of Research Data

Unit 1: Measurement Properties of Research Instruments

Measurement properties – Dimensionality, reliability and validity; Dimensionality – Unidimensionality and multidimensionality, Methods of assessing dimensionality, Formative and reflective constructs; Validity - Importance, Internal validity - face validity; content validity, Substantive Validity, Structural Validity; External validity - Convergent and Discriminant Validity, known-group validity, Criterion-Related Validity, Consequential Validity, nomological validity; Methods of assessing various forms of validities – Judges rating, Lawshe's Content Validity Ratio, Item-objective congruence index; latent variable method; Reliability - Internal consistency reliability – Split-Half, Cronbach alpha; Temporal Stability reliability - test-retest method; Interrater Consistency and Consensus – inter rater reliability and interrater agreement; Alternative Forms or parallel forms reliability – Reliability of difference - Factors Affecting the Validity and Reliability of Test Scores; Generalizability Theory

Unit 2: Threats to Data Quality

Errors and biases; Errors – Meaning and sources; Types - Sampling error, Non-sampling or measurement error and Processing error – Meaning, causes; Effects of errors and biases on data quality; Bias in behavioural research – Meaning, causes, Types – Respondent and researcher biases; Methods of reducing errors and biases in surveys, questionnaires, personal interviews, focus groups and online methods

Block 2: Scales, Indexes and Tests

Unit 1: Scales, Indexes and Tests-1

Approaches to measurement and scale development - Classical test theory. Formative or index models, The C–OAR–SE approach and Item Response Theory; Item analysis in Classical test theory – item difficulty and item discrimination; Scoring performance in scales and tests – meaning, types and methods; Scale development strategies – deductive and empirical; Stimulus-centred scales – method of equally appearing intervals, paired comparison, Person scaling – Q methodology; Subject-centre scales – The Likert scale and Semantic Differential

Unit 2: Scales, Indexes and Tests-2

Steps in constructing a multi-dimensional scale using confirmatory factor analysis,; Response scales - Guttman's scalogram analysis and The Rasch method; Indexes –Meaning, types, importance; Similarities and differences with scales, Methods of constructing indexes; Common indexes used in extension. Measurement invariance –Meaning, types, methods of assessing measurement invariance. Tests – meaning, types, importance; steps in conducting various tests – knowledge test

Block 3: Emerging Research Approaches and Designs

Unit 1: Qualitative Research Methods

Qualitative methods – Meaning; Types – Ethnography, Grounded theory, Phenomenology, Ecological psychology, Discourse Analysis; Observational research; Case study research – Sampling and sample size; Data collection methods - In-depth interviews, Focus groups, Direct observation, Record review; Content analysis;

Unobtrusive Measures; Projective and semi-projective techniques; Selecting right qualitative method – Strengths and limitations of qualitative research; Analysis and interpretation of qualitative research data; Research synthesis – meaning, importance, methods; Systematic reviews and meta analysis – meaning, steps, and applications; Policy research

Unit 2: Emerging Approaches

Mixed methods research – meaning, purpose, types and applications; Participatory research – Meaning, importance, types, methods and tools and applications; Action research – Meaning, importance, Principles, Types, Steps in conducting action research, application in behavioural sciences. Social Network Analysis – Meaning, importance, types, steps in social network analysis, applications; Advanced methods of measuring perception and beliefs. Multi criteria decision making, analytical hierarchy approach

Block 4: Utilising Research Outputs

Unit 1: Publishing Research

Scholarly communication process; Research reports – Meaning, types, contents; Presentations – Meaning, types, principles of good presentation - Tell 'Em" and KISS 'Em" principles; Research publications – meaning, importance, types; Guidelines for preparing research papers - Peer review process, citation styles; Open access publishing; Publishing in social media. Software in academic writing

Unit 2: Ethics in Extension Research

Ethics in conducting behavioural research; Human subject research – Meaning, history, and ethical guidelines; Ethical aspects of collecting and using Indigenous knowledge and farmers technologies; Ethical practices in publishing; Plagiarism – meaning, sources, Identifying and correcting plagiarism in a research paper using anti-plagiarism software

V. Practicals

- Practice in developing research instruments
- Methods of assessing measurement properties of research instruments - dimensionality, reliability and validity
- Hands-on exercise in minimising errors and biases
- Hands-on experience in constructing tests, scale and indexes
- Practice in summated scale development using confirmatory factor analysis
- Hands on experience in assessing measurement invariance
- Practicing and collecting data using participatory tools and techniques, analyzing and interpreting qualitative data
- Hands-on experience in writing systematic review using meta-analysis
- Field practice in conducting action research
- Practical experience in writing research paper
- Hands on exercises using software for qualitative data analysis
- Practice in detecting and correcting plagiarism using software

IX. Suggested Reading

Berg B. 2009. *Qualitative Research. Methods for the Social Sciences*. Boston: Allyn& Bacon.

Creswell JW .2007. *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: SAGE Pub.

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Raykov T and Marcoulides GA. 2010. *Introduction to Psychometric Theory*. New York, NY: Taylor & Francis

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Sekaran U and Bougie R. 2013. *Research Methods for Business A Skill-Building Approach*. 6th Edition, Wiley, New York.

Sivakumar PS, Sontakki BS, Sulaiman RV, Saravanan R and Mittal N. (eds). 2017. *Good Practices in Agricultural extension Research. Manual on Good Practices in Extension Research and Evaluation*. Agricultural EXtension in South Asia. Centre for research on innovation and science and policy (CRISP), Hyderabad. India. http://www.aesanetwork.org/wp-content/uploads/2018/07/6.pdf

I. Course Title : Technology Commercialisation And Incubation

II. Course Code : EXT 603

III. Credit Hours : 2+1

IV. Theory

Block 1: Technology Commercialisation and the Modern Context

Unit 1: Basics of technology commercialisation

Technology - Definition, functions, process of technological advancement – invention, discovery, innovation and technology; types of innovation - Basic research, Breakthrough innovation, Disruptive Innovation and Sustaining Innovation; Technology transfer and commercialisation

Unit 2: Nature of Agricultural Technology

Agricultural technology – meaning, types; technology generation system; technology life cycle

Unit 3: Basics of Technology transfer and commercialisation

Technology transfer Vs Commercialisation; Technology commercialisation process – elements, models, systems and processes; Technology transfer model – research, disclosure, development and commercialisation

Block 2: Intellectual Property Resources (Ipr) Management

Unit 1: Overview of Intellectual Property Resources

Introduction to IPR; Overview & Importance; Genesis; IPR in India and IPR abroad; Patents, copyrights, trademarks & trade secrets, geographical indication, industrial design; Emergence of IPR Regimes and Governance Frameworks - Trade-Related Aspects of Intellectual Property Rights (TRIPS), Convention on Biological Diversity (CBD), Cartagena Protocol, International Union for Protection of New Plant Varieties (UPOV), and BIMSTEC.

Unit 2: Systems for Protecting IP

IPR protection laws and systems – National IPR Policy; and IPR laws; procedures for filing IP protection; Systems of IP protection and management in agricultural universities and research institutions and also by stakeholders

Unit 3: Management of IPR

Mechanisms of IPR Management – Institutional arrangement, IP Management processes – invention disclosure; IP portfolio management; Infringement management

Unit 4: Protection and Management of Biological Resources

Introduction; National Biodiversity Act (2002); Protection of Plant Varieties and Farmers Rights Act (2001); Guidelines for registration and transfer of biological resources; Farmers rights; Mechanisms of documenting/ collecting, protecting and commercialising farmers varieties and other biological resources; National Biodiversity Authority, PPVFRA and other agencies involved in management of biological resources in India. Access to Genetic Resources and Sharing of Benefits

Unit 5: Protection, Management and Commercialisation of Grassrootand Farmers Innovations, Traditional and Indigenous Knowledge

Traditional and Indigenous Knowledge, Grassroot and Farmers Innovations – Meaning, forms and importance; Systems of documentation, registration, protection

and commercialisation. Documentation of traditional indigenous knowledge - Traditional Knowledge Digital Library (TKDL), Community Biodiversity Registers (CBRs), People's Biodiversity Registers (PBRs), Plant Biodiversity Register, and Honeybee Network.

Unit 6: Geographical Indications (GI) and Appellation of Origin

Geographical indications and appellation of origin – meaning, origin; Geographical Indications of Goods (Registration and Protection) Act (1999); Documentation, registration and commercialisation of GI protected materials and processes.

Unit 7: Genetically Modified Organisms (GMO), Agriculture and Biosafety

The Global Concerns on Use of Genetically Modified Organisms in Food and Agriculture; The Cartagena Protocol on Bio-safety; Regulation of GMO in India - Recombinant DNA Advisory Committee (RDAC), Institutional Bio-safety Committee (IBSC), Review Committee on Genetic Manipulation (RCGM), Genetic Engineering Approval Committee (GEAC), State Bio-safety Coordination Committee (SBCC) and District Level Committee (DLC). Laws and Acts for regulation of GMO - Guidelines for Research in Transgenic Plants, 1998; Seed Policy, 2002; Plant Quarantine Order, 2003; Regulation for Import of GM Products Under Foreign Trade Policy, 2006; National Environment Policy, 2006

Block 3: Technology Commercialisation

Unit 1: Technology Assessment and Refinement

Meaning; Importance; Approaches and methods of assessment and refinement of various technologies – stakeholder oriented approaches including participatory technology assessment and refinement; assessment and refinement of traditional and indigenous knowledge and grassroot innovations

Unit 2: Technology Valuation

Returns to investment; IP Valuation-Oxford context, IP Valuation methods - Cost approach; Income approach - Discounted Cash Flow, Risk-Adjusted Net Present Value, Net Present Value with Monte Carlo Simulation and Real Options Theory; Market approach - Industry Standards Method, Rating/Ranking Method, Rules of Thumb Approach and Auction Method; Hybrid approaches; Royalty rate method

Unit 3: Technology Commercialisation Strategies

Meaning- approaches for technology commercialisation – technology scaling up, technology licensing, handholding, agripreneur development, technology business incubation

Unit 4: Scaling up of Technologies

Meaning, types and stages of technology scaling up; mechanisms

Unit 5: Technology Licensing

Meaning and types - Procedures of licensing, preparing licensing documents; Management of technology licensing process

Unit 6: Technology Takers and Entrepreneurship

Meaning; types of technology takers; Technology Taking as a Strategy; Types of entrepreneurship – agripreneurs, startups, small businesses, Producer Organizations, Self Help Groups, Clusters and other forms of entrepreneurship

Unit 7: Policy support for Technology Commercialisation and Entrepreneurship Development

Policy support for entrepreneurship development in India - National Policy on Skill

Development and Entrepreneurship and other polices; Government of India Support for Innovation and Entrepreneurship – Startup India, Make in India, Digital India, Atal Innovation Mission and others; Entrepreneurship policy and schemes at different states of India; Organisations promoting entrepreneurship in India

Block 4: Technology Incubation

Unit 1: Basics of Technology Incubation

Meaning, functions and types; stakeholder oriented incubation process – Livelihood incubation, village incubators

Unit 2: Technology Incubation in India

System of technology incubation- incubation process; its effectiveness; Managing profit oriented and non-profit incubators; Schemes for promoting incubators in India

Block 5: Technology Promotion And Essential Skills For Technology Commercialisation

Unit 1: Technology Promotion

Technology promotion – meaning, types, business meetings, scientist-industry/ entrepreneur meets, technology conclave, business plan competition, farmers fairs, technology shows

Unit 2: Dealing with Entrepreneurs, Agripreneurs and Other Stakeholders

Business communication; Business Etiquette; business networking

Block 6: Emerging Approaches in Technology Commercialisation and Incubation

Unit 1: Technology Scouting

Technology Scouting and Innovations in technology incubation

V. Practicals

- Understanding the technology commercialisation process – Visit to Technology Commercialisation Unit of ICAR Institute/ Agricultural University
- Understanding the IPR protection practices – Visit to Patent Attorney office
- Hands-on experience in drafting IPR application – Patent/Copyright/ Trademark
- Understanding protection of biological resources including plant varieties – Visit to PPVFRA Branch office/ ICAR Institute or Agricultural University involved in plant variety protection
- Documenting Traditional and indigenous knowledge – Field experience in using various protocols of using traditional and indigenous knowledge
- Protecting unique local goods through Geographical Indications – Hands on experiences in documenting and registering Geographical indications
- Technology assessment/ validation of traditional and indigenous knowledge – QuIK and other methods
- Hands on experience in technology valuation
- Hands on experience in technology licensing process including drafting agreements
- Understanding the Technology Business Incubation – Visit to Agri Business Incubator or Technology Business incubator
- Hands on experience in planning and organising technology promotion events

- Hands on experience in various techniques in business communication and Business etiquette

VI. Suggested Reading

Bandopadhyay D. 2018. *Securing Our Natural Wealth: A Policy Agenda for Sustainable Development in India and for Its Neighbouring Countries.* Singapore; Springer.

Ghosh, S. and Joshi, A. 2017. *Handbook for Non-Profit Incubator Managers.* New Delhi: Deutsche Gesellschaftfür Internationale.

Gupta AK. 2016. *Grassroots Innovation: Minds on the margin are not marginal minds.* Gurgaon: Penguin Books.

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Sharma G and Kumar H. 2018. *Intellectual property rights and informal sector innovations: Exploring grassroots innovations in India.* The Journal of World Intellectual Property. 1-17. DOI: https://doi.org/10.1111/jwip.12097.

Stevens AJ. 2016. *Intellectual property valuation manual for academic institutions* (Report No. CDIP/17/INF/4). Geneva: Committee on Development and Intellectual Property (CDIP).

WIPO and ITC. 2010. *Exchanging Value – Negotiating Technology Licenses, A Training Manual.* World Intellectual Property Organization (WIPO).

I. Course Title : Educational Technology and Instructional Design

II. Course Code : EXT 604

III. Credit Hours : 2+1

IV Theory

Block 1: Educational Technology

Unit 1: The Landscape of Educational Technology and Instructional Design

Understanding various terms - educational technology, instructional design, instructional systems design, curriculum design, pedagogy, andragogy; Brief overview of the origin and evolution of ET and ID as theory and practice; what is the relevance of ET and ID relevant in extension and rural advisory services? Extensional professionals as instructional designers and architects of the learning experience

Unit 2: Theories of Learning

What is learning? Critical overview of Behaviorism, Cognitivism, Constructivism and Complex learning theories; instructional designers and learning theories; Types of learning or learning domains- Bloom's taxonomy of the cognitive domain, Krathwohl and Bloom's affective domain and Simpson's psychomotor domain

Unit 3: Technology Enabled Learning

What is the role of technology in education? Digital media, new tools and technology; Open and distance Learning (ODL); Online Education - Synchronous and Asynchronous learning models; eLearning, Massive Open Online Courses - SWAYAM, Open Education Resources (OERs), Course CERA, EduEx, CoL, RLOs; digital education and its applications in higher agricultural education; Smart classrooms and Campuses, Web-based remote laboratory (WBRL); Integrating media and digital tools into ID; types and implications of disruptive technologies for higher education and extension; Augmented learning; Adaptive learning; meaning, features and good practices in using open source Learning Management Systems (Moodle); Quality assurance and certification in e-learning.

Block 2: Instructional Design

Unit 1: Theories and Models of Instruction

Howard Gardner's Theory of Multiple Intelligences, David Kolb's Experientialearning Cycle, Albert Bandura's Social Learning Theory, Rand Spiro's Cognitive Flexibility Theory and Its Application In eLearning, Wlodkowski's MotivationalFramework for Culturally Responsive Adult Learning; ADDIE Model, Dick andCarey Model, SAM Model, Bloom's Taxonomy; integrating the theories of instructioninto the practice of ID in extension and RAS ecosystem.

Unit 2: Creating Instruction

Overview of planning, designing and implementing the curricula and learning experiences; Needs Analysis - meaning, approaches and steps; Task and content analysis - meaning, approaches, steps and techniques (topic analysis, procedural analysis, and the critical incident method); Learner analysis – meaning, importance and approaches, relevance of Maslow's Hierarchy of Needs and learning styles, Captive Audience vs. Willing Volunteers, Universal vs. user-centered design, Learner Analysis Procedures; Writing learning objectives: Meaning of Learning Goal and Learning Objectives; ABCDs of well-stated objectives; Setting goals, translating goals into objectives; Contextualising ADDIE process within the Extension learning environment

Unit 3: Instructional Strategies

Organizing content and learning activities - scope and sequence of instruction; Posner's levels of organizing (Macro, Micro, Vertical, and Horizontal) and structures of organizing (content vs. media) instruction, Gagne's events of instruction, Edgar Dale's Cone of Experience; Methods of Delivery- classroom teaching, programmed instruction, synchronous and asynchronous modes of distance education; Changing role of a teacher in classroom and teaching competencies

Unit 4: Evaluating Instruction

Meaning of Assessment, Measurement and Evaluation; Developing learner evaluations and their reliability & validity; assessment techniques for measuring change in knowledge, skill and attitude of learners - Objective Test Items, Constructed-Response Tests, Direct Testing, Performance Ratings, Observations and Anecdotal Records, Rubrics, Portfolios, Surveys and Questionnaires, Self- Reporting Inventories, Interviews; Conducting learner evaluation pre-, during and post-instruction; Formative and Summative Evaluation- meaning, approaches and steps; Evaluating Learner Achievement and the Instructional Design Process; Evaluating the success of instruction; Performance appraisal of teachers

Unit 5: Trends in Instructional Design

Alternatives to ADDIE model - Rapid prototyping and constructivist ID, reflections on instructional design as science and as an art; Relating ID models and process in extension learning environment; political economy of higher education in developed and developing countries; University assessment and rating methods, returns from agricultural higher education; research in education and instructional design.

VI. Practicals

- Exercises on preparation of the Analysis Report that includes the task/content analysis and learner analysis and the Design Plan includes learning objectives and corresponding instructional strategies and assessment items
- Prepare course outline and lesson plan with an appreciation for diverse learning styles based on temperament, gender, and cultural/ethnic differences and deliver a lecture for UG/PG students
- Assessing learning styles through Barsch and Kolb inventories
- Development and testing of survey instruments for evaluating learning outcomes/ competencies of students
- Development and testing of survey instruments for performance appraisal / competency assessment of teachers.
- Design an online e-learning module on a topic of interest as a capstone project - integrate and apply the knowledge and skills gained from the course for creating an effective learning experience for a target audience
- Designing and developing a theme based knowledge portals
- Exercises on designing an online course using open source LMS like moodle or EdX
- Select and evaluate or design for social al media
- Prepare a short research paper on recent theories and models of instructional design
- Interview an instructional designer of your choice and prepare a synthesis report about what job roles he/she perform, What ID processes does he or she use, challenges faced
- Develop a prototype for one of the lessons in your design plan using PowerPoint or a website builder such as Weebly to create the screens integrating multimedia content and various functionalities
- Field visit to a virtual learning / augmented learning labs, e-learning labs, distance

learning centres, etc.

- Hands-on practice with video-editing software, web conferencing and video conferencing solutions

VII. Suggested Reading

Agarwal JC. 2007. *Essentials of Educational Technology Innovations in Teaching* – Learning. 2nd Ed. Vikas Publ. House.

Allen M. 2013. *Leaving ADDIE for SAM: An Agile Model for Developing the Best Learning Experiences*
https://www.alleninteractions.com/about

Anglin GJ (Ed.), 1995. *Instructional technology: Past, present, and future.* Englewood, CO: Libraries Unlimited.

Anonymous. 2000. *Contents Pages of the Journal Educational Technology* from January, 2OO0 to December, 2O15 Volume 40-Volume 55
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Bandura A. 1977. *Social learning theory*. Englewood's Cliffs, NJ: Prentice-Hall

Bandura A. 2001. *Social cognitive theory: An agentic perspective.* Annual Review of Psychology, 52, 1–26

Britain S. 2004. *A Review of Learning Design: Concept, Specifications and Tools. A report for the JISC E-learning Pedagogy Programme*, May 2004.

Brown AH and Timothy DG. 2016. *The essentials of instructional design: connecting fundamental principles with process and practice*, Third edition, Routledge
https://ikhsanaira.files.wordpress.com/2016/05/the-essential-of-instructional-design.pdf

Challa J and Reddy NM. 2008. *Education Technology for Agricultural Sciences,* NAARM, Rajendra Nagar, Hyderabad, Telangana, India.

David HJ. 2003. *Learning to Solve Problems: An Instructional Design Guide.*

Duffy TM and Cunningham DJ. 1996. *Constructivism: Implications for the design and delivery of instruction.* In Jonassen D (Ed.), Handbook of Research for Educational Communications and Technology (pp. 170-198). New York: Simon & Schuster Macmillan Edward T. 2013. Power Point Is Evil.
https://www.wired.com/2003/09/ppt2/

Ellen R. 2004. *Instructional Design and Curriculum Development: Deconstructing the Difference,* Educational Technology, Vol. 44, No. 2 (March-April 2004), pp. 3-12.
https://www.jstor.org/stable/44428883

Gardner H. 2008. *Multiple intelligences: New horizons in theory and practice.* New York, NY: Basic Books.

Gayle VDS, Karen LR, Patrick RL. 2018. Web-Based Learning: Design, Implementation and Evaluation, 2nd Edition Hsu YC, Hung JL, and Ching YH. 2013. *Trends of educational technology research: More than a decade of international research in six SSCI-indexed refereed journals.* Educational Technology Research and Development, 61(4), 685-705.
https://www.academia.edu/1141731/Aesthetic_principles_for_instructional_design?auto=download

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Kolb D. 2014**.** *Experiential learning: Experience as the source of learning and development* (2nd ed.). Upper Saddle River, NJ: Prentice Hall

Koper R. 2006. *Current Research in Learning Design*, Educational Technology & Society, 9 (1), 13–22.

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Merrill MD, Drake L, Lacy M J and Pratt J. 1996. *Reclaiming instructional design* (PDF). Educational Technology. 36 (5): 5–7. Archived (PDF) from the original on 2012-04-26.

Parrish PE. 2007. *Aesthetic principles for instructional design*, Education Technology Research

Parrish PE. 2005. *Embracing the aesthetics of instructional design.* Educational Technology, 45(2), 16–25.
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Reiser RA. 2001. *A History of Instructional Design and Technology: Part I: A History of Instructional Media.* Educational Technology Research and Development, 49 (1), 53-64.
Reiser RA. 2001. *A History of Instructional Design and Technology: Part II: A History of Instructional Design.* Educational Technology Research and Development, 49 (2), 57-67.
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Spiro R. 2018. *Cognitive Flexibility Theory & the Post-Gutenberg Mind:* Rand Spiro's Home Page, https://postgutenberg.typepad.com/newgutenbergrevolution/?utm_campaign=elearningindustry.com&utm_source=%2Fcognitive-flexibility-theory&utm_medium=link
Tennyson R, Dijkstra S, Schott F and Norbert S. 1997. *Instructional Design: International Perspectives. Theory, Research, And Models.* Vol. 1. Mahwah, NJ: Lawrence Erlbaum Associates, Inc. p. 42. ISBN 0805814000.
The Encyclopedia of Educational Technology. *What is Educational Technology?* http://www.etc.edu.cn/eet/eet/articles/edtech/index.htm
Wlodkowski, Raymond J. 2008. *Enhancing adult motivation to learn: a comprehensive guide for teaching all adults*, 3rd ed., The Jossey-Bass higher and adult education series http://ekladata.com/iJLoOLufKEurVuG5mA2Ke1rJ5dQ/-Raymond_J._Wlodkowski-_Enhancing_adult_ motivation-Bokos-Z1-.pdf

Websites

e-Learning Industry– https://elearningindustry.com/
Instructional Design Central– https://www.instructionaldesigncentral.com/
Instructional Design– http://www.instructionaldesign.org/theories/
International Society for Educational Technology– https://www.isfet.org/courses/
Educational Technology– https://educationaltechnology.net/
AESA-Agricultural Extension in South Asia– http://www.aesanetwork.org/
GFRAS-Global Forum for Rural Advisory Services– http://www.g-fras.org/en/

I. Course Title : Risk Management and Climate Change Adaptation

II. Course Code : EXT 605

III. Credit Hours : 2+1

IV. Thory

Block 1: Risk Management in Agriculture

Unit 1: Understanding Risk and Distress

Introduction to risk, risk management, uncertainty, sensitivity and distress, General risk theory, Risk analysis methods, Risk perception and decision making, Indicators of risk and distress in agriculture – identification, selection and assessment, Understanding the agrarian distress in Indian agriculture, Sources of distress in Indian farming -changing farm size, land use, cropping patterns, pricing policy, markets and terms of trade, Typology of crisis in agriculture; Droughts, floods and Indian agriculture, Distress and farmer suicides - causes and socio-economic consequences

Unit 2: Managing Risk and Distress

Ways to reducing/managing risk and distress in Indian agriculture; crop and life insurance; Developing support systems; Planning, implementation and evaluation of risk/distress management programs; Institutional frameworks for risk and disaster management - NDMA & SDMAs; Developing District Agriculture Contingency Plans; Risk management by diversification; Good practices and lessons from other countries; Responses of government, non-government and extension system to agrarian crisis; National Farmers Policy.

Unit 3: Extension Professionals and Risk management

Understanding social-psychological and behavioural dimensions of farmers under risk/distress; Risk perception and communication; Helping farmers manage farm level risks - mobilising resources, linking with markets, strengthening capacities; Working with village level risk management committees; Operational skills for preparing contingency and disaster management plans; Institutional and extension innovations in managing risk and distress; Policy and technological preferences for dealing with drought and flood.

Block 2: Adapting to Climate Change

Unit 1: Introduction to Climate Change Science

Basic concepts of and terms in climate change science; impacts of climate change; anthropogenic drivers of climate change, Climate change and Indian agriculture; climate adaptation vs. disaster risk reduction; anticipated costs of adaptation; climate change and poor; Overview of UNFCCC framework and institutions, Kyoto Protocol and beyond; India's National Action Plan on Climate Change and National Mission on Strategic Knowledge on Climate Change; National Coastal Mission, Institutional arrangements for managing climate change agenda.

Unit 2: Introduction to Climate Change Adaptation and Mitigation

Introduction to Climate Change Adaptation, Conducting a vulnerability assessment (CVI and SEVI frameworks), Identifying and selecting adaptation options; Global, national and state level initiatives and plans to support climate change adaptation, private sector and civil society initiatives and activities; Mainstreaming climate change adaptation into development planning, Financing climate adaptation and budgetary allocations for programmes, Gender and climate change adaptation, Agricultural development programmes and strategies towards climate change adaptation and mitigation, Community based and Ecosystem based adaptation

strategies, preparing evidence based intervention plans for vulnerability reduction at micro and macro-levels.

Unit3: Climate Smart Agriculture (CSA) and Extension &Advisory Services

Climate smart agriculture; Developing climate smart and climate resilient villages; Stakeholders and determinants involved in climate smart agriculture; Climate smart agriculture and EAS; Innovative extension approaches used in CSA; Climate information services, Farmers perceptions about climate change; Farm and household level manifestations and adaptation strategies; Barriers and limits to adaptation; Farmers feedback on performance of extension methods; Skills, competencies and tools required for extension professionals at different levels and development departments in up scaling CSA.

V. Practicals

- Hands-on practice in using risk assessment/analysis tools
- Case studies on risk / distress assessment in agriculture -Indian and global
- Lessons / Experiences from NICRA Project in agriculture and allied sectors
- Developing criteria, indicators and indices for assessment of risk, vulnerability and resilience
- Hands on practice on use of vulnerability and risk assessment tools and techniques
- Case studies on success stories of climate change adaptation and community based initiatives
- Developing district and village level intervention plans for climate change adaptation
- Field Visits to State Disaster Management Authority
- Case studies on climate smart agriculture / villages from India and world
- Case studies on impact assessment of crop insurance programs, disaster management programs
- Capstone project on documenting ITKs and local practices related to reducing risk / climate resilience agriculture

VI. Suggested Reading

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Websites

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GFRAS-Global Forum for Rural Advisory Services– http://www.g-fras.org/en/

AESA-Agricultural Extension in South Asia– http://www.aesanetwork.org/

NICRA-National Innovations in Climate Resilient Agriculture–
http://www.nicra-icar.in/nicrarevised/

CRIDA-Central Research Institute for Dryland Agriculture– http://www.crida.in/

UNCC: Learn- UN Climate Change Learning Partnership– https://www.uncclearn.org/

DST- Department of Science and Technology- Climate Change Programme, GoI–
http://www.dst.gov.in/climate-change-programme

I. Course Title : Livelihood Development

II. Course Code : EXT 606

III. Credit Hours : 1+1

IV. Theory

Block 1: Understanding of Livelihood

Unit 1: Concept of Livelihoods

Basic concepts of livelihood and Development, Types of development-Immanent/ inherent and interventionist/ intentional; Why promote livelihood; Livelihood intervention: definition, types-Spatial, segmental, sector –sub-sector; Systemic view of Livelihoods, Understanding Rural Livelihoods-Farm, Non-Farm, and off farm; Linkages with Farm and Off-farm Livelihoods; Economic Models

Unit 2: Livelihood Challenges

Livelihood Challenge- Political economy of Livelihoods, Issues of access to farm and non-farm livelihoods; Livelihoods from a Gender Perspective-Feminization of agriculture/ poverty, women in the unorganized sector, the issue of unpaid and informal work; Livelihood Coping Mechanism- Climate Change and Livelihoods; Livelihoods and Disasters

Block 2: Livelihood Analysis

Unit 1: Livelihood Frameworks

Sustainable Livelihoods Approaches (SLAs)-Definition and origins of SLA; Assets or capitals and capabilities in SLA and its linkage to the other capitals: Physical, Social, Economic, Human, Natural; Vulnerability Assessment- Shocks, trends, seasonality; Policies, institutional context and processes; Conceptual Frameworks-DFID, CARE, UNDP, OXFAM, BASIX livelihood triad, Nine square Mandala or Rural Livelihood System's Framework, etc.; Past, Present and possibilities for the future of the SLA, critiques of the approach

Unit 2: Designing Livelihood Intervention and Promotion

Designing a suitable livelihood intervention-Observing and Understanding the Local Economy; Selecting livelihood activities suitable for the poor in the area; Deciding on the interventions. Livelihood promotion approaches-Poverty and livelihood: Approaches and programs in India; Livelihood and a Rights Based Approach-MGNREGA and its critique; Livelihood and a Social Capital based approach: NRLM

Block 3: Livelihood Augmentation (LA)

Unit 1: Pathways for LA

Basic concepts; Pathways: a) Entrepreneurial strategies for LA; b) NRM based intervention; c) Market based interventions including Value-chain analysis; d) ICT based interventions; e) Livelihood and allied agriculture (dairy, poultry, Goatery, etc.) based livelihood; f) Forest based Livelihoods vis a vis Livelihood Protection and Promotion: Contribution of NTFP in supporting rural livelihoods

Note: Block 'A' and 'B' is theoretical; Block 'C' should be covered in the form practical's supported by few classroom discussion through cases

V. Practicals

- Village stays to understand the livelihood pattern of villagers and how the other socio-economic factors affect the livelihood of people
- Visit to institutes/ universities adopted and/or nearby villages to experience the

life and natural resources in rural communities-understanding of village culture, evolution, social structure, livelihood pattern, trends, governance arrangements, and the natural context (landscape layout, land use, vegetation types etc)

- Application of participatory rural appraisal skills for understanding village context; Engagement of working with rural communities and their grass-root institutions, understanding dynamics of working in a group
- Visit to different agri-business models as mentioned in the Block 'C'. Group assignments may be given to document the field experience in the form of case study of an enterprise/ entrepreneur/ members and other related stakeholders

VI. Suggested Reading

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I. Course Title : Facilitation for People Centric Development

II. Course Code : EXT 607

III. Credit Hours : 2+1

IV. Theory

Block 1: Introduction to Facilitation for Development

Unit 1: Facilitation for development in the AIS

Facilitation for development in the AIS; Understanding facilitation for development; Importance of facilitation as a core function of eXtension within the Agricultural Innovation Systems (AIS)

Unit 2: Principles, Attributes and Skills for Facilitation for Development

Basic principles of facilitation for development; Desired attributes of facilitator for development- Cognitive attributes, Emotional attributes (Emotional intelligence), Social, behavioural and attitudinal attributes; Technical skills of a facilitator for development- Design processes, Facilitation techniques and tools, the art of questioning and probing, Process observation and documentation, Visualisation

Block 2: Facilitating Change in Individuals, Groups and Organisations

Unit 1: Realise Potential- Self-Discovery

Self-discovery to realise our potentials, Tools for self-discovery, formulating a personal vision, Taking responsibility for your own development

Unit 2: Group Dynamics and Working Together

Understanding the dynamics of human interaction, Group dynamics and power relations, Managing relationships, Shared vision and collective action, Tools for team building

Unit 3: Organizational Change Process

Organizational change process, Organizational learning to adapt to changing environments, Enhancing performance of organizations, Leadership development, Tools for organizational change

Block 3: Facilitating Operational Level Multi-stakeholder Engagements

Unit 1: Multi-Stakeholder Interactions

Defining stakeholders, Development of collective and shared goals, Building trust and accountability, Tools for stakeholder identification and visioning

Unit 2: Innovation and Policy engagement Platforms

Visualising innovation platforms (IPs), Why are IPs important?, Different models of IPs for multi-stakeholder engagement, policy engagement platforms, Generating issues and evidence for policy action, Advocacy for responsive policy processes

Block 4: Brokering Strategic Partnerships, Networking And Facilitation

Unit 1: Linkages, Partnerships, Alliances and Networking

Brokering linkages and strategic partnerships, Identification of critical links, Knowledge brokering, Creating linkages with markets, Learning alliances and networking, Coordination of pluralistic service provision within the AIS, The concept of action learning and reflective practitioners, Networking

Unit 2: Facilitating Capacity Development

Facilitating Capacity Development-Facilitate participation and learning in development programs and projects. Virtual platforms- skills for strengthening

dialogue, collaboration, shared commitment amongst diverse actors and stakeholders

V. Practicals

- Practicing facilitation techniques,
- Self discovery exercises,
- Working together and interaction (task based),
- Arrangement for multi-stakeholder interactions,
- Understanding organisational change process tools and techniques,
- Case analysis on organisational change process,
- Participating with innovation platforms,
- Policy engagement platforms,
- Stakeholder analysis mapping,
- Exercise on networking skills,
- Facilitating capacity building programmes
- Facilitating virtual platforms
- Filed visit to multi-stakeholder partnership projects

X. Suggested Reading

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Websites

- **MSU**–Michigan State University EXtension Facilitation– https://www.canr.msu.edu/facilitation/
- **TAPipedia**– Tropical Agriculture Platform– https://www.tapipedia.org/
- **CGSpace**- A Repository of Agricultural Research Outputs by CGIAR– https://cgspace.cgiar.org/handle/10568/33667
- **UMaine**– The University of Maine– https://eXtension.umaine.edu/community/strengthening-your-facilitation-skills/
- **GFRAS**– Global Forum for Rural Advisory Services– http://www.g-fras.org/en/

I. Course Title : Multivariate Statistical Methods For Extension Research

II. Course Code : STAT

III. Credit Hours : 2+1

IV. Theory

Block 1: Overview of Multivariate Statistical Methods

Unit 1: Basics of Multivariate Statistical Methods (MVSM)

What is multivariate data analysis; Basic concepts in MV – variate, measurement error; Power analysis and effect size; SPSS software

Unit 2: Classification and Types of MVSM

Independence and dependence techniques; Factor analysis – principal component, exploratory factor analysis; Multiple correlation and multiple regression; Discriminant analysis; Logistic regression; Cluster analysis; Conjoint analysis; Multi Dimensional Scaling/ Perceptual mapping; Correspondence analysis; Structural equation model

Unit 3: Selecting Appropriate MVSM

Selection based on purpose - Dimension reduction, identifying latent variables, strength of relationship among multiple dependent/ independent variables, identifying choice and estimating their utility; etc and type of variables – metric and non-metric

Unit 4: A Structured Approach for Building Multivariate Statistical Models

Steps in planning and conducing MVSM

Unit 5: Basic Econometric Methods-1

Nature of regression analysis; Two variable and multivariable regression models; Linear and non-linear regression models; Estimation methods

Unit 6: Basic Econometric Methods-2

Simultaneous-equation models; Panel data models; **Forecasting** - Time series and other models

Block 2: Data Preparation and Cleaning

Unit 1: Missing Data Analysis and Outlier Management

Missing data - Meaning, types, methods of missing data processing, advantages and limitations, **Outliers-** Meaning, types, methods for identifying and managing outliers

Unit 2: Testing Assumptions of MVSM and Data Transformation

Testing assumption of parametric analyses – normality, linearity, multicollinearity; Data transformation methods

Block 3: Methods for Assessing Human Choice/ Preferences and Decision-making

Unit 1: Assessing Human Preference Structures Using Conjoint Analysis

Meaning- Importance, guidelines for selecting variables, steps in designing a conjoint experiment – objectives, design, data collection and analysis. Applications in extension

Unit 2: Assessment of Adoption of Agricultural Technologies Using Limited Dependent Variable Models

Meaning, importance, types – logit, probit and tobit and their variations; steps in analysis and interpretation of results, applications in extension

Unit 3: Multidimensional Scaling

Meaning, importance and types, steps and applications in extension

Unit 4: Multi-criteria decision-making

Meaning, importance, methods – analytical hierarchy process, Applications in extension

Block 4: Methods of Assessing Association and Causality

Unit 1: Multiple Correlations and Multiple Regressions

Meaning, importance, types, methods of estimation, analysis and interpretation of results, application sin extension

Unit 2: Discriminant Analysis

Meaning, types, steps in conducting discriminant analysis, Applications in extension

Block 5: Methods Of Grouping Objects/ Variables Based On Latent Variables

Unit 1: Principal Component Analysis (PCA) and Common Factor Analysis

Meaning, importance, types of factor analysis, difference between types, steps in conducting PCA/ Common Factor Analysis, applications in extension

Unit 2: Structural Equation Modelling (SEM) – Two units

Meaning, importance, types – confirmatory factor analysis and structural model; steps in conducting SEM, Applications in extension

Unit 3: Cluster Analysis

Meaning, importance, types – Steps; Applications in extension

Block 6: Emerging MV Statistical Methods

Unit 1: Emerging MV Statistical Methods

Canonical correlation, partial least square (PLS)

V. Practicals

- Hands on experience of following methods using SPSS/ AMOS software
- Selecting appropriate MVSM
- Missing data analysis and outlier management
- Testing assumptions of MVSM and data transformation
- Assessing human preference structures using conjoint analysis
- Assessment of adoption of agricultural technologies using limited dependent variable models – logit, probit and tobit.
- Multidimensional scaling
- Multiple correlation and multiple regression
- Discriminant analysis
- Principal Component Analysis (PCA) and Common Factor Analysis
- Structural Equation Modeling (SEM)
- Cluster analysis

VI. Suggested Reading

Agresti, A. 2002. *Categorical data analysis*. Second edition. New York, NY: John Wiley & Sons.

Belsley, D. A. 1991. *Conditioning diagnostics: Collinearity and weak data in regression*. New York, NY: Wiley.

Bollen, K.A. 1989. *Structural equations with latent variables*. New York: John Wiley and Sons.

Burnham, K. P. and Anderson, D. R. 2002. *Model selection and multimodel inference*. New York, NY: Springer.

Byrne BM. 2010. *Structural equation modeling with AMOS: Basic concepts, applications, and programming*. New York: Routledge.

Chambers, J., Cleveland, W., Kleiner, B., and Tukey, P. 1983. *Graphical methods for data analysis*. Wadsworth.

Field A. 2013. *Discovering statistics using IBM SPSS Statistics*, 4th edition. Sage, London.

Greene, W. 2000. *Econometric Analysis* Fourth edition. New York, NY: Wiley.

Hair JJF, Black WC, Babin BJ and Anderson RE. 2010. *Multivariate Data Analysis: A Global Perspective*. 7th Edition, Pearson.

Hosmer, D. W. and Lemeshow, S. 2000. *Applied logistic regression*. Second edition. New York, NY: John Wiley & Sons

Kelloway, K. E. 1998. *Using LISREL for structural equation modeling: A researcher's guide*. Thousand Oaks: Sage

Long, J. S. 1997. *Regression models of categorical and limited dependent variables*. Thousand Oaks, CA: Sage

Ray, S. 2016. *A comprehensive guide to data exploration*. https://www.analyticsvidhya.com/blog/2016/01/guide-data-exploration/

Sivakumar SP, Sontakki BS, Sulaiman RV, Saravanan R, Mittal R. 2017. *Manual on Good Practices in Extension Research & Evaluation*. Agricultural EXtension in South Asia. http://www.aesanetwork.org/manual-on-good-practices-in-extension-research-and-evaluation/

Stokes, M. E., Davis, C. S., and Koch, G. G. 2000. *Categorical data analysis using the SAS system*. Cary, NC: SAS Institute Inc

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 2

Social Sciences

– Agri-Business Management

Preface

Rapid advancement in agriculture has resulted in increased demand for qualified managers to manage this sector. Indian agriculture is facing numerous challenges with a rapidly changing business environment, pace of technological change, globalisation, competitive environment and changing role of government. These challenges will place unparalleled demands on the capabilities of tomorrow's managers. Agribusiness Management has enormous potential to address key national and global challenges of inclusive growth, and food and nutritional security. With increasing incomes, the demand for value added agricultural products will also increase, driving the demand for Agribusiness Managers. Increasing integration of World food markets and the expansion of organized retail also imply that the scope of agribusiness is becoming increasingly global. The Agribusiness Management Education System in India is uniquely placed to meet the demand for professional agribusiness managers across the globe.

Agri business management is a specialized two-year MBA programme which focuses on business aspect of agriculture production and its international trade. The postgraduate course aims to craft professional business leaders and entrepreneurs in food, agriculture and allied sectors. The course is offered in premier business schools in and State Agricultural Universities in India and across the globe and focuses on managerial skill development in the agricultural sector. Students learn how to make sustainable business decisions and minimize risk while working in the agricultural sector. The course curriculum is designed to build and enhance a global perspective among students. The course also needs to create awareness among students about the environmental forces that impact managerial decisions.

In light of the above mentioned issues and concerns, courses and programmes in the field of agri-business management must also be reformed to increase the employability and entrepreneurship opportunities for the Post Graduates and Doctoral participants at the same time prepare them for handling global competitiveness without compromising farmers' and farming community needs and demands.

The sub-committee on Agri Business Management constituted by ICAR (under the ICAR Broad Subject Matter Area (BSMA) for Social Sciences) has kept above development in view while revising the PG and PhD Curricula in Agri Business Management. We also addressed the issue of repetitions of content, updating them with the recent trends in the industry, under-graduate curricula in agriculture. To do these, we identified first the core competencies that are required at the different levels and worked backwards based on the areas and organising them into courses.

We are also recommending summer internship-2 at the Master's level (each for 4-6 weeks with agri based organisations) and we propose a credit load of 10 and 4 for each of these internships/ attachments at PG level. We believe this will help the students to have more relevant practical experience and this will boost their job prospects.

We have organised the curriculum under different block and units and each course has an introduction explicitly stating the purpose of this course (why this course), aim of the course (what it tries to provide) and learning outcomes. Several new reading references are

also provided at the end of each course. The committee recognised the need for organising training of teachers to impart some of the new courses and this could be further elaborated in consultation with ICAR and other organisations that can support or even lead this exercise.

The committee organised a stakeholders meeting with agri based industry executives, academicians from reputed institutions, alumni from different ABM programmes of the SAUs, teachers involved in ABM teaching in selected SAUs at Bikaner on September 17, 2018 for development of curricula.

Our heartfelt gratitude to all the core committee members and stakeholders for their specific contributions to development of this revised curricula especially Mr Kamal Kumar, Advisor, Dhanuka Agritech Ltd; Dr Vikram Singh, Dean, NIAM, Jaipur; Dr Ranjit Singh, Professor, NAARM; Dr Seema Nath, Associate Dean, College of Agriculture, PJTSAU; Dr Radhika, Associate Professor, PJTSAU; Dr Madhu Sharma, Professor, SKRAU, Bikaner, Dr Swati Sharma, Assistant Professor, Navsari Agricultural University, Navsari; Dr Dinesh Jain, Associate Professor, RAJUVAS, Bikaner and Dr Amita Sharma, Assistant Professor, IABM, Bikaner.

Finally, we thank Dr NS Rathore, Deputy Director General (Education), ICAR for organising the BSMA for undertaking curricula revision and for his valuable guidance and support in this regard.

Dr Samarendra Mahapatra, Member
Dr Aditi Mathur, Member
Dr Lipi Das, Convener
Dr Kalpana Sastry, Chairperson

May 31, 2019

Course Title with Credit Load
MBA in Agri-Business Management

Major Courses 20 Credits

Course Code	Course Title	Credit Hours
ABM 501	Principles of Management and Organisational Behaviour	3
ABM 502	Managerial Accounting and Control	3
ABM 503	Applied Agribusiness Economics	2
ABM 504	Human Resource Management for Agricultural Organizations	2
ABM 505	Production and Operations Management	2
ABM 506	Agricultural and Food Marketing Management- I	2
ABM 507	Agricultural and Food Marketing Management- II	2
ABM 508	Agri Supply Chain Management	2
ABM 509	International Trade for Agricultural Products	2

Minor Courses 8 Credits

It is suggested the student may choose at least four courses out of the courses listed below as part of minor courses as these are related to specific areas of agri business and aim to build larger understanding of the subject. The final choice of the minor courses should be mandatorily approved by the Student Advisory committee/HoD.

Course Code	Course Title	Credit Hours
ABM 510	Food Technology and Processing Management	3
ABM 511	Rural Marketing	3
ABM 512	Fertiliser Technology and Management	3
ABM 513	Management of Agro-Chemical Industry	3
ABM 514	Seed Production Technology Management	3
ABM 515	Technology Management for Livestock Products	3
ABM 516	Fruit Production & Post Harvest Management	3
ABM 517	Farm Power & Machinery Management	2
ABM 518	Food Retail Management	2
ABM 519	Management of Agricultural Input Marketing	2
ABM 520	Feed Business Management	2
ABM 521	Management of Veterinary Hospitals	2
ABM 522	Poultry And Hatchery Management	2
ABM 523	Management Of Floriculture And Landscaping	2
ABM 524	Risk Management In Agri Business	2
ABM 525	Management Of Agri-Business Co-Operatives	2

Course Code	Course Title	Credit Hours
ABM 526	Business Analytics for Agriculture	2
ABM 527	Dairy Business Management	1
ABM 528	Agri Extension Management	1
ABM 529	Renewable Energy Sources Management	1
ABM 530	Quality Management for Agri Business	1
ABM 531	Advertising And Brand Management	1
ABM 532	Agri Infrastructure and Warehousing Management	1
ABM 533	Contract Farming	1
ABM 534	Human Resource Competence And CapacityBuilding Systems	1
ABM 535	Agri Commodity Markets And Futures Trading	1

Supporting Courses 6 Credits

Course Code	Course Title	Credit Hours
ABM 536	Strategic Management for Agri Business Enterprises	2
ABM 537	Operations Research	2
ABM 538	Financial Management in Agri Business	2

Common Courses 5 Credits

1. Technical Writing and Communications Skills
2. Intellectual Property and its management in Agriculture
3. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/MOOCs. The students may be allowed to register these courses/similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/she may be permitted to register for other related courses with the prior approvalof the HoD/BoS.

Master's Seminar 01 Credit

Course Code	Course Title	Credit Hours
	Research (Summer Internship + Research Project)	**30 (10+20)**
	Summer Internship/ Industrial Attachment	4
	Basic Courses mandatory for Summer Internship	6
ABM 539	Communication for Management and Agri Business	3
ABM 540	Research Methodology for Agri Business Mgmt	3
	Research Project	**20**
	Project work	**10**
	Basic courses mandatory for Project	10

Course Code	Course Title	Credit Hours
ABM 541	Computer Applications for Agri Business	3
ABM 542	Project Management and Agri Business Entrepreneurship	3
ABM 543	Agribusiness Environment and Policy	2
ABM 544	Agri Business Laws and Ethics	2

Course Contents
MBA in Agri-Business Management

I. Course Title : Principles of Management and Organizational Behaviour

II. Course Code : ABM 501

III. Credit Hours : 3+0

IV. Aim of the course

Provide students with opportunities to understand a wide variety of topics related to business management, focusing on fundamental management principles and concepts that apply to agribusiness, traditional management skills, and new competencies needed to succeed in a fast-paced environment that demands ongoing innovations.

The course is organized as follows:

No	Blocks	Units
1.	Basic Concepts of Management	1. Introduction to Management 2. Planning, Organising, Directing and Controlling
2.	Insights about Organisational Behaviour	1. Foundations of Individual behaviour 2. Group Dynamics
3.	Organisational Dynamics	1. Understanding and managing organisational culture 2. Concept of Organisational Development

V. Theory

Block 1: Basic Concepts of Management

Unit-I: Introduction to Management: Nature, Scope and Significance of Management, Evolution of Management Thought, Approaches to Management, functions and skills of a manager

Unit-II: Management functions: Planning – Types, Steps, Objective, Process, Strategies, Policies, MBO, Organizing – Structure & Process, Line, Staff, Authority & Responsibility, Staffing – Recruitment and Selection, Directing – Training, Communication & Motivation, Controlling- Significance, Process, Techniques, Standards & Benchmarks, Management Audit

Block 2: Insights About Organizational Behavior

Unit III: Nature, Scope and Significance of Organizational Behavior; Foundations ofIndividual behaviour – Emotions, Personality, Values, Attitudes, Perception, Learning and individual decision making, Motivation- Types of motivation, theories of motivation, motivational practices at workplace, managing stress and work life balance

Unit IV: Group dynamics- types of groups, group formation, Group decision making, teambuilding and developing collaboration, leadership styles and influence process; eadership theories, leadership styles and effective leader

Block 3: Organisational Dynamics

Unit V: Understanding and managing organisational culture, power and political behavior inorganisations, conflict Management, negotiation, managing organizational change, concept of organisational development

VI. Teaching methods/activities

- Interactive Lectures
- Assignment (Reading/Writing)
- Student presentations
- Case study related to basics of management and organizational behaviour

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the basic concepts of management and organizational behaviour
- Develop a overall view about the various management functions, managerial skills and approaches
- Get insights about the fundamentals of individual and group behavior in the orgnisational setting
- Analyse the organisational level challenges in managing the resources optimally

VIII. Suggested Reading

- Robbins SP, Coulter M and Vohra N. 2010. *Management.* Pearson Edu.
- Weihrich H, Cannice MV and Koontz H. 2015, *Management, A Global, Innovative and Entrepreneurial Perspective,* 14th Edition, McGraw Hill Education Pvt Ltd.
- Beierlein JG, Schneeberger KC, Osburn DD. 2014. *Principles ofAgribusiness Management.* Fifth edition. Waveland Press
- Neck CP, Houghton JD and Murray EL. 2017, *Organizational behavior,* Sage Publication India Private Limited.
- Greenberg J. 2013, *Behavior in Organisations*, PHI Learning Private Limited, New Delhi.
- John A, Wagner III JA and Hollenbeck JR. 2015. *Organizational Behaviour*, Routledge Taylor & Francis Group, New York.
- Koontz H and Weighhrich K. 2010. *Essentials of Management*. Tata McGraw Hill

I. Course Title : Managerial Accounting and Control

II. Course Code : ABM 502

III. Credit Hours : 3+0

IV. Aim of the course

The objective of this course is to expose the learner to the concept and methods of financial and management accounting. Focus will be on understanding techniques, uses and applications of financial and management accounting.

No	Blocks	Units
1.	Financial Accounting	1. Introduction to financial accounting 2. Accounting standards 3. Double Entry system 4. Use of accounting softwares
2.	Managerial Accounting	1. Meaning of Managerial accounting 2. Analysis of financial statements 3. Cash flow and fund flow analysis
3.	Cost Accounting	1. Introduction to cost accounting 2. Standard costing 3. Variance Analysis 4. Budget and budgetary control

V. Theory

Block 1: Financial Accounting

Unit I: Financial Accounting- Meaning, Need, Accounting principles: Accounting Conceptsand Conventions; Branches of Accounting, Users of Accounting information, Advantages and Limitations of Financial Accounting, Accounting Standards

Unit II: The Double Entry System- Its Meaning and Scope, The Journal, Cash Book, Ledger, Trial Balance, Trading Account Profit and Loss Account, Balance Sheet, entries and adjustments of different heads in different Books and Accounts, Introduction of Company Accounts, Use of Accounting Software

Block 2: Managerial Accounting

Unit III: Management Accounting-Meaning, Functions, Scope, Utility, Limitations and Toolsof Management Accounting, Analysis of Financial Statements- Ratio, time series, common size and Du pont Analysis, Comparative and Common Size Statements, Cash Flow and Fund Flow Analysis

Block 3: Cost Accounting

Unit IV: Cost Accounting–Nature, Course, Significance of Cost Accounting; Classification ofCost, Costing for Material; Labour and overheads; Marginal Costing and cost volume profit Analysis- Its Significance, Uses and Limitations; Standard Costing – Its Meaning, Uses and Limitations, Determination of Standard Cost, Variance Analysis-Material, Labour and Overhead.

Unit V: Budget and Budgetary Control- Meaning, Uses and Limitations, Budgeting and Profitplanning, Different Types of Budgets and their Preparations: Sales Budget, Purchase Budget, Production Budget, Cash Budget, Flexible Budget, Master Budget, Zero Based Budgeting. Mergers and Acquisition, Tax System- GST

VI. Teaching methods/activities

- Lecture
- Case studies for making the participants get a clear idea about the real life budgeting and accounting practices
- Live project in the firms finance departments for getting the first hand experience

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Develop a clear understanding about the concepts of financial and managerial accounting
- Understand the basics of cost accounting through various tools and techniques available
- Get a insight about the budget and budgetary control methods

VIII. Suggested Reading

- Jain SP and Narang KL. 2014. *Financial Accounting*. 12th Edition. Kalyani publisher
- Sharma and Gupta. 2018. *Management Accounting* 13th Edition, Kalyani Publisher
- Maheshwari SN and Maheshwari SK. 2018. *Financial Accounting*. 6th Ed. Vikas Publ. House.

I. Course Title : Applied Agribusiness Economics

II. Course Code : ABM-503

III. Credit Hours : 2+0

IV. Aim of the course

This course applies basic economic tools and models to problems involving supply, demand, individual consumer and firm behavior, and market structure. Basic market structure models covered include perfect competition, monopolistic competition, oligopoly, and monopoly. Economic tools and models are related to business strategies throughout the course.

The course is organized as follows:

No	Blocks	Units
1.	Overview of Managerial Economics	1. Basic managerial economics principles 2. Mathematical concepts used in managerial economics 3. Introduction to behavioral economics
2.	Production, cost and supply analysis	1. Production Function 2. Cost Concepts 3. Determinants of price
3.	Macroeconomics	1. The national income 2. Flow of money in the market and economy 3. Business decisions under certain and uncertain situations

V. Theory

Block 1: Overview of Managerial Economics

Unit I: Scope of managerial economics, objective of the firm and basic economic principles; mathematical concepts used in managerial economics. Introduction to behavioral economics

Unit II: Indifference curves and budget sets - Demand analysis - meaning, types and determinants of demand; demand function; demand elasticity; demand forecasting-need and techniques.

Block 2: Production, Cost and Supply Analysis

Unit III: Production, cost and supply analysis- production function, Multi period productionand cost least-cost input combination, factor productivities and returns to scale, cost concepts, cost-output relationship, short and long-run supply functions.

Unit IV: Pricing-determinants of price - pricing under different market structures, pricing ofjoint products, pricing methods in practice, government policies and pricing. Price discrimination (First, Second and Third level)

Block 3: Macroeconomics

Unit V: The national income; circular flow of income: consumption, investment and saving: money-functions, factors influencing demand for money & supply of money; inflation; economic growth; business cycles and business policies; business decisions under certain and uncertain situations

VI. Teaching methods/activities

- Interactive Lectures
- Assignment (Reading and Writing)
- Cases on recent developments in economic environment
- Live projects to understand the principles of economics for an organisation
- Group analysis of newspapers covering national level economic trends

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the concepts of managerial economics and its implications on the agri business environment
- Develop a clearer overview on the macroeconomic environment that exists for a agri business enterprise to understand and adapt for optimizing the output

VIII. Suggested Reading

- Dwivedi DN. 2015. *Managerial Economics*. 8th Edition, Vikash Publishing
- Gupta GS. 2015. *Managerial Economics*. Tata McGraw Hill
- Savatore D. Srivastav R. 2012. *Managerial Economics*. 7th Edition, Oxford University Press
- Suma Damodaran. 2010. *Managerial Economics*. Oxford

I. Course Title : Human Resource Management for Agricultural Organisations

II. Course Code : ABM 504

III. Credit Hours : 2+0

IV. Aim of the course

The objective of this course is to expose the learner to the field of human resource management. The focus will be on human resource practices and their utility for managers in agri based organizations.

The course is organized as follows:

No	Blocks	Units
1	Overview of Human Resource Management	1. Meaning and scope of Human Resource Management 2. Human Resource Planning 3. Recruitment, Selection and Training 4. Performance Appraisal 5. Compensation Management
2	Industrial Relations	1. Trade Union 2. Grievance Management 3. Health and Safety of HR
3	Ethical and Global issues in HRM	1. Global HRM 2. HR Metrics, HRIS and workplace analystics

V. Theory

Block 1: Introduction to Human Resource Management

Unit I: Strategic Human Resource Management, Human Resource Planning-Nature andSignificance, Job Analysis and talent management process, Job Description, job Specification, Job enlargement, Job enrichment, Job rotation

Unit II: Recruitment and Selection Process, Induction, Training and Human Resource Development-Nature, Significance, Process and Techniques, e- recruitment, use of Big Data for recruitment, use of Artificial Intelligence and machine learning tools in recruitment practices Career planning and Development Internal mobility including Transfers, Promotions, employee separation.

Unit III: Performance Appraisal–Significance and methods, Compensation management, Strategic pay plans, Job Evaluation, Wage and Salary Administration; Wage Fixation; Fringe Benefits, Incentive Payment, bonus, and Profit Sharing

Block 2: Industrial Relations

Unit IV: Role and Status of Trade Unions; Collective Bargaining; Worker's Participation inManagement, employee retention. Quality of work life, employee welfare measure, work life balance, Disputes and Grievance Handling Procedures; Arbitration and Adjudication; Health and Safety of Human Resources;

Block 3: Ethical And Global Issues In Hrm

Unit V: Ethical issues in HRM**,** Managing Global Human Resources, Managing Human Resources in Small and Entrepreneurial firms, Human Resources accounting, Human Resources outsourcing. HR Information System, Human Resource Metrics and Workforce Analytics, Future trends in workforce technologies.

VI. Teaching methods/activities

- Lectures
- Videos showing trends and practices of innovative human resource management

- Live project for understanding the application of concepts in the real life situation
- Interaction with the HR managers of the agri based organsiations to understand the intricacies involved in the managing the human resource
- Group tasks to study the policy framework and regulatory environment that exists in India and globally to manage human resource

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the basic concept of HRM and SHRM
- Develop an insight into important human resource management functions like job analysis, job planning, recruitment, selection, performance appraisal, training, development, compensation management etc with major reference to the agri based organisations
- Get a clearer view about the status of employee – employer relationship in Indian agri enterprises and global agri based organizations
- Understand the ethical and recent trends in managing human resource effectively

VIII. Suggested Reading

- Gary Dessler & Biju Varkkey 2016, *Human Resource Management*, XIV Edition, Pearson India
- VSP Rao. 2010, *Human Resource Management, Text and Cases*, 3rd Edition, Excel Books
- Ashwathapa K. 2016. *Human Resource Management, Text and Caes*. Tata McGraw Hill
- Michael J. Kavanagh, Mohan Thite & Richard D. Johnson. 2016, *Human ResourceInformation Systems*, Sage Publications
- Subba Rao P. 2004. *Essentials of Human Resource Management and Industrial Relations*. Himalaya Publ. House.

I. Course Title : Production and Operations Management

II. Course Code : ABM 505

III. Credit Hours : 2+0

IV. Aim of the course

The objective of this course is to expose the learner to the field of production and operations management. The focus will be on imparting knowledge of the basic concepts, tools, and functions of production management.

The course is organized as follows:

No	Blocks	Units
1	Introduction to Production and Operations Management	1. Concept and scope of production and operations management 2. Operations strategy 3. Productivity variables and measurement
2	Inventory management	1. Determination of material requirement 2. Industrial safety 3. Cloud operations management
3	Overview of Quality Management	1. Statistical process control 2. Reengineering and Value engineering

V. Theory

Block 1: Introduction to Production and Operations Management

Unit I: Nature Concept and Scope of Production and Operations Management; FactorsAffecting System; Facility location, Types of Manufacturing Systems and Layouts, Process Selection and Facility Layout, Layout Planning and Analysis, Forecasting

Unit II: Operations Strategy: Operations Strategy, Competitive Capabilities and CoreCompetencies, Operations Strategy as a Competitive Weapon, Linkage Between Corporate, Business, and Operations Strategy, Developing Operations Strategy, Elements or Components of Operations Strategy, Competitive Priorities, Manufacturing Strategies, Service Strategies, Global Strategies and Role of Operations Strategy.

Unit III: Productivity Variables and Productivity Measurement, Production Planning andControl, Mass Production, Batch Production, Job Order Manufacturing, Product Selection, Product Design and Development, Process Selection, Capacity planning.

Block 2: Inventory Management

Unit IV: An Overview of Inventory Management Fundamentals, Determination of MaterialRequirement, Safety Management Scheduling, Maintenance Management Concepts, Work Study, Method Study, Work Measurement, Work Sampling, Work Environment, Production Planning and Control (PPC) Industrial Safety, human-machine interface, types of interface designs. Cloud operations management

Block 3: Quality Management

Unit V: Quality Assurance, Accepting Sampling, Statistical Process Control, Total QualityManagement, ISO standards and their Importance, Introduction to re-engineering, value engineering, check sheets, Pareto charts, Ishikawa charts, JIT Pre-requisites for implementation Six Sigma, Lean Management, Reliability Engineering, Safety Engineering, Fault Tree Analysis.

VI. Teaching methods/activities

- Interactive sessions
- Live projects
- Assignments (reading and writing)
- Presentations of quality management practices by leading agri and food organizations

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the basic concepts of production and operations management including manufacturing systems, layout planning and analysis
- Develop a understanding about the operations strategy, productivity variables, and their measurement along with product design and development
- Get an insight about fundamentals of inventory management, safety management, quality assurance practices and techniques with major emphasis on agri and food based industries

VIII. Suggested Reading

- William J. Stevenson. 2014. *Operations Management*, 12th Edition, McGraw-Hill
- Panneerselvam K. 2012. *Production and Operations Management* 3rd Edition, Prentice Hall India Learning Private Limited
- S. N Chary, 2017. *Production and Operations Management*, McGraw Hill Education; 5 edition

I. Course Title : Agricultural And Food Marketing Management-I

II. Course Code : ABM 506

III. Credit Hours : 2+0

IV. Aim of the course

To develop the understanding the concept of marketing system with specific inputs of product, pricing, availability and promotional details

The course is organized as follows:

No	Blocks	Units
1.	Marketing concept	1. Overview of Marketing Management 2. Developing the product mix 3. Branding decisions 4. Packaging technology
2	Pricing decisions	1. Pricing Objectives 2. Types of pricing
3	Channel Management and Physical Distribution	1. Distribution channels 2. Warehouse management, Inventory management 3. Transport management
4	Marketing Communications	1. Marketing communications mix 2. Digital Marketing, Mobile Marketing, Social Marketing and Social Media Marketing 3. Marketing efficiency and effectiveness

V. Theory

Block 1: Overview Of Marketing Management

Unit 1: Introduction and Concept/ philosophies of Marketing Management; Product Management: The product, The product mix, Product line extensions, Product linedeletions, Branding products, The advantages and disadvantages of branding, Branding decisions Brand loyalty models, Homogenous first-order markov models, Higher-order markov models Packaging, The functions of packaging, Packaging technology, Recent developments in packaging

Block 2: Pricing Decisions

Unit 2: Pricing objectives, The laws of supply and demand, Elasticity of demand Cross-price elasticity of demand, Practical problems of price theory, Cost - revenue - supply relationships, The meaning of price to consumers, Price as an indicator of quality, Pricing strategies, Cost-plus methods of price determination, Breakeven analysis, Market-oriented pricing, Psychological pricing, Geographical pricing, Administered pricing

Block 3: Channel Management and Physical Distribution

Unit 3: Channel decisions in relation to marketing strategy, The value of middlemen, Key decisions in channel management, Types of distribution system, Marketing to middlemen, Power and conflict in distribution channels, Physical distribution, Customer service levels, Developing a customer service policy, The total distribution concept, Warehouse management, Inventory management, Calculating the economic order quantity, Transport management, Technological advances in physical distribution, Vehicle scheduling and routing, Fixed and variable routing systems, Vehicle scheduling tools, Vehicle scheduling models, Computer-based vehicle scheduling

Block 4: Marketing Communications

Unit 4: The nature of marketing communications, Setting marketing communication objectives, Factors influencing the communications mix, The marketing communications mix, Advertising, Sales promotion, Public relations, Personal selling, Digital Marketing, Mobile Marketing, Social Marketing and Social Media Marketing, Training the sales force, Change agents, Selecting the media, Establishing the promotional budget, Monitoring the effectiveness of marketing communications

Unit 5: Marketing Costs And Margins: Assessing the performance of a marketing system, Marketing efficiency and effectiveness, Operational efficiency, Pricing efficiency, Identifying marketing costs and margins, The reference products concept, Handling costs, Packaging costs, Transport costs, Storage costs, Processing costs, Capital costs

VI. Teaching methods/activities

- Lectures
- Cases studies from recent marketing trends from the agri and food organisations
- Assignments (Group/ Individual)
- Live project based upon marketing practices adopted by various organizations
- Group discussions on contemporary marketing practices

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the basics of marketing with specific emphasis on managing the product details
- Get detailed insight on the pricing techniques and managing the demand and supply relationship profitably
- Develop the understanding about the marketing channels and intermediaries involved
- Understand the promotional strategies and communication development tools and methods

VIII. Suggested Reading

- Kotler P, Keller K, Koshy A and Jha M. 2013. *Marketing Management–Analysis, Planning, Implementation and Control.* Pearson Education.
- Ramaswamy VS. 2017. *Marketing Management: A Strategic Decision Making Approach*
- McGraw Hill Education
- Saxena R. 2009. *Marketing Management*. Mc Graw Hill.4th Edition
- William Perreault Jr., Mccarthy E. Jerome., 2006, *Basic Marketing: A Global Marketing Approach*, Tata McGraw Hill
- Gay R, Cjarlesworth A, Esen R. 2014, *Online Marketing*, Oxford University Press
- Mohammed, Fisher, Jaworski and Cahill: *Internet Marketing – Building Advantage in a networked economy* Tata McGraw-Hill
- Strauss J and Frost R. 2013. *E-Marketing*, Prentice-Hall
- Roberts M. 2018. *Internet Marketing*, Cengage Learning
- Vassos: *Strategic Internet Marketing – Practical e-commerce and branding Tactics*, Que Books
- Chaffey, Meyer, Johnston and Ellis – Chadwick. 2009. *Internet Marketing*, Prentice-Hall/ Financial Times

I. Course Title : Agricultural and Food Marketing Management-II

II. Course Code : ABM 507

III. Credit Hours : 2+0

IV. Aim of the course

To develop learning about the basic concept of marketing with major emphasis on agri and food marketing by equipping the students with the understanding of ecosystem in which the agri organization functions to meet the requirements of the customer profitably

The course is organized as follows:

No	Blocks	Units
1.	Agricultural and Food Marketing	1. Marketing concept and marketing systems 2. Market Liberalisation
2.	Marketing Strategy, Planning and Control	1. Marketing planning 2. New Product Development:
3.	Commodity Marketing	1. Grain marketing, 2. Livestock and meat marketing, 3. Poultry and eggs marketing, marketing of fresh milk

V. Theory

Block 1: Agricultural and Food Marketing

Unit 1: The importance of agricultural and food marketing to developing countries, the marketing concept and marketing systems, Marketing sub-systems Marketing functions, Links between agriculture and the food industry, Agricultural and food marketing enterprises, Marketing boards in developing countries, Co-operatives in the agriculture and food sectors, Control and management of secondary co-operatives, The weaknesses of co-operatives, Selling arrangements between co-operatives and their members

Unit 2: Market Liberalisation: Economic structural adjustment programmes, Macro-economicstabilisation, The role of the state in liberalised markets, Strategies for reforming agricultural marketing, Obstacles to be overcome in commercialisation and Privatisation of agricultural marketing, Dealing with accumulated deficits, Encouraging private sector involvement in agricultural marketing, Impediments to private sector participation in agricultural markets, impact of the macro-economic environment on private traders, Government action to improve private sector performance

Block 2: Marketing Strategy, Planning and Control

Unit 3: Marketing Strategy, Planning and Control: Strategy, policy and planning, Strategic businessunits, The need for marketing planning, The process of marketing planning, Contents of the marketing plan, Monitoring, evaluating and controlling the marketing planning, Marketing controls, Marketing plan control, Efficiency control

Unit 4: New Product Development: The impetus to innovation, New product development process

The adoption process, The effect of products characteristics on the rate of adoption, Buyer behavior: The influences on buyer behaviour, Exogenous influences on buyer behaviour Endogenous influences on buyer behaviour, The consumer buying decision process, Buyer behaviour and market segmentation, Lifestyle segmentation, Organisational markets Industrial markets, Industrial buyer characteristics

Block 3: Commodity Marketing

Unit 5: Stages in a commodity marketing system, Grain marketing, Challenges for grain marketing systems, fruits and vegetables, Livestock and meat marketing, Poultry and eggs marketing, marketing of fresh milk

VI. Teaching methods/activities

- Lectures
- Cases studies from recent marketing trends from the agri and food organisations
- Assignments (Group/ Individual)
- Live project based upon marketing practices adopted by various organizations
- Group discussions on contemporary marketing practices

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the agricultural and food marketing concepts and systems
- Get an insight about the marketing planning and strategies for developing products for meeting the specific needs of the final customers
- Develop a clear view about the commodity marketing practices in India and in International markets

VIII. Suggested Reading

- Acharya SS and Agarwal NL. 2011. *Agricultural Marketing in India*. 4th Ed. Oxford and IBH.
- Kohls RL and Uhj JN. 2005. *Marketing of Agricultural Products*. 9th Ed. Prentice Hall.
- Mohan J. *Agri-Marketing Strategies in India*, NIPA
- Sharma Premjit. 2010. *Agri-Marketing Management*, Daya Publishing House

I. Course Title : Agri Supply Chain Management

II. Course Code : ABM 508

III. Credit Hours : 2+0

IV. Aim of the course

To introduce the students to the concepts, processes and framework of agricultural supply chain management.

The course is organized as follows:

No	Blocks	Units
1	Overview of Supply Chain Management	1. Introduction to Agri Supply Chain Management 2. Demand Management in Supply Chain 3. Manufacturing Management
2	Procurement Management	1. Purchasing Cycle 2. Material Requirement Planning
3	Logistics Management	1. Distribution Strategies and Management 2. Warehouse Management 3. IT application in ASCM

V. Theory

Block 1: Overview Of Supply Chain Management

Unit I: Supply Chain: Changing Business Environment; SCM: Present Need; ConceptualModel of Supply Chain Management; Evolution of SCM; SCM Approach; Traditional Agri. Supply Chain Management Approach; Modern Supply Chain Management Approach; Elements in SCM. Innovations in Global Agri-SCM

Unit II: Demand Management in Supply Chain: Types of Demand, Demand Planning andForecasting; Operations Management in Supply Chain, Basic Principles of Manufacturing Management. SCM Metrics/Drivers and Obstacles.

Block 2: Procurement Management in Agri. Supply Chain

Unit III: Purchasing Cycle, Types of Purchases, Contract/Corporate Farming, Classification ofPurchases Goods or Services, Traditional Inventory Management, Material Requirements Planning, Just in Time (JIT), Vendor Managed Inventory (VMI).

Block 3: Logistics Management

Unit IV: History and Evolution of Logistics; Elements of Logistics; Management; Distribution Management, Distribution Strategies; Pool Distribution; Transportation Management; Fleet Management; Service Innovation; Warehousing; Packaging for Logistics, Third-Party Logistics (TPL/3PL); GPS Technology.

Unit V: Concept of Information Technology: IT Application in SCM; Advanced Planning andScheduling; SCM in Electronic Business; Role of Knowledge in SCM; Performance Measurement and Controls in Agri. Supply Chain Management-Benchmarking: introduction, concept and forms of Benchmarking. Case Studies on

the following: (a) Green Supply Chains (b) Global Supply Chains (c) Coordination in a SC. Value of and distortion of information: Bullwhip effect (d) Sourcing and contracts in SC (e) Product availability with uncertain demand (f) Inventory planning with known/ unknown demand (g) Cases from FAO/IFPRI, etc.

VI. Teaching methods/activities

- Lectures
- Case study on the real life situations regarding the supply chain management practices
- Assignments (Group and individual)
- Live projects
- Newspaper analysis
- Presentations of best practices in the industry
- Videos and guest lectures by the eminent and successful organizations

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the various elements involved in managing agri supply chain from farm to fork
- Relate well with the issues and challenges involved in managing and forecasting the demand of the products
- Develop insights on the techniques of procurement management and handling inventory
- Assess the importance of managing logistics along with adequate handling and packaging intricacies
- Get a overall clarity about the use of information technology to make the agri supply chain more efficient and rewarding

VIII. Suggested Reading

- Acharya SS and Agarwal NL. 2011. *Agricultural marketing in India*. Oxford and IBH.
- Altekar RV. 2006, *Supply Chain Management: Concepts and Cases*. PHI
- Chopra S, Meindl P and Kalra DV. 2016. *Supply chain management: Strategy, Planning, and Operation*, Pearson Education India
- Mohanty RP. 2010. *Indian Case studies in Supply Chain Management & other Learning Resources*. Oxford.
- Chandrasekaran N. 2010. *Supply Chain Management: Process, system & Practice*. Oxford.
- Singh S. 2004. *Organic Produce Supply Chains in India-Organisation and governance*. Allied Publ.

I. Course Title : International Trade in Agricultural Products

II. Course Code : ABM 509

III. Credit Hours : 2+0

IV. Aim of the course

To impart knowledge to the students about international trade in agriculture andvarious provisions under WTO in the new trade regime. The course is organized as follows:

No	Blocks	Units
1.	Introduction to International Trade	1. Basic concepts of International Trade 2. WTO and its implications for Indian agri business sector 3. International trade restrictions and support systems
2.	Regulations and policy measures International trade	1. India's foreign trade policy frameworkfor 2. Market entry methods 3. Export procedures & documentations

V. Theory

Block 1: Introduction To International Trade

Unit I: International trade–basic concepts, WTO and its implications for Indian economy ingeneral and agriculture sector in particular.

Unit II: TRIPS, TRIMS quotas, anti dumping duties, quantitative and qualitative restrictions, tariff and non-tariff measures, trade liberalization, subsidies, green and red boxes, issues for negotiations in future in WTO; CDMs and carbon trade. **Unit III:** Importance of foreign trade for developing economy; absolute and comparativeadvantage, foreign trade of India. Cases on agri business commodity trade practices

Block 2: Regulations and Policy Measures for International TRADE

Unit IV: India's balance of payments; inter regional Vs international trade; tariffs andtradecontrol; exchange rate; the foreign trade multiplier.

Unit V: Foreign demand, supply side analysis, opportunity cost, trade and factor prices, implications for developing countries, market entry methods, export procedures & documentations.

VI. Teaching methods/activities

- Lectures
- Cases on contemporary issues
- Group assignments
- Live projects
- Policy discussions
- Guest lectures
- Industrial visits to firms exporting agri commodities

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the basic concepts of International trade with reference to WTO andInternational agreements on Agriculture
- Assess the practices of trade of agri business commodities
- Develop a clear understanding about the significant regulations and policy measures for International Trade

VIII. Suggested Reading

- Study materials by the Center for WTO Studies, ITPO, New Delhi, *The Future of Indian Agriculture*
- Brouwer F and Joshi PK. 2016. *International Trade and Food Security*, LEI - Wageningen UR, The Netherlands.

I. Course Title : Food Technology and Processing Management

II. Course Code : ABM 510

III. Credit Hours : 3+0

IV. Why this course?

As a discipline, Food Technology is the combination of engineering, food science, hotel management, and home science. It is an advanced study of the technology and processing methods used to develop, research, manufacture, produce, preserve and process food with related substances.

V. Aim of the course

Food Technology is the application of food science to the selection, preservation, processing, packaging, distribution and use of safe, wholesome and nutritious food. The food processing industry covers a range of food products.

The Course is organized as follows:

No	Blocks	Units
1.	Food Technology	1. Food Industry in India
2.	Processing Management	1. Basics of Food Processing 2. Food Safety and Costs Analysis 3. Case studies on project formulation in various types of food industries

VI. Theory

Block 1: Food Technology

Unit 1: Food Industry in India: Present status of food industry in India; Organization in food industry; Introduction to operations of food industry; Deteriorative factors and hazards during processing, storage, handling and distribution.

Block 2: Processing Management

Unit 2: Basics of Food Processing: Basic principles of food processing and food preservation through technology interventions; Application of energy, radiations, chemicals and other agents for food preservation; aseptic modes of processing-freezing, quick, cryogenic, high pressure, membrane technology; Packaging of foods, labelling techniques, advanced technologies for packaging.

Unit 3: Food Safety and Costs Analysis: Analysis of costs; risk management; Laws and regulations w.r.t to food industry including production, processing and marketing; Food Safety and Quality Standards-AGMARK, BIS/ISO, FPO, FSSAI, TQM, HACCP etc.

Unit 4: Case studies on project formulation in various types of foodindustries: Discussion sessions and analysis of Case studies related to dairy, cereal milling, sugarcane production; baking/confectionary, vegetable storage, handling, egg processing, fish and meat products; Cases related HACCP.

VII. Learning outcome

After completion of this course, the students are expected to be able to acquaint the students with different food processing techniques and their management.

VIII. Suggested Reading

- Acharya SS and Aggarwal NL. 2004. *Agricultural Marketing in India*. Oxford & IBH.
- Early R. 1995. *Guide to Quality Management Systems for Food Industries*. Springer

- Jelen P. 1985. *Introduction to Food Processing*. Reston Publishing.
- Potly VH and Mulky MJ. 1993. *Food Processing*. Oxford & IBH
- Fellows PJ. 2016. *Food Processing Technology Principles and Practice*, Woodhead Publishing, 4th Edition
- Potter NN. 2018. *Food science*. McGraw-Hill Education, 6th Edition
- Singh RP, Heldman DR. 2013. *Introduction to Food Engineering*. Elsevier Inc., 5th Edition
- Smith JS, Hui YH. 2013. *Food Processing: Principles and Applications*, Wiley

I. Course Title : Rural Marketing

II. Course Code : ABM 511

III. Credit Hours : 3+0

IV. Aim of the course

To explore the possibilities and potential of the rural market. It aims at critically analysing the market opportunities, consumer trends and patterns and development of better marketing strategies for the rural areas.

The Course is organized as follows:

No	Blocks	Units
1	Rural MarketingEnvironment	1. Rural Market Concept & Scope 2. Environmental factors 3. Rural finance 4. Rural consumer's behavior
2	Rural Marketing Strategy	1. Rural Product strategy 2. Pricing for rural markets 3. Promotion and communication strategy

V. Theory

Block 1: Rural Marketing Environment

Unit 1: Rural Market Concept & Scope: Concept, Definition and Scope of rural marketing, nature and characteristics of rural markets, potential of rural markets in India, rural V/S urban market.

Unit 2: Environmental factors: Socio-cultural, economic, demographic, technological and other environmental factors affecting rural marketing.

Unit 3: Rural finance: Concept, demand, banking model; Finance Schemes of NABARD, Other Schemes of State Govt, Central Govt.

Unit 4: Rural consumer's behavior: Behavior of rural consumers and farmers; buyer characteristics and buying behavior; customer relationship management, rural market research.

Block 2: Rural Marketing Strategy

Unit 1: Rural Product strategy: Marketing of consumer durable and non-durable goods and services in the rural markets with special reference toproduct planning; marketing mix, product mix.

Unit 2: Pricing for rural markets: Pricing policy and pricing strategy, distribution strategy, Rural retailing and modern store formats in rural areas.

Unit 3: Promotion and communication strategy: Media Planning, Distribution channels, personal selling strategies in rural markets, innovations in rural marketing

Teaching methods/activities

- Lectures
- Discussion
- Case Studies
- Student-led presentations

V. Learning outcome

After completion of this course, the students are expected to be able to develop understanding regarding issues in rural markets like marketing environment, consumer behaviour, distribution channels, marketing strategies, etc.

VI. Suggested Reading

- Krishnamacharyulu and Ramakrishnan. 2010. *Rural Marketing: Text and Cases*: Pearson Education. 2nd edition
- Singh S. 2004. *Rural Marketing: Focus on Agricultural Inputs*, Vikas Publishing
- Kashyap P. 2011. *Rural Marketing*. Pearson Education
- Kumar D and Gupta P. 2017. *Rural Marketing: Challenges andOpportunities*. Sage Publications.

I. Course Title : Fertilizer Technology and Management

II. Course Code : ABM 512

III. Credit Hours : 3+0

IV. Why this course?

Provide exposure to most recent Nitrogenous and Complex fertilizer production technologies. Improve participants' technical knowledge over a varied range of fertilizer production techniques

V. Aim of the course

Enhance the participants' analytical and trouble-shooting skills by generating awareness to identify and resolve operational inefficiencies, if any, of their facilities. The Course is organized as follows:

No	Blocks	Units
1	Fertilizer Production	1. Fertilizer development 2. Raw material 3. Production efficiency
2	Testing and Field Trials	1. Testing 2. Field trials

VI. Theory

Block 1: Fertilizer Production

Unit 1: Fertilizer development: Concept, scope, need, resource availability; import and export avenues for fertilizer; types of fertilizers, grading and chemical constituents, role of fertilizers in agricultural production, production and consumption of fertilizer in India.

Unit 2: Raw material Supply; Principles of manufacturing-potassic fertilizers, secondary and micro-nutrient formulations

Unit 3: Production efficiency: Production efficiency and capacity utilization; quality control and legal aspects fertilizer control order

Block 2: Testing and Field Trials

Unit 1: Testing facilities; constraints in fertilizer use; assessment of demand and supply of different fertilizers, fertilizer distribution, fertilizer storage.

Unit 2: Field trialsand demonstrations; environmental pollution due to fertilizers

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

Provide a platform to exchange ideas on a varied range of production topics, opportunity for active interaction with leading technology experts and to acquaint the students in latest advances in fertilizer technologymanagement.

IX. Suggested Reading

- Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- *Fertilizer Control Order* (different years). Fertilizer Association of India, New Delhi.
- *Fertilizer Statistics* (different years). Fertilizer Association of India, New Delhi
- *Indian Journal of Fertilizers* (different years). Fertilizer Association of India, New Delhi.
- San Chilli V. 1960. *Chemistry and Technology of Fertilizers*. American Chemical Soc. Monograph Series. Reinhold Publ. Corp.
- Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 2002. *Soil Fertility and Fertilizers*. 5th Ed. Prentice Hall

I. Course Title : Management of Agro Chemical Industry

II. Course Code : ABM 513

III. Credit Hours : 3+0

IV. Why this course?

The agrochemicals (pesticides, hydrogels, plant growth regulators etc.) have played a pivotal role in the past in increasing agricultural productivity and production, and in protecting and preserving the human and animal food, feed, health and the belongings.

V. Aim of the course

Plant protection chemicals have and will continue to play a crucial role in meeting the food, feed and fiber needs of the mankind.

The Course is organized as follows:

No	Blocks	Units
1.	Agro Chemicals	1. Agro Chemicals 2. Insecticides 3. Fungicides
2.	Insecticide Act and Plant Protection	1. Insecticide Act. 2. Plant Protection

VI. Theory

I. Course Title : Seed Production Technology Management

II. Course code : ABM 514

III. Credit Hours : 3+0

IV. Aim of the course

The course covers a wide range of seed science and technology issues related to production of high quality seeds, processing, testing, certification, quality control, seed policies and regulations, variety release and registration, seed quality management in *seed* multiplication systems, seed storage, marketing.

The Course is organized as follows:

No	Blocks	Units
1.	Seed Technology	1. Seed Technology
2.	Seed Management Programmes	1. Development and Management of Seed
No	Blocks	Units
		2. Maintenance of genetic purity 3. Management of seed processing plant 4. Seed Marketing

V. Theory

Block 1: Seed Technology

Unit 1: Seed Technology: Role of Seed Technology, its Course Objective and goal, Seed Industry in India, National Seed Corporation – Tarai Seed Development, Corporation, State Seed Corporations, National Seed Project and State Farms and their role.

Block 2: Seed Management

Unit 1: Development and Management of Seed Programmes: Seed Village Concept, Basic Strategy of Seed Production and Planning and Organization of Seed Programme; Types of Seed Programme–Nucleus seed, Breeders seed, Foundation seed and Certified seed etc.

Unit 2: Maintenance of genetic purity: Minimum seed certification standard and Management of breeders & Nucleus seed; Management of seed testing laboratory and research and development.

Unit 3: Management of seed processing plant seed storage management; seed packaging and handling.

Unit 4: Seed Marketing: GM Crop seed, IPR, PBR, Patents and related issues and their impact on developing countries; Statutory intervention in the seed industry; Seed legislation and seed law enforcement, Seed act; Orientation and visit to seed production farms, seed processing Units, NSC, RSSC, RSSCA and seed testing laboratories.

VI. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VII. Learning outcome

To apprise students regarding principles and efficient management of seed production technology.

VIII. Suggested Reading

- Agrawal RL. 2017. *Seed Technology*. Oxford & IBH.
- Desai BB, Katecha PM and Salunkhe DK. 2009. *Seed Handbook: Biology, Production, Processing and Storage*. Marcel Dekker.
- Kelly A. 1988. *Seed Production of Agricultural Crops*. Longman.
- McDonald MB Jr. and Copeland LO. 2012. *Seed Production: Principles and Practices*. Chapman & Hall.

I. Course Title : Technology Management for Livestock Products

II. Course code : ABM 515

III. Credit Hours : 3+0

IV. Why this course?

Students may study two major topics include meat technology and dairy technology. They may also do research activities on product development, development of functional meat, an extension of shelf life, and development of milk products.

V. Aim of the course

The main aim of this course is to disseminating knowledge about hygienic milk production, hygienic slaughter, utilization of slaughterhouse by-products, preparation of value-added meat products, preparing of value-added indigenous as well as milk products, and dressing of food animals.

The Course is organized as follows:

No	Blocks	Units
1.	Livestock product & Technology	1. Status of livestock product and technology 2. Manufacturing technologies
2.	TQM and Marketing of Livestock Products	1. TQM in processing 2. Marketing livestock products

VI. Theory

Block 1: Livestock Product and Technology

Unit 1: Present status of livestock products industry in India: Dairy, meat, skin and hides, wool, etc; SWOT analysis of livestock product industry, importance of value addition of livestock products, Concept of organic milk and meat. New techniques of biotechnology for improving food value.

Unit 2: Manufacturing technologies: Dairy-Manufacturing technologies of various dairy products and byproduct utilization. Meat- Manufacturingtechnologies of meat and its products, industrial processing and utilization of wool and animal by-products, valueadded egg product development.

Unit 3: Milk and meat processing plant: Layout and designing of milk and meat processing plant, abattoir design, sanitation and basic slaughterhouse practices, Plant Management- Production, planning and control, packaging, preservation and storage system for livestock products; transportation system for domestic markets and international markets.

Block 2: TQM and Marketing of Livestock Products

Unit1: Total quality management in processingTotal quality management in processing of milk and its byproduct, meat and byproduct, value added eggduct and wool, Quality control measures during storage transit; extent of losses during storage and transport, management measures to minimize the loss.

Unit 2: Marketing livestock products

Milk, meat, wool, fish etc and its byproduct, Marketing and distribution system of animal products; National and international specifications and quality standards for various products; environmental and legal issues involved.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation
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VIII. Learning outcome

To impart knowledge about management of livestock products, product development, quality control, preservation and marketing strategies for livestock products.

IX. Suggested Reading

- Mandal PK and Biswas AK. 2014. *Animal Products Technology*, Studium Press India Pvt. Ltd.; 1st Edition
- Bishwas AK and Mandal PK. 2014. *Textbook of Poultry, Egg and FishProcessing Technology*, Studium Press (India) Pvt. Ltd.

I. Course Title : Fruit Production and Post-Harvest Management

II. Course Code : ABM 516

III. Credit Hours : 3+0

IV. Why this course?

Postharvest management of fruits and vegetable: A potential for reducing a minimum postharvest losses as well as can potentially reduce production cost .

V. Aim of the course

A dual purpose of preventing losses that occur due to harvest losses of fruits and vegetables vary from 25% to 40%, depending on the kind of produce and the pre and post-harvest practices they are put through. The Course is organized as follows:

No	Blocks	Units
1.	Fruit Production	1. Introduction 2. Management of horticultural crops
2.	Post-Harvest Management	1. Post harvest management in horticulture-procurement 2. Post harvest management in horticulture process 3. Marketing of fruits

VI. Theory

Block 1: Fruit Production

Unit 1: Introduction: Global and National Status of Horticultural production in India and emerging scenario

Unit 2: Management of horticultural crops: Establishing an orchard, basic cultural practices, regulation of flowering, fruiting and thinning, protection against insect-pest, weeds: Maturity indices, Harvesting and its relationship with quality, sorting and grading, pre-harvest crop management practices and their influence on quality during storage and marketing.

Block 2: **Post-Harvest Management**

Unit 1: Post-harvest management in horticulture-procurement: Procurement management, important factors for marketing, standardization and quality control, packaging. Physiology of ripening and senescence. Storage system: on-farm storage-evaporatively cooled stores, ventilated storage, pit storage etc. Refrigerated storage refrigeration cycle, controlled/modified atmosphere, hypobaric storage.

Unit 2: Post harvest management in horticulture process: Application of growth regulators for quality assurance, post-harvest treatments: pre cooling, heat treatments (hot water, hot air and vapor heat), fungicides & biologically safe chemicals, irradiation, curing, pulsing *etc*. Packingline operations, packaging of horticultural produce. Transportation rail, road, sea, air. Codex norms for export ofperishables. Development of fruit-based carbonated drinks, development of dehydrated products from someimportant fruits, storage of pulp in pouches, essential oils from fruit waste, dehydrated fruits. Market structure andexport potential of fruits.

Unit 3: Marketing of fruits: Problems in marketing of fruits, and government policy; quality standards for domestic and international trade.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

To impart knowledge about management of horticultural crops and post-harvest technologies

IX. Suggested Reading

- Rathore NS, Mathur GK and Chasta SS. 2013. *Post-Harvest Management and Processing of Fruits and Vegetables*, ICAR.
- Chadha KL and Pareek OP. 1993. *Advances in Horticulture*. Vols. I-IV. Malhotra Publ. House.
- Kader AA. 1992. *Post-harvest Technology of Horticultural Crops*. Univ. of California. Div. of Agri. & Natural Resources.
- Jacob JP. 2012. Handbook on Post Harvest Management of Fruits and Vegetables, ASTRAL Publishing.
- NIIR Board of Consultants & Engineers. 2016. *The Complete Technology Book on Processing, Dehydration, Canning, Preservation of Fruits & Vegetables*, NIIR PROJECT CONSULTANCY SERVICES; 3rd Revised Edition
- Thompson K. 2003. *Fruit and Vegetables: Harvesting, Handling and Storage*, Wiley-Blackwell; 2nd Edition

I. Course Title : Farm Power and Machinery Management

II. Course Code : ABM 517

III. Credit Hours : 2+0

IV. Why this course?

The role of mechanization and its relationship to productivity, employment, social and technological change; performance and *power* analysis(Various sources of *farm power*, their availability and utilization) cost analysis of mechanized agriculture.

V. Aim of the course

Agricultural machinery management is the section of farm management that deals with the optimization ofthe equipment phases of agricultural production. It is concerned with the efficient selection, operation, repair and maintenance, and replacement of machinery.

The Course is organized as follows:

No	Blocks	Units
1.	Farm Power and Machinery	1. Farm power and tractors 2. Tillage and Tillage machinery 3. Sowing, Planting and Intercultural Equipment
2.	Agricultural equipments industry and Cost analysis of operations	1. Agricultural equipments industry 2. Cost analysis of operations

VI. Theory

Block 1: Farm Power And Machinery

Unit 1: Farm power and tractors: Farm power in India - sources, IC engines – working principles, two stoke and four stoke engines, IC engine terminology, different systems of IC engine. Tractors – types and utilities.

Unit 2: Tillage and Tillage machinery: Tillage – ploughing methods – primary tillage implements – mould board, disc plough and chisel plough – secondary tillage implements –cultivators, harrows and rotovators – wetland equipment – puddlers, tramplers and cage wheels.

Unit 3: Sowing, Planting and Intercultural Equipment: Sowing methods – seed drills, seed cum fertilizer drills – Paddy transplanters – nursery requirements – implements for intercultural operations – wet land, dry land and garden land intercultural tools. **P**lant Protection Gadgets, Harvesting Machinery and Horticulture tools: Plant protection equipment, tools for horticultural crops.

Block 2: Agricultural Equipments Industry and Cost Analysis Of Operations

Unit 1: Agricultural equipments industry: Agricultural equipments production, marketing and constraints; establishment of agricultural engineering enterprises (agro service centers, etc.). Equipment for land development and farm machinery selection: Equipment for land development and soil conservation.

Unit 2: Cost analysis of operations: Cost analysis ofoperations using different implements, economic performance of machines, optimization of tractor implements system and transport of farm produce. Cost of operation of farm machinery – Tractor and implement selection

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

To equip the students with sufficient theoretical knowledge and practical skills about farm power and tractor power, implement resources used in agriculture, their cost of operation and selection.

IX. Suggested Reading

- Senthilkumar T, Kavitha R and Duraisamy VM. 2015. *A text book of farm machinery*, Thannambikkai Publications, Coimbatore.
- Jagadishwar S. 2010. *Elements of agricultural engineering.* Standard Publishers Distributors, New Delhi.

I. Course Title : Food Retail Management

II. Course Code : ABM 518

III. Credit Hours : 2+0

IV. Why this course?

Study a short *course* in *Retail Management* to learn how to run a retail store or department efficiently and to introduce you to key issues and concepts associated with the *retail* environment. Topics covered in the *course* typically include business administration, visual merchandising, and marketing.

The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Introduction to Food market 2. Value Chain in Food Retailing
2.	Retail Marketing Strategy	1. Marketing MiX in Food Retail Management 2. Managing Retail Operations 3. Retail Sales Management

VI. Theory

Block 1: Introduction

Unit 1: Introduction to Food market: Introduction to International Food market, India's Competitive Position in World Food Trade, Foreign Investment in Global Food Industry, Retail management and Food Retailing, The Nature of Change in Retailing, Organized Retailing in India, E-tailing and Understanding food preference of Indian Consumer, Food consumption and Expenditure pattern, Demographic and Psychographic factors affecting Food Pattern of Indian Consumer.

Unit 2: Value Chain in Food Retailing: **V**alue chain and value additions across the chain in food retail, Principal trends in food wholesaling and retailing, Competition and pricing in food retailing, various retailing formats, the changing nature of food stores, market implications of new retail developments, food service marketing.

Block 2: Retail Marketing Strategy

Unit 1: Marketing MiX in Food Retail Management: Merchandise Management, Pricing Strategies used in conventional and non-conventional food retailing, Public distribution system, Promotion miX for food retailing, Management of sales promotion and Publicity, Advertisement Strategies for food retailers & Brand Management in Retailing.

Unit 2: Managing Retail Operations: Managing Retailers' Finances, Merchandise buying and handling, Logistics, procurement of Food products and Handling Transportation of Food Products.

Unit 3: Retail Sales Management: Types of Retail Selling, Salesperson selection, Salesperson training, Evaluation and Monitoring, Customer Relationship Management, Managing Human Resources in retailing, Legal and Ethical issues in Retailing.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

It will equip the students with desired knowledge and skills for managing food retail operations.

IX. Suggested Reading

- Singh S. 2011. *Fresh food retails in India: Organisation and impacts*, Allied publishers Pvt. Ltd., New Delhi
- Mahapatra. S, *Food Retail Management*, Kalyani Publishers
- Zentes, Joachim, Morschett, Dirk, Schramm-Klein, Hanna 2017. *Strategic Retail Management: Text and International Cases*, Springer Gabler.
- Agrawal N and Smith SA. 2015. *Retail Supply chain Management: Quantitative Models and Empirical Studies*, Springer; 2nd revised edition.

I. Course Title : Management of Agricultrual Input Marketing

II. Course Code : ABM 519

III. Credit Hours : 2+0

IV. Why this course?

It will help in gaining a deeper understanding of the four P's of marketing as applied to agricultural input marketing and an exposure to social and ethical issues is oriented in the course.

V. Aim of the course

The present course aims at familiarizing the participants with various aspects of agricultural input marketing in India.

The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Market for agricultural inputs 1. Marketing of seeds
2.	Marketing of Agricultural Inputs	2. Marketing of fertilizers 3. Marketing of pesticides 4. Marketing of tractors

VI. Theory

Block 1: Introduction

Unit 1: Market for agricultural inputs: Nature of demand, promotional media, nature of competition, a framework for understanding the markets for inputs, agronomic potential, agro economic potential, effective demand, actual consumption.

Block 2: Marketing of Agricultural Inputs

Unit 1: Marketing of seeds: Government policy, product, trade practices in seed production, seed pricing, input costs, distribution system, management of seed distribution. proper storage of seeds, promotion, problems faced by seed industry, strategy for a seed enterprise, source of seeds, terms of transaction for seed procurements.

Unit 2: Marketing of fertilizers: Nature of Indian fertilizer market, product, fertilizer distribution, marketing cost and margins, credit, dealer selection and management, fertilizer promotion and extension, promotional program, advertising in fertilizers, emerging marketing mix in fertilizer, extension strategy for the future, marketing of biofertilizers, strategies for fertilizer marketing.

Unit 3: Marketing of pesticides: Market profile, structure of industry, farmer behaviour, problems of farmers in pesticide purchase and usage, marketing mix, bio pesticides market development and promotion activities, problems in marketing of bio pesticides. Integrated pest management.

Unit 4: Marketing of tractors: Segments in tractor market, market share, nature of demand, buyer behaviour, role of distribution, promotion, MNC's. Marketing of credit-Nature of market, market segment, market players, marketing mix, marketing options. Strategies for input marketing-Client and location specific promotion, joint promotion, interdependence of input markets, management of demands, developmental marketing, usp, extension services, ethics in business, sustainability.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

To enhance the understanding and analytical capabilities with respect to products, market environment, and operational issues in marketing of agricultural inputs.

IX. Suggested Reading

- Mahapatra. S. *Management of Agricultural Inputs*, NIPA Publishers
- Seetharaman SP.: *Agricultural Input Marketing*, Oxford & IBH Pub. Co.
- Krishnamacharyulu CSG. : *Rural Marketing: Text and Cases*, Pearson Education India Venugopal P. 2014. *Agri-input Marketing in India*, SAGE Publication; 1st Edition.

I. Course Title : Feed Business Management

II. Course Code : ABM 520

III. Credit Hours : 2+0

IV. Why this course?

It will help in gaining a deeper understanding of the production, processing and marketing of cattle feed, poultry feed and fish feed.

V. Aim of the course

The present course aims at familiarizing the participants with various aspects feed for livestock and poultry.

The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Feed resources 2. Nutrients requirements of livestock and poultry
2.	Feed Preparation and Distribution	1. Feed preparation 2. Importance of mineral mixture 3. Feed Distribution

VI. Theory

Block 1: Introduction

Unit 1: Feed resources: Gap between demand and availability of nutrients; status of feed industry in India and world, constraints in the development of Indian feed industry.

Unit 2: Nutrients requirements of livestock and poultry: Knowledge about the quality of feed ingredients used in feed manufacturing. Procurement procedure of feed ingredients, scientific storage of feeds and feed ingredients. BIS, CLAFMA and all other commercial standards of all class of livestock and poultry feeds.

Block 2: Feed Preparation and Distribution

Unit 1: Feed preparation: Layout and design of feed plants, feed plant management; Basic principles of processing of feeds, Feed preparation for cattle and poultry and as specialty feeds for aqua and pet animals.

Unit 2: Importance of mineral mixture: Feed additives, supplements and pass feed, to know the new technology regarding improving the feeding value of poor quality roughages. To acquaint the concept of silage technology, complete feed block technology, hydroponics technology and UMMB technology.

Unit 3: Feed Distribution: Distribution channels, regulations relating to manufacture and sale of feed stuffs.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

To acquaint the students with the role and importance of feed industry and the production of feed for livestock and poultry.

IX. Suggested Reading

- Morrison FB. 1961. *Feeds and Feeding*, Abridged, Morrison Publishing; 9th edition John.

- Moran. 2005. Tropical Dairy Farming: Feeding Management for Small Holder Dairy Farmers in the Humid Tropics, Csiro Publishing.
- Moran J and McDonald S. 2010. *Feedpads for Grazing Dairy Cows,* Csiro Publishing.
- Kellems RO and Church DC. 2009. *Livestock Feeds and Feeding,* Pearson; 6th Edition

I. Course Title : Managmement of Veterinary Hospitals

II. Course Code : ABM 521

III. Credit Hours : 2+0

IV. Aim of the course

It will help in gaining a deeper understanding of the Veterinary Science is the science of *treating* and curing the diverse types of Animals.
The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Feed resources 2. Nutrients requirements of livestock and poultry
2.	Feed Preparation and Distribution	1. Feed preparation 2. Importance of mineral mixture 3. Feed Distribution

V. Theory

Block 1: Veterinary Hospital Administration

Unit 1: Needs, aims and objectives: Objectives of Veterinary hospitals; the existing and simulated situations under which veterinary hospitals work or are to work.
Unit 2: Designing and planning an ideal hospital: Optimizing the use of resources - human, space, equipment, drugs, time, capital, etc.; Materials management and problems Normal purchase procedure. Receipt; storage and distribution of materials Cost reduction & scientific inventory control. Information system and materials management performance. Equipment maintenance, condemnation & disposal.
Unit 3: Authority, responsibility: Accountability of management for optimizing the use of skill, developing and upgrading skills and technology; efficient system of record keeping and accounting; Concept of quality & Total quality management (TQM) Introduction to Veterinary audit, Statistical quality control (SQC), Quality control Circle (QCC).

Block 2: Information System & Quality Control

Unit 1: Hospital information system: Hospital information system as an aid to efficient controlling and monitoring; need for financial resources - investment and working capital; Records: Types & Methodology, Reports and Reporting system. Contemporary and need-based methods of accounting; General consideration. Need based information system. Applicability in surveillance & monitoring; planning & policy making; cost control.
Unit 2: Quality control system: Economic functions and quality control system; Animal health Economics: An introduction Need for financial resources (type and need). Investment planning and working capital; Budgeting and cost cutting (cost control). legal aspects in the functioning of the hospital.

VI. Learning outcome

The objective of this course is to acquaint the students about the designing, planning, organizing, and controlling the veterinary hospitals for optimizing the use of space, capital, skill and other resources.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

I. Course Title : Poutlry and Hatchery Management

II. Course Code : ABM 522

III. Credit Hours : 2+0

IV. Why this course?

This course introduces about updated production standards achievable under field conditions and financial viability of poultry operations. This specialized course is designed to train persons in Incubation and Hatchery Management and is meantfor those engaged in or scheduled to take up Hatchery operations.

V. Aim of the course

To give the opportunity for trainees to learn about raising chickens for their meat and eggs in order to manage a small-scale, commercial poultry enterprise that willbe profitable

The Course is organized as follows:

No	Blocks	Units
1	Introduction	1. Poultry and hatchery Business 2. Poultry and hatchery unit
2	Hatcheries and Risk Management	1. Incubation and hatching 2. Franchise hatcheries management 3. Personal management and insurance

VI. Theory

Block 1: Introduction to Poultry and Hatchery Industry

Unit 1: Poultry and hatchery Business: Poultry and hatchery industry; Present scenario of Poultry industry, Integration in poultry farming, Scope and future perspective, role of management in poultry industry.

Unit 2: Poultry and hatchery unit: Planning and establishing a poultry and hatchery unit- location, size and construction; farm and hatchery equipments and physical facilities; organizing and managing a poultry farm and hatchery.

Block 2: Hatcheries and Risk Management

Unit 1: Incubation and hatching Production of quality chicks and eggs; factors affecting hatchability; bio-securityand hatchery sanitation; handling of hatching eggs; maintaining chick quality-chick grading,transportation and chick delivery.

Unit 2: Franchise hatcheries management: Custom hatching; brooding; growing and laying management; crisis management; industrial breeding, feeding, housing and disease management; waste management; Record management; cost accounting and budgetary control.

Unit 3: Personal management and insurance: Labour relations including wagesand salaries, job evaluation and employee appraisal; marketing management direct sale and sale through franchisees/ agents, advertisement, sale and after sale services, other innovative sales strategies.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

The course provides an insight into the importance of management in poultryindustry, managing a poultry and hatchery enterprise, planning production of poultry products, financial, personnel and marketing management

IX. Suggested Reading

- Handbook of Poultry Science.
- Rathinam GK. 2015. *Manual of Hatchery Management: For Poultry Professionals* Hardcover.

I. Course Title : Management of Floriculture and Landscaping

II. Course Code : ABM 523

III. Credit Hours : 2+0

IV. Why this course?

It deals with the cultivation of flowers and ornamental crops from the time of planting to the time of harvesting. It also includes production of planting materials through seeds, cuttings, budding, grafting, etc, up to the marketing of the flower and flower produce.

V. Aim of the course

The objective of this course is to expose the students with floriculture and landscaping technologies and their Agri-business implications including international trade.

The Course is organized as follows:

No	Blocks	Units
1.	Management of Floriculture	1. Introduction 2. Indoor and ornamental plants
2.	Landscaping and Trading	1. Introduction 2. Landscape gardening 3. Value-addition in floriculture

VI. Theory

Block 1: Management Offloriculture

Unit 1: Introduction: Introduction, importance and scope of floriculture industry and landscaping; Recent advances in floriculture industry.

Unit 2: Indoor and ornamental plants: Raising of foliage plants in pots, production technology of ornamental plants, commercial cultivation of flower crops (rose, jasmine gladiolus, tuberose, marigold, aster, carnation, gerbera, cilium chrysanthemum; special techniques for forcing of flowers for export.

Block 2: Landscaping and Trading

Unit 1: Introduction: Drying and dehydration of flowers; bonsai; scope of landscaping, response of flowering plants to environmental stresses;

Unit 2: Landscape gardening: Styles of gardening; modern and traditional garden planning; Socio-aesthetic planning; use of computers in designing gardens; planning towns

Unit 3: Value Addition in floriculture: Extraction, purification and storage of essential oils and perfumes; post-harvest storage changes; packing techniques of produce harvesting of flowers for export and home use, Export-Import trade in flowers and their specifications along major trading countries.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

Students are suitable for it working independently and apply the latest trends to

their work. They should be able to understand about floriculture and landscaping.

IX. Suggested Reading

- Banker N. 2011. *Landscape gardening*, IBDC publishers, Lucknow
- Misra RL and Misra S. 2012. *Landscape gardening*, Westville Publishing House, New Delhi
- Chadha KL and Choudhary B. 2006, *Ornamental Horticulture in India*. ICAR. New Delhi
- Grindal EW. *Every Day Gardening in India*. DB Tarporevala Sons.
- Randhawa GS and Mukhopadhyay A. 1998, *Floriculture in India*. Allied Publ., New Delhi

I. Course Title : Risk Management in Agri Business

II. Course Code : ABM 524

III. Credit Hours : 2+0

IV. Why this course?

Risk and uncertainities is involved in food and Agribusiness industries. Government to formulate policy that will encourage investors adopt the highlighted risk keeping in view priority of food security for rising population. The focus is to foster profitability in agri-allied sector.

V. Aim of the course

Identification, mitigation and management of risk is unique to agriculture-production, markets, finance, Institutions and HR. Policy implications at local, regional, national as well as international level. Data analysis and research findings to help in decision making at firm and industry levels using history to guide future events/projection, Degree of risk varies in agri-business compared to other sectors. The Course is organized as follows:

No	Blocks	Units
1.	Risk Management process	1. Financial intermediation 2. Strategic Issues in Bank Marketing 3. Credit policy in banks
2.	Introduction to banking Operations and Risk Management	1. Banking operations 2. Definition of Risk and risk management techniques

VI. Theory

Block 1: Risk Management Process

Unit 1. Financial Intermediation, Indian Financial system, Origin and Growth of Banking. RBI and its functions. Principles of Banking, Banking Law and Practice. Nationalization of Banks in India, Deposit Products, Lending Activities, Retail Banking, Wealth Management, Financing SMEs, Corporate Banking, Forex Management, Fee-Based & Subsidiary Services, Plastic Money, Role of Central Banks, Emerging Trends in Banking, Fundamentals of International Banking.

Unit 2: Strategic Issues in Bank Marketing, Positioning Bank Services in the Market, New Product Development, Pricing and Launching, New Distribution Channels for Bank Marketing, Communicating and Promoting Bank Services, Improving Quality and Productivity, Customer Relationship Management in Banks, Globalizing Bank Services, Opportunities and Challenges in Bank Marketing.

Unit 3: Credit Policy in Banks, Principles of Credit Management, Objectives of Credit Management, Credit Disbursal and Monitoring, Credit Deployment and Types of Borrowers, Follow up and Recovery Management, Treasury Operations, Introduction to Risk Management in Banks, Rural Banking in India, Security Considerations, Control System in Banks, Corporate Governance in Banks, Annual Reports and Statutory Audit.

Block 2: Introduction to Banking Operations and Risk Management

Unit 1: Introduction to Banking Operations, Front Office and Back Office Operations, Operational Controls, Demand Forecasting and Resource Allocation, Policy Framing – Deposits, Advances and Investments, Services Design and Delivery Strategies in Banks, Service Quality Metrics, Work Measurement and Quality Assurance, Payment and Settlement Systems, RTGS and Clearing House, Cash Management Services, Facilities Planning, ERP in Banks, BPR in Banks, IT Enabled

Supply Chain Management, Disaster and Recovery Management.

Unit 2. Introduction to Risk, Risk Management Essentials, Measurement of Risk, Loss Exposure, Risk Management – Non-insurance Techniques, Introduction to Insurance, Principles of Insurance, Insurance Industry, Insurance Market, Insurance as Risk Management Techniques, Selection and Implementation of Risk Management Techniques.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

Developing an understanding of the different types of risk in general to agriculture sector and with special reference to agriculture business.

IX. Suggested Reading

- Sethi J and Bhatia N. 2012. *Elements of Banking and Insurance.* PHI Learning
- Jian W and Rehman A. 2016. *Risk Management in Agriculture: Theories and Methods*. Science Publishing group
- Hardaker JB, Huirne RBM, Anderson JR and Lien G. 2004. *Coping With Risk in Agriculture,* CABI Publishing, 2nd Edition
- Rose PS and Hudgins SC. 2006. *Bank Management & Financial Services.* Mcgraw-Hill College; 7th edition

I. Course Title : Management of Agribusiness Cooperatives

II. Course Code : ABM 525

III. Credit Hours : 2+0

IV. Why this course?

Proper management enables **c**ooperatives to offer high quality, efficient and effective services to their members. Moreover, well managed agricultural cooperatives can also contribute to wider development issues such as food security, sustainable use of natural resources and inclusive employment creation.

V. Aim of the course

These cooperatives were usually initiated by small scale farmers, as a response to their weak position in the market. By joining forces they could improve this position and obtain better prices and services for the purchase of inputs and the marketing of produce.

The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Cooperative administration 2. Cooperative management
2.	Cooperative Movement and Management	1. Cooperative Movement 2. Human resource management 3. Overview of agribusiness cooperative

VI. Theory

Block 1: Introduction

Unit 1: Cooperative administration: Global perspective, ecology of cooperative administration, cooperative sector and economic development.

Unit 2: Cooperative management: Nature, functions and purpose of cooperatives –procurement, storage, processing, marketing, process of cooperative formation, role of leadership in cooperative management.

Block 2: Cooperative Movement and Management

Unit 1: Cooperative Movement: The state and cooperative movement, effects of cooperative law in management, long range planning for cooperative expansion, policy making.

Unit 2: Human resource management: Placement and role of board of directors in cooperative management.

Unit 3: Overview of agribusiness cooperative: Credit cooperatives, cooperative marketing, dairy cooperative; financing agribusiness cooperative.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

To provide the students an understanding about the agribusiness cooperative organizations and their management.

IX. Suggested Reading

- Kamat GS. 2011. *New Dimensions of Cooperative Management*. Himalaya Publ. House.
- Ansari AA. 1990. *Cooperative Management Patterns*. Anmol Publ.
- Ravichandran and Nakkiran. 2009. *Cooperation* (*Theory & Practice*) Neha Publishers & Distributors;
- Sah AK. 1984. *Professional Management for the Cooperatives*. Vikas Publ. House.
- Anwar SA. *HRM Practise in Cooperative Sector*. Idea Publishing.

I. Course Title : Business Analytics for Agriculture

II. Course Code : ABM 526

III. Credit Hours : 1+1

IV. Why this course?

Analytics can enble farmers to make data-based decisions like which crops to plant for their neXt harvest. Reality as actionable insights to make decisions on data and information to improve agronomic opportunities, such as timing of applications, product decisions, amounts of products, and profitability of decision making.

V. Aim of the course

To make the students understand the concepts of data science tools and techniques and develop the skills for using it strategically and for the developing of the agri business sector.

The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Introduction 2. Fundamentals of Research
2.	Machine and Deep Learning	1. Supervised machine learning-1 2. Supervised machine learning-2 3. Deep learning

VI. Theory

Block 1: Introduction

Unit 1: Introduction to data science, evolution of data science, work profile of a data scientist, career in data science, nature of data science, typical working day of a data scientist, importance of data science in agribusiness; defining algorithm, big data, business analytics, statistical learning, defining machine learning, defining artificial intelligence, data mining; difference between analysis and analytics, business intelligence and business analytics, typical process of business analytics cycle.

Unit 2: Fundamental of Research

Fundamentals of R and RStudio, fundamentals of packages of RStudio, data manipulations, data transformations, normalization, standardization, missing values imputation, dummy variables, data visualization (2D and 3D), basic architecture of machine learning analytical cycle, descriptive analytics-case study covering data manipulation, measures of central tendency, measures of dispersion, measures of distribution, measures of associations, t-test, f-test, ANOVA, Chi-square test, basic statistical modeling framework.

Block 2: Machine and Deep Learning

Unit 1: Supervised machine learning: Basic framework, regression models and classification models. Linear regression, nonlinear regression, multiple regression, polynomial regression, lasso regression, ridge regression, stepwise regression, quantile regression, logistic regression.

Unit 2: Supervised machine learning: Linear discriminant analysis, principal component analysis, factor analysis, support vector machines, naïve Bayes, nearest neighbors, decision trees, random forest, ensemble methods, *k*-fold cross validation, X gradient boosting. Unsupervised machine learning—basic framework, concept of clustering, k-means, c-means, hierarchical clustering, hidden markov models, forecasting models (AR, MA, ARMA and ARIMA).

Unit 3: Deep learning: Basic framework of neural nets, types of neural nets, computer vision, object detection and localization, gradient descent optimization for loss function, regularization L1 and L2, feed forward neural nets, back propagation, recurrent neural nets, convolutional neural nets, reinforcement neural net, concurrent net, introduction to IoT. All the illustrations used in the syllabus of Data Science in Agribusiness will be primarily from agribusiness domains and RStudio will be used for practical purposes.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

To equip students of agribusiness with knowledge, skills and attitude for using data science tools and techniques so that agribusiness get competent professionals who can strategically and successfully implement data science applications.

IX. Suggested Reading

- *Deep Learning with R*. MEAP Edition, Manning Early Access Program. Version 1, © 2017, Manning Publication.
- James RG, Witten D, Hastie T and Tibshirani R. 2017. *An Introduction to Statistical Learning with Application*. Springer Publication
- Millstein F. 2018. *Machine Learning With Tensorflow: A Deeper Look At Machine Learning With Tensor Flow* Frank Millstein
- Stanton J. 2012. *Introduction to Data Science*. Version 3, SAGE Publications, Inc.

I. Course Title : Dairy Business Management

II. Course Code : ABM 527

III. Credit Hours : 1+0

IV. Why this course?

The main objective of dairy management course is to provide basic input to students about production, planning and management of dairy farms, entrepreneurship development in milk preservation, entrepreneurship development in dairy processing and management of dairy farm, co-operative and industry.

V. Aim of the course

To emphasize on the application of Principles of Management in dairy business with special emphasis on co-operative dairy units. The emphasis shall be on main functional areas like Finance, Marketing, Human Resources, Production and Information Technology.

The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Introduction to commodity derivatives 2. Dairy Plant Management System
2.	Dairy Business Strategy:	1. Marketing Management, Supply Chain and International Trade in Dairy sector 2. Strategic, HR Management and Entrepreneurship in Dairy Sector 3. Financial Management and Financial Analysis in dairy sector

VI. Theory

Block 1: Introduction

Unit 1: Dairy Development in India: Dairy organizations: functioning, Challenges and Opportunities, Anand pattern dairy Cooperatives: features and impact; Public sector dairy schemes, Dairy Development schemes, Dairy problems and policies, National Dairy Plan-I, Rise of Producer Companies. Policy Frameworks in context to dairying.

Unit 2: Dairy Plant Management System: Production Planning and control in dairy plants, milk procurement from the rural milk producer, milk processing and products manufacturing. Pricing and marketing of milk and milk products. Survey on milk production potential and marketed surplus of milk for setting up of milk plants, energy utilization, Conventional and nonconventional sources of energy used in dairy sector. Concept of Quality; TQM concept and Kaizen in Dairy Industry, new concepts in quality assurance (HACCP; ISO certification); patent laws, pollution control laws in relation to dairy plants. Guidelines for obtaining ISO/HACCP certification for dairy plants. SQC in dairy operations.

Block 2: Dairy Business Strategy:

Unit 1: Marketing Management, Supply Chain and International Trade in Dairy sector: Marketing- mix in relation to dairy sector, marketing environment,. Marketing Opportunities Analysis in Milk and Milk Products: Demand status of Milk and milk products in the country, growth rates, Marketing research and marketing information systems; Market measurement present and future demand; Market forecasting. Market segmentation, Product-mix; Promotion mix decisions. Advertising; Sales Promotion. Food and Dairy Products Marketing, Consumer Buying Behaviour; New product development processPrice determination and pricing policyInternational Marketing Marketing; Composition & direction of Indian exportsExports- Direct exports, indirect exports; WTO and its Implications; SPS/ TBT; Supply chain Management in Dairy sectorLogistics Management: Primary and Secondary Markets; Distribution channels; chilling points

Unit 2: Strategic, HR Management and Entrepreneurship in Dairy Sector: PESTLE analysis, BCG matrix, Strategic Management in dairy industry, Governance Structure in Dairy Sector, Management control System. Organisational Performance parameters – Quantitative and Financial, Use of Balanced Score card and other strategy control tools. HR management practices in dairy sector, Promotions, transfers employee remuneration and other HR benefits and problems. Motivation, turnover, employee capacity building, Training and orientation etc. social and business economics; industrial relations and human values; labour laws; trade unionism Business Plan Preparation; TIDP plant setting; Compliances Systems in Dairy Industry

Unit 3: Financial Management and Financial Analysis in dairy sector: Nature and uses of financial analysis, Liquidity ratios, Leverage ratios, Activity ratios, Profitability ratios, Utility of Ratio analysis. Sources of long term capital in dairy Industry: Grants from NDDB, Grants from NABARD, Government and Other Schemes, cost of debt, debentures, preference share capital, equity share capital & retained earnings, overall cost of capital. Capital budgeting in dairy Industry. Various techniques: NPV, IRR, etc. Financial Planning and control in dairy Industry: Budgeting process, Problems and practices in Budgeting and evaluation. Cost Volume

– Profit analysis and operating leverage, Break-even analysis, Profit analysis and operating analysis, Utility of CVP analysis. Costing in Dairy sector: Costing Techniques and Costing of various dairy products – Milk costing based on Fat and SNF, Ice cream, milk, Paneer, etc. Essentials of sound costing system. Different

methods of costing, elements of cost: Labour- recording of time, idle time, methods of remunerating labour, Premium & Bonus Plans, Materials, Overheads.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

- To understand the overall scenario of dairy and develop insights in managing dairy as a entrepreneurial venture.
- To enhance the Decision making, Critical thinking and the problem solving capabilities of the students.
- To bring out the hidden potential and entrepreneurship aptitude of the students and also to encourage team building activities.

IX. Suggested Reading

- Acharya R M and Kumar P. *Dairy Production & Business Management* EIRI, Dairy Darming
- Rao Venkateswara, *Dairy Farm Busines Management*
- Singh Umashankar, *Dairy Farming*

I. Course Title : Agri Extension Management

II. Course Code : ABM 528

III. Credit Hours : 1+0

IV. Why this course?

To enhance the techno-managerial competence of extension functionaries and to acquaint the extension functionaries on the latest developments in the field of agricultural extension

V. Aim of the course

To equip the extension functionaries in latest tools and techniques for participatory decision making and to develop an insight into various extension models to enrich the agri - value chain

The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Approaches of Agricultural Extension 2. Cyber Extension
2.	Implications and contemporary issues	1. Implications of WTO 2. Extension and contemporary issues

VI. Theory

Block 1: Introduction

Unit 1: Approaches of Agricultural Extension: A critical analysis of different approaches of agricultural extension.Importance and relevance of indigenous knowledge system, identification and documentation of ITK, Integration of ITK system in research formulation, Concept of Agricultural Knowledge and Information System, Training of Stakeholders of AKIS.

Unit 2: Cyber Extension: Concept of cyber extension, national and international cases of extension projects using ICT and their impact of agricultural extension, alternative methods of financing agricultural extension - Scope, limitations and experience and cases. Research -Extension -Farmer - Market linkage: Importance, Scope, Implications etc., Market – Led Extension, Farmer - Led Extension, Concept of Farm Field School, Farm School, Public - Private Partnership: Meaning, Models, Identification of various areas for partnership. Stakeholder's analysis in Extension. Main streaming gender in Extension - Issues and Prospects

Block 2: Implications and Contemporary Issues

Unit 1: Implications of WTO: OA for extension services, re-orientation of extension services for agri-business and marketing activities, GOI- NGO collaboration to improve efficiency of extension.

Unit 2: Extension and contemporary issues: Extension and issues related to rural poverty. Privatization of Extension. Intellectual Property Rights (IPRs). Extension Reforms in India –Decentralized decision making, Bottom up planning, Farming System and Situation based Extension Delivery System, Extension delivery through Commodity Interest Groups. Organization innovations in Extension - ATIC, IVLP, Kisan Call Centres.

Block 2: Implications and Contemporary Issues

Unit 1: Implications of WTO: OA for extension services, re-orientation of extension services for agri-business and marketing activities, GOI- NGO collaboration to improve efficiency of extension.

Unit 2: Extension and contemporary issues: Extension and issues related to rural poverty. Privatization of Extension. Intellectual Property Rights (IPRs). Extension Reforms in India –Decentralized decision making, Bottom up planning, Farming System and Situation based Extension Delivery System, Extension delivery through Commodity Interest Groups. Organization innovations in Extension - ATIC, IVLP, Kisan Call Centres.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

By the end of the course student will be able to critically analyze different Agricultural Extension approaches, understand Agricultural Knowledge Information System (AKISs) ITK, Understand Advances in Extension - Cyber extension, ICT enabled extension services; Market Led Extension, Public Private Partnership, Mainstreaming gender in extension organizational Innovations.

IX. Suggested Reading

- Bagchi J. 2007. *Agriculture and WTO Opportunity for India*.
- Sanskruti Chambers R, Pacy A and Thrupp LA. 1989. *FarmersFirst*. Intermediate Technology Publ.
- Crouch BR and Chamala S. 1981. *Extension Education and Rural Development*. Macmillan.
- John KC, Sharma DK, Rajan CS and Singh C. 1997. *Farmers Participation in Agricultural Research and Extension Systems*. MANAGE, Concept Publ. Co.
- Khan PM. 2002. *Text Book of Extension Education*. Himanshu Publ.
- Narasaiah ML. 2005. *Agricultural Development and World Trade Organization*. Discovery Publ.
- Talwar S. 2007. *WTO Intellectual Property Rights*. Serials Publ.
- Van den Ban BW and Hawkins BS. 1998. *Agricultural Extension*. S.K. Jain Publ.
- Venkaiah S. 2001. *New Dimensions of Extension Education*. Anmol Publ.

I. Course Title : Renewable Energy Sources Management

II. Course Code : ABM 529

III. Credit Hours : 1+0

IV. Why this course?

Renewable Energy Management will contribute to the promotion of renewable energy sources in countries, especially developing nations.

V. Aim of the course

The course aims to provide fundamental clarity regarding various renewable&alternative energy sources/ technologies options available today, its usage potential & related aspects like cost, impact on environment, etc.

The Course is organized as follows:

No	Blocks	Units
1	Introduction	1. Introduction 2. Commercial application
2	Implications and contemporary issues	1. Institutional Framework 2. Devices for renewable energy development

VI. Theory

Block 1: Introduction

Unit 1: Introduction: Concept on alternate and non-conventional energy sources. Biofuels, Geothermal, Ocean, Hydropower, Biogas, Solar and Wind energy.

Unit 2: Commercial application: Commercial application of renewable energy sources and its benefits. Government Policy towards promoting renewable energy.

Block 2: Institutional Framework and Types

Unit 1: Institutional Framework: MNRE, CREDA-Renewable Energy Development Authority, State level Renewable Energy Development Agency, Society of Renewable Energy.

Unit 2: Devices for renewable energy development: Biogas plant, Wind Mills, Solar Cells – Solar Pumps, Solar Dryers, Solar water heating system, etc.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

To provide an insight to the meaning and concepts of Renewable energy resources development and Institutional support as well as Government policy framework.

IX. Suggested Reading

- Sorensen B. 2010. *Renewable Energy: Physics, Engineering, Environmental Impacts, Economics and Planning*, Elsevier Publishing; 4th Edition
- Armaroli N, Balzani V and Serpone N. 2013. *Powering Planet Earth–Energy Solutions for the Future*, Wiley
- Boyle G. 2012. *Renewable Energy: Power for a Sustainable Future*, Oxford; 3rd Edition
- Twidell J, Weir T. 2013. *Renewable Energy Resources*, CRC Press; 3rd Edition
- Ahmed AI. *Renewable Energy Sources* by Jain Brothers

I. Course Title : Quality Management for Agribusienss

II. Course Code : ABM 530

III. Credit Hours : 1+0

IV. Why this course?

The focus of the process is to improve the quality of organizations outputs, including goods and services, through continual improvement of internal practices

V. Aim of the course

The course will help the students to have an understanding of the quality standards in agribusiness.

The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Basic concepts of quality management 2. TQM
2.	Quality grades, standards and Control	1. Quality grades and standards 2. Statistical to quality control 3. Food quality standards

VI. Theory

Block 1: Introduction

Unit 1: Basic concepts of quality management: importance of quality and the role of quality assurance in agribusiness.

Unit 2: Total Quality Manangement: TQM and business strategy. Quality control process and its relevance.

Block 2: Quality Grades, Standards And Control

Unit 1: Quality grades and standards: Overview and relevance, benefits to consumers, producers and food processors, food grades and standards for various food commodities; cereals, fruits and vegetables, meats, poultry products.

Unit 2: Statistical to quality control: Statistics relevant to quality control, quality control charts used in the food industry, process control to assure food quality, food processing.

Unit 3: Food quality standards: Food quality standards and world food trade. HACCP, ISO9000, auditing and certification.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

The course will help the students to have an understanding of the quality standards in agribusiness.

IX. Suggested Reading

- Luning PA, Marcelis WJ. 2009. *Food Quality Management: Technological and Managerial Principles and Practices*. Wageningen Academic Publishers
- Dale BG. 2004. *Managing Quality*. Blackwell Resources

I. Course Title : Advertising and Brand Management

II. Course Code : ABM 531

III. Credit Hours : 1+0

IV. Why this course?

To impart basic understanding among the candidates about the advertising along with detailed aspects of brand management practices and techniques.

V. Aim of the course

It aims to ensure consistency of message and the complementary use of media. ... measurable, persuasive brand communication programs with consumers.
The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Introduction to Advertising Management 2. Message Strategy 3. Consumer Promotions and Trade Promotions
2.	Branding Decision	1. Major Brand Concepts and branding Decision 2. Managing Brand Equity and Loyalty

VI. Theory

Block 1: Introduction

Unit 1: Introduction to Advertising Management: Integrated Marketing Communications, Setting Goals and Objectives, How advertising works: Segmentation and Positioning Assess the strengths, weaknesses, opportunities and threats (SWOT) of different kinds of promotional campaigns
Unit 2: Message Strategy: Attention and comprehension, Advertising appeals, Associating Feelings with the Brand, Brand Equity, Image and Personality and Group Influence and word of month advertising, Media Planning and Media Strategy, Media Strategy and Tactics, Legal, Ethical and Social concerns of Advertising.
Unit 3: Consumer Promotions and Trade Promotions: Their purpose and types How to plan and evaluate a successful promotion, The relationship between advertising and promotions, Introduction to Global Marketing, Advertising and sales promotion.

Block 2: Branding Decision

Unit 1: Major Brand Concepts and branding Decision: Identifying and selecting brand name Building brand personality, image and identity; Brand positioning and re-launch; Brand extension; Brand portfolio; communication for branding Enhancing brand image through sponsorship and even management.
Unit 2: Managing Brand Equity and Loyalty: Brand Building in Different Sectors - Customers, industrial, retail and service brands. Building brands through Internet, social Media. Building Indian brands for global markets.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

This course investigates various promotional tools used in the communication mix, such as advertising, sales promotion, and publicity, to sell products and services.

Concepts include: advertising planning processes, determining advertising and promotional goals and objectives, control and evaluation of advertising and promotional programs, and regulatory issues. Students will develop a comprehensive advertising campaign for a real or imaginary product.

IX. Suggested Reading

- Keller KL. *Strategic Brand Management;* Pearson education, New Delhi Verma, Harsha*: Brand Management;* Excel Books; New Delhi
- Kapferer JN. *Strategic Brand Management;* Kogan Page; NewDelhi
- Kumar S. Ramesh; *Marketing and Branding–The Indian Scenario;* Pearson Education; New Delhi Kapoor, Jagdeep; *24 Brand Mantras*, Sage Publications; New Delhi
- Sengupta S. *Brand Positioning: Strategies for competitive advantage*; Tata McGrawHill; New Delhi.
- Clifton R and Simmons J. *Brands and Branding*; The Economist; Delhi

I. Course Title : Agri Infrastructure and Waregousing Management

II. Course Code : ABM 532

III. Credit Hours : 1+0

IV. Why this course?

To create a pool of Agricultural storage infrastructure, logistics and warehouse professionals with capacity to manage agri-warehouse operations efficiently includes the overall inventory turnover and working capital management.

V. Aim of the course

The course provides an introduction to the key principles and activities related to the warehousing function in a modern organization designed for receiving, shipping, picking, packing etc. It also includes cold chain project, logistics awareness & training programs.

The Course is organized as follows:

No	Blocks	Units
1.	Introduction	1. Agricultural Infrastructure in India 2. Warehouse Functions: 3. Warehouse Types, Characteristics
2.	Warehouse Management	1. IT for Warehouse Management (WM): 2. Agri-warehousing Management in India

VI. Theory

Block 1: Introduction

Unit 1: Agricultural Infrastructure in India: Incentive schemes, Agri-infra fund, Agri-market Infrastructure, Agri-technological infrastructure fund, Central Government policy on Infrastructure promotion for the development of primary sector such as Irrigation, Watershed development, Rural electrification, Connectivity, Communication and Markets in coordination with the Institutional framework.

Unit 2: Warehouse Functions: Meaning of Warehousing - Importance –Functions: Receiving: Logistics support for Inward Transportation, Unloading, Inspection, Acceptance and Recording; Storing: Space allocation, Facilitation to stocking, Guarding &Recording; Risk bearing- Processing- Grading and branding – Disinfecting services -Issuing: Order preparation, Picking, Dispatching/ Delivery & Recording- Handling, Transportation & Storage of ISO Containers– Utility and Advantages of warehouses- Problems and issues in receiving processes.

Unit 3: Warehouse Types, Characteristics: Warehouse Types, Characteristics of ideal warehouses- Warehouse Layout-Principles and Facilities- Types, Internal Operations: Measures and metrics of warehouse operations, Logistics in the warehouse- Localization of materials in a warehouse, Identification and classification of Materials and products in the warehouse, Managing the material/products turns in warehouse (FIFO/LIFO) - Problems and issues in shipment processes. Warehousing Equipment, Inventory management.

Block 2: Warehouse Management

Unit 1: IT for Warehouse Management (WM): Warehouse documentation- Information flows in the warehouse- ERP-WMS - Bar code – RFID- Organization Data- Warehouse Structure- Warehouse Master Data - WM Material master view- Organization Data- Define Warehouse structure, Warehouse number - Storage type- Storage section - Storage Bin - Picking Area -Storage unit – Quantity- Creating Transfer requirement automatically/ manually – Creating Transfer requirement

for storage.

Unit 2: Agri-warehousing Management in India: Agri-warehousing in India, capacity development and utilisation, Role and significance of Central Warehousing Corporation, State warehousing Corporation, Private sector in Agri-warehousing. Status of Warehousing Industry:

Agri-warehousing organisations in India, e-NAM to promote agri-warehouse.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

To study the status of development of Agricultural infrastructure as well as the role of Warehouses to boost Agricultural sector.

IX. Suggested Reading

- Study materials of NABARD as well as by the Ministry of Rural development
- Edward F. 2001. *World-Class Warehousing and Material Handling*, McGrraw Hill
- Jeroen P. Van Den Berg. 2009. *Integral Warehouse Management*, Management Outlook Max Muller. 2009. *Essentials of Inventory Management*. AMACOM
- Steven M. Bragg. 2011. *Inventory Best Practices*. Wiley

I. Course Title : Contract Farming

II. Course Code : ABM 533

III. Credit Hours : 1+0

IV. Why this course?

To assess the need of Contract farming arrangement . It relates to agricultural production carried out according to an agreement between a buyer and farmers,

V. Aim of the course

The course provides an agreement between a farmer and a buyer. At the same time, the buyer also needs to provide the farmer with the necessary inputs required for the farm like land preparation, technical aspects etc. It is an effective means to develop markets and bring about crop rotation.

The Course is organized as follows:

No	Blocks	Units
1	Introduction	1. Need for contract farming 2. Project formulation and management
2	Policies, prospects and global issues	1. Policies for promoting contract farming 2. Prospects of contract farming in India 3. Global issues

VI. Theory

Block 1: Introduction

Unit 1: Need for contract farming: objectives and its definition; contract farming framework, contract farming arrangement-centralized model, nucleus estate model, multipartite model, informal model, intermediary model.

Unit 2: Project formulation and management: Coordination, crop husbandry, human resource. Advantages of contract farming for farmers and sponsors and the problems faced by them.

Block 2: Policies, Prospects And Global Issues

Unit 1: Policies for promoting contract farming: Agreement for contract farming-parties, duration, produce and quality specification, delivery arrangements pricing, insurance, support services, etc.

Unit 2: Prospects of contract farming in India: Prospects of contract farming in India in view of interest for commercialization of agriculture. Active organizations in contract farming and their success stories.

Unit 3: Global issues: lobal issues in contract farming, Contract farming and WTO agreement

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

To provide the students an understanding of concepts, policies, strategies and decisions relating to marketing that can be associated with agribusiness organizations. It involves agricultural production being carried out on the basis of an agreement between the buyer and farm producers. The farmer undertakes to supply agreed quantities of a crop or livestock product, based on the quality standards and delivery requirements of the purchaser.

IX. Suggested Reading

- Sharma P. 2007, C*ontract Farming*, Genetech Books
- Kuzilwa JA, Fold A, Henningsen A and Larsen MN. *Contractfarming and the development of smallholder* agricultural business. Routledge
- Kumaravel KS 2006. *Contract farming in India* - An Introduction.

I. Course Title : Human Resource Competence and Capacity Building Systems

II. Course Code : ABM 534

III. Credit Hours : 1+0

IV. Why this course?

Capacity development is the process by which individuals and organizations obtain, improve, and retain the skills, knowledge, tools, equipment and other resources needed for Human resource development.

V. Aim of the course

This course is designed to provide an in-depth understanding and enable the participants to manage capacity building processes and performance system for developing human resource.

The Course is organized as follows:

No	Blocks	Units
1	Introduction	1. Human Resource competence 2. Competency modelling and assessment
2	Capacity building	1. Competency based training and development 2. Performance Management System 3. Capacity building systems in agriculture and agri business

VI. Theory

Block 1: Introduction

Unit 1: Human Resource competence: Concept and rationale; processes, Organization and Management of competence and competency mapping.

Unit 2: Competency modelling and assessment: Approaches, tools and techniques, competency based human resource management applications.

Block 2: Capacity Building

Unit 1: Competency based training and development: Training methods compared with objectives, learning process and facilities, Developing Group and the Climate: the social process – indicators of group development, the training climate, Trainers And Training Style: Post training support for improved performance at work.

Unit 2: Performance Management System: Establishing and operationalising performance management system; measuring performance- results and behaviour; conducting performance review discussions; harnessing performance management system for performance improvement.

Unit 3: Capacity building systems in agriculture and agri business: Capacity building of farmers and agri stakeholders through e-learning, knowledge management for agri business.

VII. Teaching methods/activities

- Lecture and Discussion
- Case Study
- PPT presentation

VIII. Learning outcome

Proactive human resources management is essential to achieve the excellence through Capability Development and Planning. A Competence Profile for Staff Supporting the formal and informal training, job-rotation, traditional class-room courses, internal vs external training.

IX. Suggested Reading

- Kandula SR. 2013. *Competency Based Human Resource Management*. PHI
- Noe RA and Kodwani AD. 2012. *Employee Training and Development*. McGraw Hill Education. Fifth Edition
- Saks AM and Haccoun RR. 2013. *Managing Performance through Training and Development*. Cengage Learning. Sixth Edition

I. Course Title : Agri-Commodity Markets and Futures Trading

II. Course Code : ABM 535

III. Credit Hours : 1+0

IV. Aim of the course

To make the students understand the marketing procedure for commodity futures through commodity exchanges

The course is organized as follows:

No	Blocks	Units
1.	Overview of Commodity Market in India	i. Price risk management in agricultural markets ii. Global Specifications of futures contracts
2.	Mechanics of futurestrading	i. Option and forward transaction ii. Clearinghouse and margin system
3.	Market surveillance and risk control	i. trading in warehouse receipts ii. Regulation of futures and trading practices in leading national and regional exchanges in India

V. Theory

Block 1: Overview Of Commodity Market In India

Unit I: Introduction to commodity derivatives and price risk management in agriculturalmarkets; organizational setup of exchanges and specifications of futures contracts in world's leading commodity exchanges

Block 2: Mechanics of Futures Trading

Unit II: Futures trading; hedging price risk using futures contracts; option transaction andforward transaction – concept and mechanism, price discovery mechanism and market efficiency

Unit III: Clearinghouse and margin system; clearing, settlement and delivery of contracts

Block 3: Market Surveillance and Risk Control

Unit IV: Market surveillance and risk control; trading in warehouse receipts (WRs): WRs andcollateralized commodity financing

Unit V: Regulation of futures and trading practices in leading national and regional exchangesin India.

VI. Teaching methods/activities

- Lectures
- Live projects
- Assignments (Individual and Group)
- Presentations about the ethical practices of the firms in India
- News paper analysis about the contemporary issues

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Get an overview about the commodity markets in India
- Understand the mechanics of futures trading practices
- Know about the risk and surveillance mechanism available for agri commodity trading in India

VIII. Suggested Reading

- Hull, John C. 2017. *Fundamentals of futures and options markets*, Boston, Pearson publication.
- Ram PV and Bala SD. 2016. *Strategic Financial Management*. Snow White Publ. 80.

I. Course Title : Strategic Management for Agri Business Enterprises

II. Course Code : ABM 536

III. Credit Hours : 2+0

IV. Aim of the course

The objective of this course is to provide students a strategic orientation in conduct of the business and to develop a holistic perspective of an organization and to enable the students to analyse the strategic situation strategies in general and functional management areas.

The course is organized as follows:

No	Blocks	Units
1.	Overview of Strategic Management	1. Strategic management process 2. Environment scanning and industry analysis 3. Value Chain Analysis
2.	Strategy Formulation and Choice	1. Strategy formulation 2. Types of strategies 3. Strategic analysis tools and techniques
3.	Strategy implementation and control	1. Strategy implementation and control 2. Entrepreneurial ventures and small businesses

V. Theory

Block 1: **Overview Of Strategic Management**

Unit I: Introduction - Concepts in Strategic Management, Strategic Management Process; Corporate Governance, Social Responsibility and Ethics in strategic management, Environment Scanning and Industry analysis

Block 2: **Strategy Formulation And Choice**

Unit II: Organization appraisal and strategy formulation: organizational dynamics andstructuring organizational appraisal, business models and Value chain analysis, Strategy formulation- corporate level strategies and business strategies, Generic Strategies- Types of Strategies, tools and techniques for strategic analysis.

Unit III: Turnaround and Diversification Strategies: Turnaround strategy - Management ofStrategic Change, Strategies for Mergers, Acquisitions, Takeovers and Joint Ventures - Diversification Strategy

Block 3: **Strategy Implementation And Control**

Unit IV: Strategy implementation and control: aspects, structures, design and change: behavioural implementation-leadership, culture, value and ethics, strategic evaluation and control-an overview and techniques of strategic evaluation and control.

Unit V: Strategic issues in managing technology & innovation, entrepreneurial ventures andsmall businesses, Cases in strategic management

VI. Teaching methods/activities

- Lectures
- Live projects
- Assignments (Individual and Group)
- Presentations about the ethical practices of the firms in India
- News paper analysis about the contemporary issues

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Define the strategic management process and scanning of internal and external environment
- Get a clear picture about value chain analysis
- Understand the different types of strategic choices available and the method of analysis to choose the best among them
- Learn the method of strategic implementation and evaluation for agr entrepreneurial ventures

VIII. Suggested Reading

- Wheelen TL and Hunger JD. 2012. *Strategic Management & Business Policy, towards Global Sustainability*, Pearson India Edn. Thirteenth Edition
- David FR and David FR. 2016. Strategic Management, Concept and Cases, Pearson India Edn, Fifteenth Edition
- Thompson Jr. AA, Peteraf M and Gamble JE. 2015. *Crafting and Executing Strategy*. McGraw Hill, Irwin.
- Stead JG and Stead EW. 2014, *Sustainable Strategic Management*. Routledge Taylor & Francis Group.
- Kazmi Azhar. 2015. Strategic Management. Mcgraw Higher Ed. 4th Edition
- Srinivasan R. 2014. Strategic Management. PHI Learning 5th Edition

I. Course Title : Operations Management

II. Course Code : ABM 537

III. Credit Hours : 2+0

IV. Aim of the course

To acquaint the students with the applications of important operations research techniques for better understanding to solve business problems.

The course is organized as follows:

No	Blocks	Units
1.	Introduction to Linear Programming	1. Formulation of Linear Programming problem 2. Methods of solving linear programming problem 3. Transportation and Assignment problems
2.	Inventory control and waiting line models	1. Types of inventory and inventory costs
3.	Decision making under risk and uncertainty	1. Decision problem 2. Decision trees

V. Theory

Block 1: Introduction to Linear Programming

Unit I: Linear Programming: Objective, Assumptions, Formulation of Linear Programming Problem, Data Envelopment Analysis, Graphic Method, Simplex method, Introduction to Dynamic Programming, Transportation and Assignment Problems.

Block 2: Inventory Control And Waiting Line Models

Unit II: Inventory control Models: Costs Involved in Inventory Management, Types of Inventory, Economic Order Quantity (EOQ) Model, Continuous Review (Q) System, Periodic Review (P) System, and Hybrid System.

Unit III: Waiting Line Models: Waiting Line Problem, Characteristics of a Waiting-Line System, Single- Channel Model, Multiple-Channel Model, Constant-Service Time Model, Finite Population Model, Sequencing and Replacement models.

Block 3: Decisionmaking Under Risk and Uncertainty

Unit IV: Decision making under Risk and uncertainties, Decision problem, Maximax Criterion, Maximin Criterion, Minimax Regret Criterion, Laplace Criterion, Pay off Tables, Decision Trees, Expected Value of perfect Information, stochastic models, neural networks, Markov process.

Unit V: Game Theory - Two -Person Zero-Sum Game, Simulation, Network analysis– PERT& CPM. Financial Engineering

VI. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Knowledge and understanding about the characteristics of different types of decision-making environments and the appropriate decision making approaches and tools to be used in each type.
- Develop cognitive skills (thinking and analysis) to build and solve Transportation Models and Assignment Models

VII. Suggested Reading

- Taha HA. 2007. *Operations Research - An Introduction*. Prentice Hall.
- Vohra ND. 2017. *Quantitative Techniques in Management*. 5th Edition McGraw Hill.
- Wagner HM. 2005. *Principles of Operation Research*. Prentice Hall.

I. Course Title : Financial Management in Agribusiness

II. Course Code : ABM 538

III. Credit Hours : 2+0

IV. Aim of the course

To impart trainings to the students regarding various aspects of sources of financing agribusiness.

The course is organized as follows:

No	Blocks	Units
1.	Financial management in India	1. Agribusiness Financing in India 2. Risk and return concept and analysis 3. Money and Capital Markets 4. International financial management
2.	Capital budgeting	1. Techniques of capital budgeting decision 2. Cost of Capital 3. Sources of Long and Short term finance
3.	Current assets management	1. Management of Working Capital 2. Perspectives and operational aspects of Micro finance

V. Theory

Block 1: Financial Management In India

Unit I: Meaning, importance, nature and scope of financing in India, agribusiness financing inIndia; classification and credit need in changing agriculture scenario; finance functions, investment financing, Risk and return concept & analysis

Unit –II: Business Financing System in India, Money and Capital Markets, Regional and All -India Financial Institutions; venture capital financing and its stages, International financial management.

Block 2: Capital Budgeting

Unit III: Features, types and Techniques of capital budgeting decision. Cost of Capital, Leverage analysis, Capital structure. Theory and Policy, Sources of Long and Short term finance, Dividend Theory, Dividend Policy.

Block 3: Current Assets Management

Unit IV: Management of Working Capital, Management of Receivables, Management of cash; Cash budget, Management of collections and disbursement, Investment of Surplus cash.

Unit V: Perspectives and operational aspects of Micro finance**:** Definition, Scope andimportance of Micro Finance, Evolution of Micro Finance in India, Micro Finance credit lending models: - Association model, Community Banking model, Credit union model, Co-operative model, SHG model, Village Banking model.

VI. Teaching methods/activities

- Lectures
- Live projects
- Assignments (Individual and Group)
- Presentations about the ethical practices of the firms in India
- News paper analysis about the contemporary issues

• VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

– Understand the financial management practices in India

- Know about the concepts capital budgeting and cost of capital
- Understand the major sources of financing in India and their implications for a agri-based organization

VIII. Suggested Reading

- Nelson AG & Murrey WG. 1988. *Agricultural Finance*. Kalyani Publ.
- Gordon and Natarajan. 2016. *Financial Markets and Services*. Himalaya Publishing House; Tenth Edition
- Machiraju HR. 2010. *Indian Financial System*. Vikas Publishing House
- Pandey IM. 2015. *Essentials of Financial Management*, Vikas Publishing House
- Khan and Jain. 2014. *Financial Management*. McGraw Higher Education
- Srivastav and Misra. 2010. *Financial Management*, Oxford University Press; Second edition
- Reddy GS. 2010. Financial Management, Himalaya Publishing House

I. Course Title : Communication for Management and Business

II. Course Code : ABM 539

III. Credit Hours : 3+0

IV. Aim of the course

The course aims to make students proficient in written as well as in oral communication with focus on business related communication.
The course is organized as follows:

No	Blocks	Units
1.	Introduction to Business Communication	1. Communication process, barriers and methods 2. Types of business communication 3. Developing listening skills 4. Non verbal communication
2.	Reading and writing skills	1. Reading Comprehension and techniques 2. Business writing skills 3. Messages for electronic media
3.	Oral and visual communication Technical writing skills	1. Oral presentation skills 2. Public speaking skills
4.	Team and Interpersonal communication	1. Effective Interpersonal Communication 2. Business etiquettes 3. Problem solving skills 4. Case method of learning

V. Theory

Block 1: Introduction to Business Communication

Unit I: Communication process, barriers to communication, methods of communication, effective communication, assertive communication, types of organisational communication. Listening skills, active listening, barriers to effective listening, Non Verbal Communication

Block 2: Reading And Writing Skills

Unit II: Reading comprehension and techniques, rules of good writing, business letter writing, e-mail writing, crafting messages for electronic media, social media, business blogs, podcasts, employment messages

Block 3: Oral, Visual Communication and Technical Writing

Unit III: Visual presentation, oral presentation skills, conducting business meetings, brainstorming sessions and presentations, public speaking skills, Communicating across cultures, Various forms of scientific writings, theses, technical papers, reviews, manuals, research work, various parts of thesis and research communication Title page, authorship, contents, preface, introduction, review of literature, material and methods, experimental results and discussion, Technical Writing Style and Editing, Writing Introductions & Conclusions, Editing and Proof reading, Writing a review article and book summary

Block 4: Team And Interpersonal Communication

Unit IV: Developing interpersonal skills (transactional analysis), Business Etiquettes, essentials of business conversations. Business meeting agenda and minutes, circulars and sales letters, notices, overview of business proposals

Unit V: Developing self awareness (Johari Window), solving problems analytically andcreatively, introduction to case method of learning, case reading, approaches and analysis

VI. Teaching methods/activities

- Interactive sessions to make the participants practice communication skills
- Group and individual presentations followed by feedback
- Live projects to study the challenges faced in the organsiational communication setup
- Make the participants practice communicating on social media platforms to write blogs, make and upload videos
- Self awareness assessment based questionnaires
- Case studies to develop interest and understanding of solving real life situation analytically and creatively

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the concepts of business communication
- Practice listening, reading writing and presentation skills
- Develop clarity about the method of handling team and interpersonal communication effectively

VIII. Suggested Reading

- Cardon PW. 2015. *Business Communication, Developing leaders for a networkedworld* Mc Graw Hill Edication
- Chaturvedi PD and Chaturvedi M. 2017. *Business Communication, Skills, Concepts, Cases and Applications*, Pearson India Education
- Bovee CL, Thill JV and Chaterjee A. 2013. *Business Communication Today*, Pearson Education, Tenth Edition

I. Course Title : Research Methodology for Agri Business Management

II. Course Code : ABM 540

III. Credit Hours : 3+0

IV. Aim of the course

To develop an understanding of research methodology related to efficient agri business management

The course is organized as follows:

No	Blocks	Units
1.	Overview of research	1. Research methodology in management 2. Scales of measurement 3. Questionnaire designing
2.	Use of softwares for statistical analysis	1. Multivariate statistical analysis 2. Evaluation metrices 3. Forecasting Techniques
3.	Data science in agriculture	1. Introduction to data science in agriculture 2. Overview of deep learning and machine learning 3. Concept of cloud machine learning

V. Theory

Block 1: Overview of Research

Unit I: Meaning, Course Objective, types, and process of research; research methodology inmanagement- exploratory, descriptive, experimental, diagnostic, Problem formulation, setting of Course Objective, formulation of hypotheses, models, types of models, process of modeling.

Unit II: Scales of measurement - nominal, ordinal, interval, ratio, Likert scale and other scales; Primary and secondary data, sources of data, Questionnaire Designing, instruments of data collection, data editing, classification, coding, validation, tabulation, presentation, analysis, development process of scale, identification of variables, variable measurement, variable standardization and dummy variables.

Block 2: Use of Softwares for Statistical Analysis

Unit III: introduction to multivariate statistical analysis techniques, Multivariate linearregression models, principal component analysis, linear discriminant analysis, factor analysis, evaluation matrices and model diagnostics for regression models.

Unit IV: Logistic regression, decision trees, cluster analysis, random forest, GARCH, CARTmodels, support vector machines, Forecasting techniques (AR, MA, ARMA and ARIMA models)

Block 3: Introduction to Data Science

Unit V: Definition, scope and importance, machine learning, types of machine learning, linearand nonlinear models in machine learning, introduction to deep learning, basic differences in machine learning and deep learning, concept of cloud machine learning, Big data analysis.

VI. Teaching methods/activities

- Interactive lectures
- Group assignments
- Presentations
- Live projects for marketing research problems

- Case study on application of marketing research tools

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand research methodology concepts along with its application in marketing research
- Develop insights about the statistical analysis tools and techniques for better research outcomes
- Understand the concept of and usage of data science, big data analysis for agriculture

VIII. Suggested Reading

- Cooper DR and Schindler PS. 2006. *Marketing Research Concepts and Cases*. TMH
- Kumar R. 2014. *Research Methodology,* Sage publications, 4th Edition
- Glenn JC. 2010. *Hand book of Research Methods.* OXFORD.
- Kothari CR. 2018. *Research Methodology- Methods and Techniques*. New Age International Publishers; Fourth edition

I. Course Title : Computer Applications for Agri Business

II. Course Code : ABM 541

III. Credit Hours : 3+0

IV. Aim of the course

The course aims to instill the significance of computer applications in the organizations and handling recent trends in information technology and system for improved decision making

The course is organized as follows:

No	Blocks	Units
1.	Basics of computers	1. Concept of computers 2. System and application softwares 3. Data base management system
2.	Business value of internet	1. Cloud computing 2. Cyber security and ethical challenges
3.	Management Information System	1. Concept of MIS 2. Introduction to Artificial Intelligence 3. E-commerce agri business trends

V. Theory

Block 1: Basics Of Computers

Unit I: Concept of Computers- Brief History of Computers, Generation and Its Evolution, Characteristics of Computers, Main Areas of Computers and their Applications; Classification of Computers, Input-Output Devices, Memory Types (Cache, RAM, ROM), Memory Units,

Unit-II: System Software and Application Software, Open source software, introduction tocomputer languages, Introduction to Operating Systems – Functions, Features and Types., MS Windows and LINUX. Data Base Management System, MS Office (MS Word, MS Power Point, MS Excel, MS-Access and use of various management software Like SPSS, SAS etc.

Block 2: Business Value Of Internet

Unit III: The business value of internet, Intranet, extranet and Internet, Introduction to Web page design using HTML, Cloud Computing, Security and ethical challenges: Computer crime – Hacking, cyber theft, unauthorized use at work. Piracy – software and intellectual property. Health and Social Issues, Ergonomics and cyber terrorism.

Block 3: Management Information System

Unit IV: The concept of MIS–Definition, importance, Course Objective, pre-requisites, advantages and challenges; Information Needs of organization, MIS and Decision – Making. Types/Classification of Information System for organizations; Introduction to Artificial Intellignce (AI), Neural Networks, Fuzzy logical control systems.

Unit V: e-business/ e-commerce: e-business models, e-commerce processes, electronic paymentsystems, e-commerce trends with special reference to agri business. Applications of MIS in the areas of Human Resource Management, Financial Management, Production/Operations Management, Materials Management, Marketing Management.

VI. Teaching methods/activities

- Lectures

- Practicals
- Live project
- Assignments
- Presentations

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the fundamentals of computers
- Get a clearer idea about the application of Information technology in agri business management
- Use of e commerce, artificial intelligence and MIS for improved decision making in management

VIII. Suggested Reading

- Laudon KC and Laudon JP. 2016. *Management Information Systems- Managingthe digital Firm*, 14h Edition, Pearson India
- Turban, Volonino, Woods. Wali OP. 2015. *Information Technology for Management, Advancing Sustainable, Profitable Business Growth*, Wiley
- Jaiswal M and Mittal M. 2005. Management Information System, Oxford.

I. Course Title : Project Management and Agribusiness Entrepreneurship

II. Course Code : ABM 542

III. Credit Hours : 2+1

IV. Why this course?

This course aims at providing student an insight into the nature of small scale

industry. They will be exposed to various aspects of establishment and management of a small business unit.

The course is organized as follows:

No	Blocks	Units
1.	Concept of Project Management	1. Introduction to project management 2. Project feasibility 3. Network methods and project scheduling
2.	Introduction to Agri Entrepreneurship	1. Concept of agri entrepreneurship 2. Creativity, Innovation and Agro Entrepreneur
3.	Support System for Agri Entreprenuership	1. Sources of Financing for entrepreneurs 2. Preparation of Detail Project Report 3. Structure and Government Policy Support

V. Theory

Block 1: Concept of Project Management

Unit I: Concept, characteristics of projects, types of projects, project identification, and Project's life cycle. Project feasibility- market feasibility, technical feasibility, financial feasibility, and economic feasibility, social cost-benefit analysis, project risk analysis.

Unit II: Network Methods: Meaning, Network Analysis, Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT), Project scheduling and resource allocation. Financial appraisal/evaluation techniques- discounted/non-discounted cash flows; Net present values, profitability index, Internal rate of returns; Cost benefits ratio; Accounting rate of return, Payback period, Project implementation; Cost overrun, Project control and information system.

Block 2: Introduction to Agri Entrepreneurship

Unit III: Concept of Agri Entrepreneurship**:** Objective, Introduction to agri entrepreneurship, Entrepreneurial Development Models, Successful Models in Agro Entrepreneurship Intrapreneur, Development of women entrepreneurship with reference to SHGs, Social entrepreneurship

Unit IV: Creativity, Innovation and Agro Entrepreneur: Inventions and Innovation, The Environment and Process of Creativity, Creativity and the Entrepreneur, Innovative Approaches to Agro Entrepreneurship, Business Incubation, Steps and Procedure to start a new business, Business Opportunities in different field of Agriculture and Allied Sectors.

Block 3: Support System For Agri Entreprenuership

Unit V: Sources of Financing, Structure and Government Policy Support: Estimating FinancialRequirements, Preparation of Detail Project Report, Project Appraisal, Sources of Long-Term Financing, Working Capital Financing, Venture Capitalist, Finance from Banking Institutions, Industrial Policy Resolutions in India, Incentives and Subsidies, Schemes for Incentives, Government Organisations like SIDO, DIC, KVIC, NSIC, SIDBI, NABARD and their role, Sick Industries and their Up gradation policy measures

VI. Teaching methods/activities

- Interactive lectures

- Live project in association with innovative farmers/ agri entrepreneur
- Cases related to agri entrepreneurship
- Guest lectures by bankers, entrepreneurs, academicians and venture capitalist firms
- Assignments
- Presentations of Agri Business Plans

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

– Understand the fundamentals of project management
– Develop a understanding of agri entrepreneurship opportunities and challenges
– Understand the method of developing a agri based venture through the support system available in the Indian scenario

VIII. Suggested Reading

- Arora R and Sood SK. *Fundamentals of Entrepreneurship and Small BusinessManagement.* Kalyani Publishers, Ludhiana.
- Desai V. 2016. *Business Planning and Entrepreneurial Management,* Himalaya Publishing House, Mumbai.
- Ramachandaran K. *Managing a New Business Successfully*. Global Business Press, New Delhi.
- Shukla MB. *Entrepreneurship and Small Business Management*. Kitab Mahal, New Delhi.
- Dandekar VM and Sharma VK. 2016. *Agri-Business and EntrepreneurshipDevelopment.* Manglam Publications, New Delhi.
- Zimmerer TW, Scarborough NM. *Essentials of Entrepreneurship and small Business Management,* 5thEdition, PHI Learning Pvt Ltd
- Panigrahi SR and Singh B. 2017. *Agro Entrepreneurship.* Scientific Publishers(India)

I. Course Title : Agribusiness Environment and Policy

II. Course Code : ABM 543

III. Credit Hours : 2+0

IV. Aim of the Course

To expose the students to the environment in which the agri-business is conducted. The course is organized as follows:

No	Blocks	Units
1.	Agribusiness in India	1. Agri business environment in India 2. Major sub sectors of agri business in India
2.	Economic reforms affecting agri-business	1. Policies and regulations affecting agri business in India 2. WTO Agreement on Agriculture and its compliances
3.	Emerging trends in agri Business	1. Reforms in agri output markets 2. International trade in agri business 3. Food safety and quality management

V. Theory

Block 1: Agribusiness in India

Unit I: Role of agriculture in Indian economy; Problems of agriculture in India;

Agribusiness–definition and nature, Structure of Agriculture and linkages among sub-sectors of the agribusiness.

Block 2: **Economic Reforms Affecting Agri Business**

Unit II: Economic reforms: liberalization, privatization and globalization specifically affectingAgri Business; WTO Agreement on Agriculture and its compliances; changes in policies and regulations related to the sub sectors of agribusiness and its impact on agribusiness in India.

Block 3: Emerging Trends in Agri Business

Unit III: Emerging trends in farm supplies, farm production, agricultural finance, agroprocessing, international trade etc.; reforms in agri output markets: private markets, contract farming, futures trading in agri commodities and e-NAM, etc. Pricing of agricultural outputs, public distribution system, imports and exports.
Unit IV: Importance of food safety and quality management in agri business; Environmentalissues and including carbon markets and Clean Development Management etc.
Unit V: Other major issues: Intellectual property rights, importance of cooperative or collectiveactions in present scenario with examples of mergers and acquisitions, Farmers Producer Organisations, etc.

VI. Teaching methods/activities

- Lectures
- Role plays
- Case studies as group assignment
- Presentations
- Assignments
- Live projects

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:
- Develop an understanding about the role and problems agriculture and agri business is playing in the Indian economy
- Critically evaluate the major economic reforms that have directly or indirectly affected agri business in India
- Understand the emerging trends and challenges in the field of agri business

VIII. Suggested Reading

- Barnard FL, Akridge JT, Dooley FL, Foltz JC and Yeager EA. 2012. *Agribusiness Management*, Routledge, 4th Edition
- Aswathappa K. 2014. *Essentials of Business Environment*. Himalaya Publ.
- Francis Cherunilam 2003. *Business Environment*. Himalaya Publ.
- Kodekodi GK and Viswanathan B. 2009. *Agril. Development, Rural Institution & Economic Policy*, Oxford.

I. Course Title : Agri Business Laws and Ethics

II. Course Code : ABM 544

III. Credit Hours : 2+0

IV. Aim of the course

The objective of this course is to expose the learner to various ethical issues and laws affecting business. Focus will be on understanding provisions of various

business laws with reference to agriculture and also ethical practices to conduct the business properly.

The course is organized as follows:

No	Blocks	Units
1	Indian Legal System	1. Indian Contract Act 3. Companies Act
2.	Regulatory environment for agri-business	1. Essential Commodities Act 2. Consumer Protection Act
3.	Business ethics	1. Ethics in agri business functional areas 2. Governance mechanism

V. Theory

Block 1: Indian Legal System

Unit I: Introduction to Indian legal system, The Indian Contract Act-1872: Contract meaning, types of contract, essentials of a valid contract, offer and acceptance, capacity to contract, free consent, performance of contract.

Unit-II: Law of Negotiable Instruments: Promissory Notes, Bills of Exchange, Cheques and Bank Drafts, Endorsements, Law of Sale of Goods, Sales of Goods Act-1930-: Sale and agreement to sale, types of goods, Transfer of property in goods, mode of delivery of goods, performance of contract of sales, rights of an unpaid seller.

Unit III: Companies Act-1956: incorporation, commencement of business, types of companies, management of company, Memorandum of Association and Articles of Association, prospectus, winding of companies.

Block 2: Regulatory Environment For Agri Business

Unit IV: Essential Commodities Act, Consumer Protection Act, RTI Act, MRTP Act- majorprovisions and implications. Competition Act-2002, Regulatory environment for International Business

Block 3: Business Ethics

Unit V: Nature and importance of ethics and moral standards; corporations and socialresponsibilities, scope and purpose of business ethics; Ethics in business functional areas; industrial espionage; solving ethical problems; governance mechanism. implementing business ethics in a global economy

VI. Teaching methods/activities

- Lectures
- Live projects
- Assignments (Individual and Group)
- Presentations about the ethical practices of the firms in India
- News paper analysis about the contemporary issues

VII. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Learn about the Indian legal system that directly affects the agri business in India
- Know about the regulatory framework in which the agri business is to be conducted and managed
- Understand the importance of practicing business ethics

VIII. Suggested Reading

- Mathur SB. 2010. *Business Law*. Tata McGraw Hill Edn. Pvt Ltd.
- Gulshan SS and Kapoor GK. 2003. *Business Law including Company Law*. 10th Ed. New Age Publ.
- Kapoor ND. 2005. *Business Law*. S. Chand & Sons.
- Tuteja SK. 2005. *Business Law for Managers*. S. Chand & Sons.
- Tulsian PC and Tulsian B. 2015. *Business Law*. TMH, New Delhi.
- Singh Avtar. 2017. *Contract and Specific Relief*, Eastern Book Company; Twelfth edition
- Pathak A. 2015. *Legal Aspects of Business.* McGraw Hill Education. 6th Edition

Course Title with Credit Load
Ph.D. in Agri-Business Management

Course Code	Course Title	Credit Hours
	Major Courses	**12**
ABM 601	Econometrics for Agri Business	3 (2+1)
ABM 602	Research Methods I	3 (2+1)
ABM 603	Agri Input & Output Marketing	3 (2+1)
ABM 604	Research Methods II	3 (2+1)
	Minor Courses	**6**
ABM 605	Natural Resource Management	2+0
ABM 606	Knowledge Management	2+0
ABM 607	Value Chain Management in Agribusiness	2+0
	Supporting Courses	**5**
ABM 608	Agri-Entrepreneurship and Corporate Governance	1+0
ABM 609	International Food and Agri Business	2+0
ABM 610	Communication for Management Teachers	0+2
	Seminars	**2**
	Doctoral Seminar I	1(1+0)
	Doctoral Seminar II	1(1+0)
	Research	**75**
	Total	**100**

Course Contents
Ph.D. in Agri-Business Management

I. Course Title : Econometrics for Agri-Business

II. Course Code : ABM 601

III. Credit Hours : 2+1

IV. Aim of the course

The course is mainly designed to solid data base analysis of market and policy variables to back up their business strategies. The emphasis will be given on application rather than theoretical details.

The course is organized as follows:

No	Blocks	Units
1.	Formulation and specification of econometric models	1. Simple Regression Analysis 2. Properties of Regression Coefficients and Hypothesis Testing 3. Multiple Regression Analysis 4. Heteroscedasticity 5. Stochastic Regressors and Measurement Errors 6. Simultaneous Equations Estimation
2.	Estimation and testing of models	1. Modelling Dynamic Processes 2. Autocorrelation 3. Logit and Probit (binary choice models)

V. Theory

1. Introduction: Correlation theory, Basic concept of regression analysis, assumptions of regression model, theory of OLS, properties of least square estimates, maximum likelihood, hypothesis testing, interval estimation, prediction in linear regression model.
2. Heteroskedasticity and autocorrelation, multicollinearity, specification errors, selection of regressors, dummy variables, autoregressive and distributed models.
3. Set of regression equations, casuality and simultaneity: application.
4. Time series econometrics- stationarity, unit roots and co-integrassion, error-correction model, AR, MA, ARMA, ARIMA processes.
5. Qualitative dependent variables – LPM, Logit and probit models.

VI. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Acquire the basic knowledge of econometrics
- Learn the basics of econometric models and testing its application in the agri business environment

VII. Suggested Reading

- Gujarati, Damodar, *Basic Econometrics*, McGraw-Hill Company
- James H. Stock and Mark W. Watson: *Introduction to Econometrics*, Pearson Education

I. Course Title : Research Methods-I

II. Course Code : ABM 602

III. Credit Hours : 2+1

IV. Aim of the course

The objective of the course is to enable research scholars in developing the knowledge and skills required to specify, evaluate and utilise different types of unstructured and semi-unstructured information. They are required to develop competence in problem formulation, hypothesis generation and method of carrying scientific research in situations where research work plays a critical role. The course is practical in nature and students are expected to learn by doing live projects and studying the latest researches in different fields related to agri business.

The course is organized as follows:

No	Blocks	Units
1.	Overview of Research Methodology	1. Research process 2. Problems and Hypotheses 3. Processing and analysis of data
2.	Introduction to business analytics	1. Types of Business Analytics 2. Introduction to predictive modelling/analytic

V. Theory

Block 1: Overview of Research Methodology

Unit 1: Translating problems to research issues: Selection of qualitative vs quantitative research definitions, objectives, research methodologies rationale, sample/sources of data, data collection techniques, Questionnaire designing: use of measurement and scaling techniques, reliability testing.

Unit 2: Fieldwork: Data collection, gaining access and entry, ethical considerations, identifying key informants, validation and evaluation of fieldwork, data preparation, field notes and recording

Unit 3: Hypothesis Development and Theoretical Modelling. Business Analytics, Business Intelligence,

Block 2: Introduction To Business Analytics

Unit 4: Types of Business Analytics, Introduction to predictive modelling/analytics. Linear programming, Contemporary applications of marketing research

VI. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Learn about the basics of research methodology
- Understand the application of research for problem solving related to agri business environment

I. Course Title : Agri Input and Output Marketing

II. Course Code : ABM-603

III. Credit Hours : 2+1

IV. Aim of the course

Agricultural Input & Output marketing is a dynamic and competitive field where lot is to be done looking to the gap in technology existing and possible. Changes are taking place in manifolds ranging from farming practices to trading in domestic and international markets. Presence of private players, infrastructure development, impact on prices, concept of e mandietc are becoming more important to understand in current scenario. Scholars will also study the researches and articles to understand interesting changes going on in this field.

The course is organized as follows:

No	Blocks	Units
1.	Introduction to agri input and out marketing environment	1. Current status of agri input and output markets in India 2. Marketing mix for agri inout and output marketing
2.	Evaluation of marketing costs and efficiencies	1. Assessment of different cost components 2. Case studies on various marketing strategies adopted by national and global players

V. Theory

Block 1: Introduction to Agri Input and Out Marketing Environment

Unit 1: Agriculture input and output marketing environment-Current status, trends, market structure, infrastructure, competition, Government intervention in agricultural inputs and outputs marketing

Unit 2: Buyers/users behavior, Market Segmentation, Product and Pricing, Promotion and advancement in promotional strategies, Marketing Channels for different agri inputs and outputs

Block 2: Evaluation of Marketing Costs and Efficiencies

Unit 3: Evaluation of marketing costs and efficiencies, WTO and Indian Agriculture, Case Studies- Competitive marketing strategies and advancements in agricultural marketing, International agri marketing practices

VI. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Develop a understanding about the existing practices of agri input and output marketing in India
- Acquire a deep learning about assessing the marketing cost and related efficiencies to make the agricultural marketing profitable

I. Course Title : Research Method-II

II. Course Code : ABM 604

III. Credit Hours : 2+1

IV. Aim of the course

Once the students are equipped with the information required for interpretive research,

RM II will train the students with advanced analytical tools and their uses. The course is organized as follows:

No	Blocks	Units
1.	Hypothesis testing	1. Analysis of variance and covariance 2. Multidimensional scaling and conjoint analysis
2.	Data Mining, Data Mining Methods	1. Data Mining Methods 2. Business Process Discovery
3.	Applications of Statistical Softwares	1. Modelling with statistical softwares, Report preparation and presentation

V. Theory

Block 1: Hypothesis Testing

Unit 1: Hypothesis testing, Analysis of variance and covariance, Correlation and regression, Discriminant and Logit analysis, Factor analysis, Cluster analysis, Multidimensional scaling and conjoint analysis.

Block 2: Data Mining

Unit 2: Data Mining, Data Mining Methods—Data Dredging, Data Fishing, Data Snooping and Process Mining—Business Process Discovery, Conformance Checking and Model Enhancement. Arena Modelling.

Block 3: Applications of Statistical Software

Unit 3: Applications of Statistical Softwares like SAS, Modelling with statistical softwares. Report preparation and presentation, International Marketing Research.

VI. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the concepts of hypothesis testing
- Learn the application of statistical analysis softwares by hands on experience in agri business problem solving methods

VII. Suggested Reading

- Cohen L, Lawrence M and Morrison K. 2005. *Research Methods in Education* (5th edition). Oxford: Oxford University Press.
- Denscombes M. 2010. *The Good Research Guide: For small-scale social research projects*. Maiden-Read: Open University Press.
- Dornyei Z. 2007. *Research Methods in Applied Linguistics*. Oxford: Oxford University Press.
- Kothari CR. 1980. *Research Methodology: Research and Techniques*, New Delhi: New Age International Publishers.
- Kumar R. 2011. *Research Methodology: a step-by-step guide for beginners* (3rd edition).
- Singh YK. 2006. *Fundamental of Research Methodology and Statistics*. New International (P) Limited, Publishers, New Delhi.

I. Course Title : Natural Resource Management

II. Course Code : ABM 605

III. Credit Hours : 2+0

IV. Aim of the course

The course on Natural Resource Management will provide indepth knowledge to

the participants to look for ways to make responsible natural resource management decisions which will have an impact on all stakeholders.
The course is organized as follows:

No	Blocks	Units
1.	Introduction to natural resources	1. Types and classification of natural resource 2. Economic resource theory and applications
2.	Overview of Natural Resource Management	1. NRM sectors product marketing and their roles 2. Concept of environmental services 3. Ecotourism Policy and practices

V. Theory

Block 1: Introduction To Natural Resources

Unit-I Natural resources: Types and classification of natural resource, concept of Economic value, relevance of environmental economics, ecosystems services, direct and indirect economic benefit from – forest ecosystems, mountain ecosystems, mineral and water resources, ecotourism. Valuation and accounting: Supply and demand, conservation and management, cost/ benefit analysis, methods of costing, cost criteria, evaluating alternative projects, operational vs. total costs, determining benefiting vs. comprehensive stakeholders Application of resource accounting Methods of pricing resources- example forest and mineral resources.

Unit-II Economic resource theory and applications: Concept of CPR, open access, Ecological economics-methodology, economic valuation of non market benefits, environmental accounting, population resources and the environment, command and control vs. emission trading, emission trading vs. exposure trading, hotelling principle, future strategies for mineral resources.

Block 2: Overview of Natural Resource Management

Unit-III Natural Resource Management: Initial concept of market and marketing, NRM sectors product marketing and their roles, promoting NRM products- NTFPs, livestock, watershed, fisheries, agriculture and medicinal plants and ecotourism, Role of national and international organizations in the promotion of sustainable natural resource use and management.

Unit IV: Concept of environmental services: Definitions, ecotourism, alternative examples, development of ecotourism in India and outside. Threats due to large scale ecotourism. Payment for Ecosystem Services, the ecotourism dilemmas: High value may also be high impact, bulk ecotourism and problems, stakeholder challenges, tourist carrying capacity. Ecotourism Policy and practices, national policy frame work, example – Madhya Pradesh & Uttarakhand State case. Successful ecotourism initiative, Criteria and Indicators for sustainable Ecotourism.

VI. Suggested Reading

- Barber E. 1989. *Economics: Natural Resources Scarcity and Development*. Earthscan.
- Harris JM. 2006. *Environmental and Natural Resource Economics: A Contemporary Approach*, 2nd edition. Houghton Mifflin
- Field Barry C. 2008. *Natural Resource Economics: An Introduction*. Waveland Press.
- Honey Martha. 2008. Ecotourism and Sustainable Development: Who Owns Paradise? 2 nd edition. Island Press. 2. Seema Bhat & Syed Liyakhat 2008. Ecotourism Development in India: Communities, Capital and Conservation published by CEE, Ahmedabad

I. Course Title : Knowledge Management

II. Course Code : ABM 606

III. Credit Hours : 2+0

IV. Aim of the course

The objective of the course is to provide the basics of the emerging area of Knowledge Management to students. This course throws light on few important concepts as Knowledge management and Information Technology, Knowledge process, etc.

The course is organized as follows:

No	Blocks	Units
1.	Introduction to knowledge management	1. The Knowledge Economy 2. Knowledge Management and Information Technology
2.	Future of Knowledge Management and Industry perspective	1. Knowledge process 2. Implementation of Knowledge Management:

V. Theory

Block 1: Introduction to Knowledge Management

Unit 1: The Knowledge Economy: Leveraging Knowledge, Data-Information-knowledge-Wisdom relationship, organizational knowledge, characteristics and components of organizational knowledge –Building knowledge societies- Measures for meeting the challenges of implementing, KM programmes.

Unit 2: Knowledge Management and Information Technology: Role Information Technology in Knowledge Management Systems, Knowledge Management tools, Creative effective Knowledge Management Systems through Information Technology, ERP and BPR, Data Warehousing and Data Mining.

Block 2: Future of Knowledge Management and Industry Perspective

Unit 3: Future of Knowledge Management and Industry perspective: Companies on the road to knowledge management, Knowledge Management in Manufacturing and service industry, challenges and future of Knowledge Management.

Unit 4: The Knowledge Process: Universal appeal, Stages of KM Process, Knowledge Capital vs physical capital, Customer Relationship Management, Business Ethics And KM, The Promise of Internet and the Imperatives of the new age.

Unit 5: Implementation of Knowledge Management: Discussion on Roadblocks to success, Business Intelligence and Internet platforms, web Portals, Information Architecture: A three-way Balancing Act, KM, the Indian experience, Net Banking in India. –Role of knowledge Management in Organisational Restructuring. -The Mystique of a Learning Organisation.

VI. Suggested Reading

- Mattison: *Web Warehousing and Knowledge Management*, Tata McGraw-Hill,2009
- Becerra Fernandez: *Knowledge management: An Evolutionary view*, PHI, 2009
- Fernando: *Knowledge Management*, Pearson, 2009
- B. Rathan Reddy: *Knowledge management*, Himalaya, 2009
- Tapan K Panda: *Knowledge Management*, Excel, 2009.
- Barnes: *Knowledge Management systems*, Cengage, 2009.

- Tiwana: *The Knowledge Management tool kit*, 2/e, Pearson Education, 2009.
- Warier: *Knowledge Management*, Vikas Publishing House, 2009
- Sislop: *Knowledge Management*, Oxford University Press, New Delhi, 2009
- Debowski: *Knowledge Management*, Wiley Student Edition, Wiley India, 2007

I. Course Title : Value-Chain Management in Agribusiness

II. Course Code : ABM 607

III. Credit Hours : 2+0

IV. Aim of the course

To recognize the characteristics of Global Food Systems, the multiple variables impacting Global Food Systems, to identify value chain thinking and how it differs from supply chain thinking, the characteristics of agri-food markets, what influences their supply and demand, and what sets them apart from other markets, the role played by external factors such as population and income growth, globalization, climate change, technology, and international tradein global food systems, agribusiness and value chains, to recognize the role the consumer plays in the food system, markets, and value chains

V. Theory

Unit 1: Global Food Systems and Value-Chains

Characteristics of global food systems; identify the variables impacting global food systems; identify value chain thinking and how it differs from supply chain thinking; identify the role that external factors (for example, population and income growth, globalisation, climate change, technology and international trade) play on global food systems, agribusiness and value chains; and identify the actors in, and characteristics of, value chains, demonstrated with the building of a value chain model.

Unit 2: Agribusiness Market Dynamics

Characteristics of agri-food markets, what influences their supply and demand, and what sets them apart from other markets; identify the role that external factors, such as population and income growth, globalisation, climate change, technology and international trade, play on agri-food markets; interpret the key elements of supply and demand; andrecognise the basic characteristics of supply and demand curves.

Unit 3: The Role of the Consumer

Role the consumer plays in the food system, markets and value chains; recognise the consumer characteristics, trends and behaviours that influence value chains; and recognise some of the techniques used in market and consumer researchto better understand consumer behaviour.

VI. Suggested Reading

- Acharya SS and Agarwal NL. 2011. *Agricultural marketing in India*. Oxford and IBH.
- Altekar RV. 2006. *Supply Chain Management: Concepts and Cases*. PHI
- Chopra S, Meindl P and Kalra DV. 2016. *Supply chain management: Strategy, Planning, and Operation*, Pearson Education India
- Mohanty RP. 2010. *Indian Case studies in Supply Chain Management and other Learning Resources*. Oxford.
- Chandrasekaran N. 2010. *Supply Chain Management: Process, system and Practice*. Oxford.

• Singh Sukhpal. *Organic Produce Supply Chains in India-organisation and governance.* Allied Publ.

I. Course Title : Agri Entrepreneurship and Corporate Governance

II. Course Code : ABM 608

III. Credit Hours : 1+0

IV. Aim of the course

The course aims to make students understand the nature of ntrepreneurship, and acquaint the students with challenges of starting new ventures and enable then to investigate, understand and internalize the process of setting up a business. Objective is also to enlighten them with the importance of Corporate Good Governance and Business Ethics.

The course is organized as follows:

No	Blocks	Units
1.	Agri Entrepreneurship and Feasibility Studies	1. Nature of Entrepreneurship 2. Starting the venture 3. Functional plans and Sources of finance
2.	Introduction to Business Ethics and Corporate Governance	1. Business Ethics 2. Corporate Governance

V. Theory

Block 1: Agri Entrepreneurship And Feasibility Studies

Unit I: Nature of Entrepreneurship: Concept, knowledge, skills requirement and functions; characteristic of successful entrepreneurs; ; scenario in India and Abroad, entrepreneurship process; factors impacting emergence of entrepreneurship; managerial vs. entrepreneurial approach and emergence of entrepreneurship, Risk Reduction strategies

Unit 2: Starting the venture: generating business idea – sources of new ideas, methods of generating ideas, SWOT Analysis, environmental scanning, competitor and industry analysis; feasibility study – market feasibility, technical/operational feasibility, financial feasibility; drawing business plan; preparing project report; presenting business plan to investors.

Unit 3: Functional plans: marketing plan – marketing research for the new venture, steps in preparing marketing plan, contingency planning; organizational plan – form of ownership, designing organization structure, job design, manpower planning; Financial plan – cash budget, working capital, proforma income statement, proforma cash flow, proforma balance sheet, break even analysis.

Unit 4: Sources of finance: debt or equity financing, commercial banks, venture capital; financial institutions supporting entrepreneurs, Government Grants and Subsidies, Entrepreneurship Promotion Schemes of Department of Industries (DIC), KVIC, SIDBI, NABARD, NSIC, APSFC, IFCI and IDBI etc.; legal issues – intellectual property rights patents, trademarks, copy rights, trade secrets, licensing; franching.

Block 2: Introduction To Business Ethics And Corporate Governance

Unit 5: Necessity for Business Ethics- Salient Issues in Ethics and Commerce-

Shadow Economy – Basic Principles in Ethics –Corporate Climate and corporate climate audits – Political Issues – Nature and theory of Ethics, Corporate Governance- Historical perspective and issues of Corporate Governance –Corporate Governance mechanisms – Corporate Governance Models, – The confederation of Indian Industry's initiative.; Corporate Social Responsibility

VI. Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the concept of agripreneurship and its application for starting a new venture
- Learn the basics of making functional plans like marketing, production and financial
- Acquire the knowledge about business ethics and corporate governance

VII. Suggested Reading

- Robert Hisrich Michael Peters Dean Shepherd Entrepreneurship 10th Ed 2016 by McGraw-Hill Education
- Vasanth Desai: *Entrepreneurship*, HPH, 2011.
- David Martin: *Corporate Governance*, Viva, 2010.
- Nandan H: *Fundamentals of Entrepreneurship*, PHI, 2013.
- Barringer: *Entrepreneurship*, Pearson, 2015.
- RK Mishra, Gitarani: *Corporate Governance*, Excel, 2012.
- V. Balachandran and V. Chandrasekaran: *Corporate Governance & Social Responsibility*, PHI, 2009.
- A.C. Fernando: *Business Ethics*, Pearson, 2009.
- Laura P Hartman and Abha Chatterjee: *Business Ethics*, TMH, 2009.
- Tripat Kaur: *Values and Ethics in Management*, 2/e, Paragon International, 2009.

I. Course Title : International Food and Agri Business

II. Course Code : ABM 609

III. Credit Hours : 2+0

IV. Aim of the course

The objective of the paper is to acquaint the students with the fundamentals of international business, its environment and complexities. The paper provides exposure to multiple dimensions of the field and imparts international perspective to business decisions.

The course is organized as follows:

No	Blocks	Units
1	Global trends in International trade	1. Structure of IB environment 2. Global financial system,
2	Global manufacturing and material management	1. International product life cycle, product and branding decisions; 2. Export assistance and incentives in India 3. Harmonizing accounting difference across countries 4. Ethical dilemmas and social responsibility issues

V. Theory

Block 1: Global Trends In International Trade

Unit I: Global trends in international trade and finance; dimensions and modes of IB; structure of IB environment; risk in IB; organizational structure for IB; world trading system and impact of WTO; exchange rate systems; global financial system; barriers to IB; international business information and communication.

Unit II: Foreign market entry strategies; country evaluation and selection; factors affecting foreign investment decisions; impact of FDI on home and host countries; types and motives for foreign collaboration; control mechanisms in IB.

Block 2: Global Manufacturing and Material Management

Unit I: Decisions concerning global manufacturing and material management; outsourcing factors; managing global supply chain; International product life cycle, product and branding decisions; managing distribution channels; international promotion mix and pricing decisions; counter trade practices; mechanism of international trade transactions. EXIM policy of India. Export costing and pricing, Export procedures and export documentation. Export assistance and incentives in India.

Unit II: Harmonizing accounting difference across countries; currency translation methods for consolidating financial statements; the LESSARD-LORANGE Model; cross cultural challenges in IB; international staffing decisions; compensation and performance appraisal of expatriate staff; ethical dilemmas and social responsibility issues.

I. Course Title : Communication for Management Teachers

II. Course Code : ABM 610

III. Credit Hours : 0+2

IV. Aim of the course

Communication in management education is not limited to classroom teaching. There are lot of innovative techniques to make teaching and learning interesting, practical and effective. There are various researches are done for methodological and effectiveness aspects. This course will be dealt understanding all the methods of communication for management teaching in learning by doing method and presenting the various researches done in this field.

The course is organized as follows:

No	Blocks	Units
1.	Management education	1. Action gaps in education and latest developments and required skills
2.	Theory and techniques of communication in management	1. Active listening, group communication 2. Emotional perspective in teaching 3. Learning in management education
3.	Case teaching and writing	1. Writing a case and teaching note, Critiquing a research article

VI. Theory

Block 1: Management Education

Unit 1: Management education: Action gaps in education and latest developments and required skills

Block 2: Theory and Techniques of Communication in Management

Unit 1: Communication: Active listening, group communication, Language process Presentation on readings- recorded and graded: Oral presentation & computer assisted presentations

Unit 2: Theory and techniques: Didacticism, Group work & discussion method, Simulation, facilitation skills and styles for experiential learning. Emotional perspective in teaching

Unit 3: Learning in management education: Experiential learning, Action Learning, Group learning, Simulation and games, Role Play, Teaching and learning through Electronic Media

Block 3: Case Teaching and Writing

Unit 1: Case method of teaching: Writing a case and teaching note, Critiquing a research article

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Basic Sciences
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Course Title with Credit Load
M.Sc. (Ag) in Biochemistry

Code Code	Course Title	Credit Hours
BIOCHEM 501*	Basic Biochemistry	3+1
BIOCHEM 502*	Intermediary Metabolism	3+0
BIOCHEM 503*	Enzymology	2+1
BIOCHEM 504	Molecular Biology	2+1
BIOCHEM 505*	Techniques In Biochemistry	2+2
BIOCHEM 506	Immuno Chemistry	2+1
BIOCHEM 507	Plant Biochemistry	2+1
BIOCHEM 508	Animal Biochemistry	3+0
BIOCHEM 509	Nutritional Biochemistry	2+1
BIOCHEM 510	Nitrogen And Sulphur Metabolism	2+1
BIOCHEM 511	Biochemistry On Xenobiotics	2+0
BIOCHEM 591	Master's Seminar	1+0
BIOCHEM 599	Master's Research	30

*Core course

Course Contents
M.Sc. (Ag) in Biochemistry

I. Course Title : Basic Biochemistry
II. Course Code : BIOCHEM 501*
III. Credit Hours : 3+1

IV. Theory

Block 1: Introduction to Biochemistry

Unit 1: Scope and importance of biochemistry (1 Lecture)

Biochemistry as modern science and its various divisions, Scope and importance of biochemistry in agriculture and allied sciences.

Unit 2: Foundation of life (2 Lectures)

Fundamental principles governing life, supramolecular structures, significance of weak non covalent interactions in biology

Unit 3 : Water (3 Lectures)

Structure of water, ionization of water, acid base concept, pH and buffers, significance of structure-function relationship.

Unit 4: Physical techniques for structure determination (2 Lectures)

General introduction to physical techniques for determination of structure of biopolymers.

Block 2: Structure And Function of Biomolecules

Unit 1: Biomolecules (10 Lectures)

Structure, classification, properties and function of carbohydrates, amino acids, proteins, lipids and nucleic acids.

Unit 2: Immunoglobulins and PR proteins (2 Lectures)

Structure, formation and different forms of immunoglobulins, PR proteins and their classification.

Unit 3: Plant secondary metabolites (3 Lectures)

Structure, classification and function of plant secondary metabolites.

Block 3: Metabolism – The Basics

Unit 1: Molecules aiding metabolism (2 Lectures)

Structure and biological functions of vitamins and coenzymes, enzymes: classification and mechanism of action; regulation, factors affecting enzyme action. Hormones: animal and plants.

Unit 2: Thermodynamics –principles and energetic of life (2 Lectures)

Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

Block 4: Catabolism and its Regulation

Unit 1: Catabolism of energy molecules (5 Lectures)

Important and basic degradative metabolic pathways of carbohydrates, lipids and proteins and their regulation.

Unit 2: ATP formation (3 Lectures)

Formation of ATP, substrate level phosphorylation, electron transport chain and oxidative phosphorylation, chemiosmotic theory and proton motive force.

Block 5: Fundamentals of Molecular Biology and Genetic Engineering

Unit 1: Molecular biology processes (4 Lectures)

Overview of replication, transcription and translation.

Unit 2: Recombinant DNA technology (3 Lectures)

Restriction enzymes, DNA cloning, applications of cloning, transgenics.

V. Practicals

- Preparation of standard and buffer solutions
- Detection of carbohydrates, amino acids and proteins
- Extraction and estimation of sugars
- Extraction and estimation of amino acids
- Extraction and estimation of proteins
- Estimation of acid value of fat/oil
- Estimation of peroxide value of fat/oil
- Estimation of saponification value in fats and oils
- Fatty acid composition in fat/oil by GC
- Estimation of DNA and RNA by spectroscopic methods
- Estimation of Ascorbic acid
- Separation of biomolecules by TLC and Paper chromatography
- Estimation of alpha amylase activity
- Qualitative tests for secondary plant metabolites.

VI. Suggested Reading

- Nelson DL and Cox MM. 2017. *Lehninger Principles of Biochemistry*. 7th edition. W. H. Freeman & Co Ltd
- Satyanarayana U and Chakrapani U. 2017. *Biochemistry*. 5th edition, Elsevier
- Moran LA, Horton HR, Scrimgeour KG and Perry MD. 2012. *Principles of Biochemistry*. 5th edition Pearson.
- Voet D and Voet JG. 2011. *Biochemistry*. 4th edition John Wiley.
- Pratt CW and Cornely K. 2014. *Essential Biochemistry*. 3rd Edition. Wiley
- Moorthy K. 2007. *Fundamentals of Biochemical Calculations*. 2nd edition. CRC Press
- Conn EE, Stumpf PK, Bruening G and Doi RH. 2006. *Outlines of Biochemistry*. 5th edition. Wiley.

I. Course Title : Intermediary Metabolism
II. Course Code : BIOCHEM 502*
III. Credit Hours : 3+0
IV. Theory

Block 1: Introduction To Metabolism

Unit 1: Overview of metabolism (4 Lectures)

The living cell - a unique chemical system, biochemical reaction types, bioenergetics, bioavailability of nutrients, transport mechanism, signal transduction.

Unit 2: Metabolic pathways (5 Lectures)

Catabolism and anabolism, compartments of metabolic pathways, experimental approaches to study metabolism, metabolic profiles of major organs.

Block 2: Metabolism of Energy Nutrients

Unit 1: Carbohydrate metabolism (5 Lectures)

Major catabolic and anabolic pathways of carbohydrate metabolism, the glyoxylatepathway.

Unit 2: Lipid metabolism (5 Lectures)

Fatty acid oxidation, ketone bodies, fatty acid biosynthesis, synthesis of triacylglycerols, cholesterol, eicosanoids.

Unit 3: Protein metabolism (3 Lectures)

General reactions of amino acid metabolism, degradative and biosynthetic pathwaysof amino acids, urea cycle, amino acids as metabolic precursors.

Unit 4: Energy transduction and oxidative phosphorylation (4 Lectures)

Mechanisms of energy transduction, electron transport system,phosphorylation, control of ATP production.

Block 3.sulphur and Nucleotide Metabolism

Unit 1: Sulphur metabolism (5 Lectures)

Sulphate reduction and incorporation of sulphur in to amino acids.

Unit 2: Nucleotide metabolism (3 Lectures)

Synthesis and degradation of purine and pyrimidine nucleotides.

Block 4: Metabolic Regulation and Defects in Metabolism

Unit 1: Regulation of metabolic pathways (4 Lectures)

Regulation of carbohydrate, lipid, protein, nucleotide metabolism and phosphorylation.

Unit 2: Defects in metabolism (4 Lectures)

Disorders of carbohydrates, lipids, amino acids and nucleic acid metabolism, andinborn errors of metabolism. Metabolic pathway engineering.

V. Suggested Reading

- Nelson, D. L. and Cox, M. M. 2017. *Lehninger Principles of Biochemistry*. 7th edition. W. H. Freeman & Co Ltd
- Satyanarayana, U. and Chakrapani, U. 2017. *Biochemistry*. 5th edition, Elsevier
- Campbell M. K. and Farrell S.O. 2009. *Biochemistry*. 6thedition Thomson Higher Educatio
- Moran L. A., Horton H. R., Scrimgeour K. G. and Perry, M. D. 2012. *Principles of Biochemistry*. 5th edition Pearson,
- Voet, D. and Voet J. G. 2011. *Biochemistry*. 4thedition . John Wiley.
- Pratt, C. W. and Cornely, K. 2014. *Essential Biochemistry*. 3rd Edition. Wiley
- Moorthy, K. 2007. *Fundamentals of Biochemical Calculations.* 2nd edition. CRC Press

Disorders of carbohydrates, lipids, amino acids and nucleic acid metabolism, and inborn errors of metabolism. Metabolic pathway engineering.

VI. Suggested Reading

- Nelson, D. L. and Cox, M. M. 2017. *Lehninger Principles of Biochemistry*. 7th edition. W. H. Freeman & Co Ltd
- Satyanarayana, U. and Chakrapani, U. 2017. *Biochemistry*. 5th edition, Elsevier
- Campbell M. K. and Farrell S.O. 2009. *Biochemistry*. 6thedition Thomson Higher Education.
- Moran L. A., Horton H. R., Scrimgeour K. G. and Perry, M. D. 2012. *Principles of Biochemistry*. 5th edition Pearson,
- Voet, D. and Voet J. G. 2011. *Biochemistry*. 4thedition . John Wiley.
- Pratt, C. W. and Cornely, K. 2014. *Essential Biochemistry*. 3rd Edition. Wiley
- Moorthy, K. 2007. *Fundamentals of Biochemical Calculations.* 2nd edition. CRC Press

I. Course Title : Enzymology

II. Course Code : BIOCHEM 503*

III. Credit Hours : 2+1

IV. Theory

Block 1: Introduction To Enzymes

Unit 1: Structure and function of enzyme (2 Lectures)

Historic perspective, general properties of enzymes, enzyme compartmentalization in cell organelles, nomenclature and classification of enzymes, ribozymes, isozymes, abzymes.

Unit 2: Extraction and purification of enzymes (2 Lectures)

Extraction of soluble and membrane-bound enzymes, purification of enzymes, measurement of enzyme activity.

Block 2: Enzyme Structure and Function

Unit 1: Chemical nature of enzyme (3 Lectures)

Enzyme specificity, monomeric and oligomeric enzymes, catalytic mechanism, mechanism of enzyme action, pseudoenzymes, enzyme promiscuity.

Unit 2: Cofactors and coenzymes (2 Lectures)

Chemical nature and involvement of cofactors and coenzymes in enzyme catalyzed reactions, metal activated enzymes and metalloenzymes, mechanism of enzyme catalyzed reactions without cofactors.

Unit 3: Nature of active site (2 Lectures)

Active site, identification of binding sites and catalytic sites.

Block 3. Enzyme Kinetics

Unit 1: Single substrate kinetics (4 Lectures)

Relationship between initial velocity and substrate concentration, Michaelis-Menten equation, Lineweaver-Burk and Eadie-Hofstee plots, analysis of kinetic data, numerical exercises.

Unit 2: Enzyme inhibition (2 Lectures)

Reversible and irreversible enzyme inhibition, uses of enzyme inhibition.

Unit 3: Kinetics of allosteric enzymes (3 Lectures)

Nature of allosteric enzymes, sigmoidal kinetics, MWC model and allosteric regulation, KNF model and allosteric regulation.

Unit 4: Regulation of enzyme activity (3 Lectures)

Feedback regulation, regulatory enzymes, control of enzymatic activity, symmetry and sequential model, reversible covalent modification of enzymes.

Block 4: Application of Enzymology

Unit 1: Industrial application of enzymes (3 Lectures)

Industrial application of enzyme catalysis in sectors like food processing, detergents, biofuels, paper and pulp, biosensors and clinical applications of enzymes.

Unit 2:

Biotechnological application of enzymes (2 Lectures)

Large scale production and purification of enzymes, immobilization of enzymes.

V. Practicals

- Soluble protein estimation
- Enzyme assay by taking any model
- enzyme
- Isolation and purification of any model enzyme
- Study of the effect of enzyme and substrate concentrations on enzyme activity
- Determination of K_m and V_{max}
- Determination of pH and temperature optima
- Effect of inhibitors on enzyme activity
- Determination of pH and temperature stability
- of
- enzyme
- Electrophoretic analysis of isozymes.

VI. Suggested
VII. Reading

1. Palmer T and Bonner PL. 2007. *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry*. 2nd edition. Woodhead Publishing
2. Okotore RO. 2015. *Essentials of Enzymology*. XLIBRIS
3. Herald J. 2016. *Essentials of Enzymology*. Syrawood Publishing House
4. Suzuki, H. 2015. *How Enzymes Work: From Structure to Function*. Jenny Stanford Publishing.
5. Bugg TDH. 2012. *Introduction to Enzyme and Coenzyme Chemistry*, 3rd Edition. WILEY
6. Guo Y. 2014. *Enzyme Engineering*. Science Press
7. Bisswanger H. 2011. *Practical Enzymology*. Wiley-Blackwell

8. exposure

I. Course Title : Molecular Biology

II. Course Code : BIOCHEM 504

III. Credit Hours : 2+1

VI. Theory

Block 1: Introduction to Nucleic Acids

Unit 1: History (1 Lecture)

Historical development of molecular biology, nucleic acids as genetic material.

Unit 2: Properties of nucleic acid (2 Lectures)

Nucleic acid structure, chemical and physical properties of nucleic acids, spectroscopic and thermal properties of nucleic acids, DNA supercoiling.

Unit 3: Genes and genome (3 Lectures)

Concept of genes and genome,genome complexity, genome organization in prokaryotes and eukaryotes, chromatin structure and function, repetitive and non-repetitive DNA, satellite DNA central dogma, genome editing.

Block 2: Synthesis of Nucleic Acid

Unit 1: DNA replication (3 Lectures)

Modes of replication, DNA polymerases, topoisomerases, DNA ligase, model of replisome, semi conservative replication in prokaryotes and eukaryotes, inhibitors of replication, DNA damage and repair.

Unit 2: Transcription (3 Lectures)

Basic principles of transcription, transcription initiation, elongation and termination, RNA processing, RNA interference, siRNAs, miRNAs and other ncRNAs, DNA/ RNA editing. regulation of transcription, reverse transcription.

Block 3. Protein Synthesis

Unit 1: Translation machinery (2 Lectures)

Ribosomes structure and function, organization of ribosomal proteins and RNA genes, genetic code, aminoacyl tRNA synthases.

Unit 2: Mechanism of protein synthesis (2 Lectures)

Initiation, chain elongation and termination of translation, energetics, inhibitors of translation.

Unit 3: Post-translational events (2 Lectures)

Post translational modifications of nascent polypeptide, protein targeting and turnover, regulation of gene expression in prokaryotes and eukaryotes, nucleases and restriction enzymes.

Block 4: Gene Manipulation

Unit 1: DNA sequencing (3 Lectures)

Importance, Sanger method,High-Throughput Sequencing (HTS) techniques, applications of DNA sequencing.

Unit 2: Recombinant DNA technology (4 Lectures)

Vectors, isolation of genes, recombinants vector, selection of recombinants, characterization and expression of cloned DNA, transformation, transgenesis, mutation, molecular mechanism of mutation, site directed mutagenesis, *in vitro* mutagenesis.

Unit 3: Techniques in molecular biology (3 Lectures)

Polymerase chain reaction (PCR), expression cloning, gel electrophoresis, molecular markers, macromolecule blotting and probing, arrays (DNA array and protein array) – principles and application.

VII. Practicals

- Isolation and purification of DNA and RNA
- To check the purity of isolated DNA and RNA
- Restriction fragmentation of genomic DNA
- Separation of oligos by agarose gel electrophoresis
- Southern blotting experiments
- Northern blotting experiments
- Cloning of DNA fragment in vector
- Selection of recombinant
- SSR analysis of DNA
- cDNA synthesis using RT- PCR
- Basic tools in bioinformatics analysis

VIII. Suggested Reading

- Snape A, Papachristodoulou D, Elliott, W. H. and Elliott, C. 2014. *Biochemistry and Molecular Biology*. Oxford University Press.
- Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. 2018. *Lewin's GENES XII*. Jones & Bartlett Learning.
- Lodish, H.,Berk, A., Kaiser, C. A., Krieger, M. And Bretscher, A. 2016. *Molecular Cell Biology*.W H Freeman & Co.
- Hoffmann, A. And Clokie, S. 2018. *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
- Primrose SB, Twyman RM and Old RW.2002. *Principles of Gene Manipulation*: 6th Ed. Wiley
- Karp, G. 2013. *Cell and Molecular Biology*. Wiley.
- Neidle, S. 2008. *Principles of Nucleic Acid Structure*. Elsevier Inc.
- Watson J, Baker TA, Bell SP, Gann A, Levine M and Losick, R. 2014. *Molecular biology of the gene* 7th edition, Pearson.

I. Course Title : Techniques in Biochemistry

II. Course Code : BIOCHEM 505*

III. Credit Hours : 2+2

IV. Theory

Block 1: Separation Techniques

Principles and applications of separation techniques.

Unit 1: Chromatography techniques (4 Lectures)

Principles and applications of paper, thin layer, gel filtration, ion-exchange, affinity, column & HPTLC, GC, HPLC and FPLC.

Unit 2: Electrophoretic technique (2 Lectures)

General principles,paper and gel electrophoresis, native and SDS-PAGE, 2D-PAGE, capillary electrophoresis.

Unit 3: Hydrodynamic methods (2 Lectures)

Hydrodyanmic methods of separation of biomolecules such as viscosity and sedimentation velocity, - their principles.

Unit 4: Centrifugation (2 Lectures)

Basic principles of sedimentation, type, care and safety aspects of centrifuge preparative and analytical centrifugation.

Block 2: Spectroscopic Techniques

Unit 1: Spectrophotometry (3 Lectures)

Principles and applications of UV-visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy.

Unit 2: Mass spectroscopy (3 Lectures)

MS/MS, LC-MS, GC-MS, MALDI-TOF, applications of mass spectrometry in biochemistry.

Unit 3: Atomic absorption spectrophotometry (2 Lectures)

Principle, function and instrumentation ofatomic absorption spectrophotometry.

Block 3. Microscopy

Unit 1: Microscopic techniques (2 Lectures)

Principles and applications, light, UV, phase contrast, fluorescence and electron microscopy, flow cytometry.

Block 4: Tracer, Imaging, Immunochemical and Other Techniques

Unit 1: Tracer technique (2 Lectures)

Tracer techniques in biology: concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of á, â and ã emitters, scintillation counters, J-ray spectrometers, autoradiography, applications of radioactive tracers in biology.

Unit 2: Imaging techniques (2 Lectures)

Principles and applications of phosphor imager, MRI and CT scan.

Unit 3: Immunochemical technique (2 Lectures)

Production of antibodies, immunoprecipitation, immunoblotting, immunoassays, RIA and ELISA.

Unit 4: Other techniques (2 Lectures)

Cryopreservation, polymerase chain reaction (PCR), FACS.

V. Practicals

- Expression of concentration in terms of dilution, molarity, normality, percent expression
- pH measurement and buffer preparation
- Determination of absorption maxima of biomolecules
- Estimation of biomolecules through spectrophotometry and other methods
- Separation of carbohydrates and amino acids by paper chromatography
- Separation and analysis of fatty acids/lipids by GC
- Separation/estimation of biomolecules through HPLC and FPLC
- Separation of proteins using ion exchange, gel filtration and affinity chromatography
- Electrophoretic separation of proteins and nucleic acids
- Centrifugation- differential and density gradient
- $(NH_4)_2SO_4$ precipitation and dialysis
- Use of radioisotopes in metabolic studies
- PCR
- ELISA
- Western blotting/ Dot blotting

VI. Suggested Reading

- Boyer R. 2011. *Biochemistry Laboratory: Modern Theory and Techniques* 2nd Edition. Pearson
- Hofmann A and Clokie S. 2010. *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology*. 7th edition. Cambridge University Press.
- Sawhney SK and Singh R. 2000. *Introductory Practical Biochemistry*. 2nd Ed. Narosa
- Katoch R. 2011. *Analytical Techniques in Biochemistry and Molecular Biology*. Springer
- Boyer R. 2009. *Modern Experimental Biochemistry*. Fifth impression. Pearson
- Lottspeich F and Engels JW. (Eds). 2018. *Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology*. Wiley-VCH
- Wilson K and Walker J. 2010. *Principles and Techniques of Biochemistry and Molecular Biology*, 7th Edition. Cambridge University Press

I. Course Title : Immunochemistry

II. Course Code : BIOCHEM 506

III. Credit Hours : 2+1

IV. Theory

Block 1: Basics of immunology

Unit 1: Introduction to immunology (7 Lectures)

History and scope of immunology, antigens, adjuvants, immune system, organs, tissues and cells, immunoglobulins, molecular organization of immunoglobulin. Haptens, ag-ab interaction, plant immunity, proteasome mediated process, plantibodies

Unit 2: Antibodies (5 Lectures)

Classes of antibodies, antibody diversity, theories of generation of antibody diversity, vaccine, monoclonal and polyclonal antibodies, hybridoma, recombinant antibodies, complement system - classical and alternate.

Unit 3: The immune responses (8 Lectures)

Cellular interactions in immune response, major histocompatibility complex, cell mediated immune response, cytokines.

Unit 4: Immunoregulation and immunological techniques (8 Lectures)

Immunoregulation, immunological tolerance, hypersensitivity, mechanisms of immunity, innate resistance and specific immunity, current immunological techniques – elisa, ria, immunoblotting, facs; basics of pcr and hybridization based methods of detection, microarray based detection, multiplexing.

V. Practicals

- Handling, inoculation and bleeding of laboratory animals
- Preparation of antigens and antisera, natural antibodies
- Carbon clearance test
- Lymphoid organs of the mouse
- Morphology of the blood leucocytes
- Separation of lymphocytes from blood, viable lymphocyte count
- Antigen-antibody interaction,
- Precipitation and agglutination
- Direct and indirect haemagglutination
- Immunoelectrophoresis
- Complement fixation
- Quantitation of immunoglobulins by zinc sulphate turbidity and single radial immunodiffusion
- ELISA
- Western blotting
- Fluorescent Ab test
- Hybridoma technique

Suggested Reading

- Punt J, Stranford S, Jones P and Owen J. 2018 . Kuby Immunology. 8th edition. W. H. Freeman
- Renshaw S. 2016. *Immunohistochemistry and Immunocytochemistry: Essential Methods*, 2nd Edition. John Wiley & Sons, Ltd.
- Abbas AK, Lichtma AH and Pillai S. 2018. *Cellular and Molecular Immunology*. 9th edition. Elsevier
- Delves PJ, Martin SJ, Burton DR and Roitt IM. 2017. *Roitt's Essential Immunology*, 13th Edition. Wiley-Blackwell

I. Course Title : Plant Biochemistry

II. Course Code : BIOCHEM 507

III. Credit Hours : 2+1

IV. Theory

Block 1: Photosynthesis

Unit 1: Photosynthetic machinery (3 Lectures)

Structure and function of plant cell and its organelles, phytochromes, chloroplast morphology structure, structure and chemistry of photosynthetic pigments, light reaction of photosynthesis.

Unit 2: Photosynthesis – the process (4 Lectures)

Carbon reduction in C_3, C_4 and CAM plants, photorespiration, sucrose-starch interconversion.

Block 2: Conversion of Photosynthates

Unit 1: Synthesis of major biomolecules (3 Lectures)

Biosynthesis of structural carbohydrates, storage proteins and lipids.

Unit 2: Nitrogen and sulphur metabolism (5 Lectures)

Basic concepts of nitrogen and sulphur metabolism: biological nitrogen fiXation, nitrate assimilation in plants, sulphur chemistry and function, reductive sulphate assimilation pathway, sulphated compounds.

Block 3: Growth and Develpoment

Unit 1: Germination and fruit ripening (4 Lectures)

Biochemistry of seed germination – stages, requirements, metabolism and mobilization of storage material; Biochemistry of fruit ripening – ripening process, cell wall degrading enzymes, role of ethylene and regulation of ethylene production.

Unit 2: Phytohormones (3 Lectures)

Different classes of phytohormones, their biosynthesis and mode of action.

Block 4: Secondary Metabolites

Unit 1: Biochemistry of plant secondary metabolites (6 Lectures)

Biochemistry and significance of plant secondary metabolites – phenolics, terpenoids, alkaloids, cyanogenic glycosides and glucosinolates, effect of biotic and abiotic factors on plant metabolism and plant defense system.

V. Practicals

- Fractionation of cell organelles,
- Estimation of starch,
- Assay of ADPG pyrophosphorylase/starch synthase,
- Assay of PAL/SOD
- Assay of PPO/LOX,
- Estimation of individual amino acids,
- Qualitative tests of secondary metabolites (alkaloids, sterols etc.)
- Content and composition of carotenoids, anthocyanin and chlorophylls
- Determination of polyphenols/phenolics
- Fractionation of storage proteins
- Estimation of glucosinolates
- Estimation of cyanogenic compounds.

X. Suggested Reading

- Buchannan BB, Gruissem W and Jones R.L. (eds.). 2000. *Biochemistry and Molecular Biology of Plants.* 2nd edition. WILEY Blackwell
- Heldt, H-W. 2010. *Plant Biochemistry and Molecular Biology*. 4th ed. Oxford University Press
- Goodwin TW and Mercer EI. 2005. *Introduction to Plant Biochemistry*. 2nd edition. CBS
- Heldt, H-W. and Piechulla, B. 2010.*Plant Biochemistry*. 4th Edition. Elsevier
- Harinda, Makkeaand Klaus. 2007. *Plant Secondary Metabolites*. Springer
- Cseke LJ, Kirakosyan A, Kaufman PB, Warber S, Duke JA, Brielmann HL. 2006. *Natural Products from Plants*. 2ndEdition. CRC Press

I. Course Title : Animal Biochemistry

II. Course Code : BIOCHEM 508

III. Credit Hours : 3+0

IV. Theory

Block 1: Animal Biochemistry

Unit 1: Biochemistry of assimilation (7 Lectures)

Digestion and absorption of food, Detoxification, biochemistry of specialized tissues – connective tissue, skin, muscle, nervous tissue and blood and other body fluids.

Unit 2: Nutrients and their biochemistry (7 Lectures)

Water, electrolyte and acid-base balance, structure, function and mechanism of major trace elements, vitamins, energy nutrients and biochemistry of respiration, bioactive peptides and functional oligosaccharides.

Unit 3: Hormones and their role (7 Lectures)

Hormones of thyroid, hypothalamus, pituitary, pancreas, adrenals and sex hormones, Membrane receptors of hormones, signal transduction.

Unit 4: Immune system (7 Lectures)

Immune systems, immunoglobulins, monoclonal antibodies, formation of antibody, antibody diversity, complement system – classical and alternate, major histocompatibility complexes, cell mediated immune response, mechanisms of immunity.

V. Suggested Reading

- Bradley, A. 2018. Animal Physiology and Biochemistry. 1st edition. Edtech Press
- Agarwal RA, Srivastava, A.K. and Kumar, K. 2010. *Animal Physiology and Biochemistry*. Fifth revised edition S. Chand.
- Rodwell VA, Bender DA, Botham KM, Kennelly PJ and Weil PA. 2018. *Harper's Illustrated Biochemistry*, 31st edition. McGraw-Hill Education.

I. Course Title : Nutritional Biochemistry

II. Course Code : BIOCHEM 509

III. Credit Hours : 2+1

IV. Theory

Block 1: Nutritional Biochemistry

Unit 1: Fundamentals of human nutrition (7 Lectures)

Fundamentals of human nutrition, concept of balanced diet, biochemical composition, energy and food value of various food grains (including cereals, pulses, oilseeds), fruits and vegetables. Physico-chemical, functional and nutritional characteristics of carbohydrates, proteins and fats and their interactions (emulsions, gelation, browning etc.). Digestion and absorption, digestive secretions, their characteristic features and control, protection of microflora of the GI tract

Unit 2: Biochemical functions of nutrients (7 Lectures)

Biochemical functions of nutrients, macro- and micronutrients- carbohydrates, fats and proteins, vitamins, water soluble and fat soluble vitamins, mineral and phytonutrients, prebiotics and probiotics, enzymes and metabolic protein factors, cofactor role, electrolytic function, constituents of skeletal tissues, interrelationship in nutrient functions, mineral deficiency diseases; nutraceuticals, antinutritional factors, biochemistry of postharvest storage.

Unit 3: Bioavailability of nutrients (7 Lectures)

Factors affecting bioavailability of nutrients, biological value of proteins; effect of cooking, processing and preservation of different food products on nutrients, energy- and micronutrient malnutrition, deficiency diseases of macro and micronutrients.

Unit 4: Food sensitivity (7 Lectures)

Food sensitivity: immunologically mediated food sensitivity, nature and properties of antigens in foods, mechanism of induction of all allergic reactions, diagnostic tests for food, hypersensitivity, non-immunologically mediated food sensitivity, food sensitivity due to metabolic diseases, gastrointestinal diseases, food additives, pharmacologic agents, food toXins and poisonous and psychological factors.

V. Practicals

- Estimation of amylose and amylopectin
- Estimation of resistant starch
- Estimation of ù3, ù6 and trans fatty acid
- Estimation of phenols in plant tissue/sample
- Estimation of carotenoids
- Estimation of amylase, trypsin and chymotrypsin inhibitor activities
- Estimation of Vitamin C in fruits
- Estimation of reducing & non reducing sugar in fruits
- Estimation of protein contents
- Estimation of dietary fibre
- Determination of limiting amino acids
- Estimation of phytate/ oXalate
- Estimation of total antioXidant activity by different methods
- Estimation of curcumin.

VI. Suggested Reading

- Damodaran S. and Parkin KL (ed.) 2017. *Fennema's Food Chemistry*. CRC Press
- Gibney MJ, Lanham-New SA, Cassidy, A and Voster HH (ed.) 2009. *Introduction to Human Nutrition*. Wiley-Blackwell

- Trueman, P. 2007. *Nutritional Biochemistry*. MJP Publishers
- Cox, C. 2015.*Nutritional Biochemistry: Current Topics in Nutrition Research*. Apple Academic Press Inc.
- Haugen, S. and Meijer, S. 2010. *Handbook of Nutritional Biochemistry: Genomics, Metabolomics & Food Supply*. Nova Science Publishers Inc.

I. Course Title : Nitrogen and Sulfur Metabolism

II. Course Code : BIOCHEM 510

III. Credit Hours : 2+1

IV. Theory

Block 1: Nitrogen and Sulfur Metabolism

Unit 1: Nitrogen metabolism (18 Lectures)

Nitrogen cycle, assimilation of inorganic nitrogen, nitrate uptake and transporters, enzymology of nitrate reduction - Nitrate reductase (NR) and Nitrite reductase (NiR), NR regulation, nitrate signaling.

Assimilation of inorganic nitrogen and N-transport amino acids - glutamine synthetase (GS), glutamate synthase (GOGAT), glutamate dehydrogenase (GDH), aspartate amino transferase (AspT) and asparagine synthetase (AS), interaction between carbon metabolism and amino acid synthesis, biosynthesis of amino acids. Nitrogen fiXation - an overview, enzymology of nitrogen fiXation - nitrogenase, *nif* genes and their regulation, symbiotic nitrogen fiXation - biochemical basis of rhizobial infection, nodule development. Mechanism of creation of microaerobic

environment for nitrogenbac teroids

.Unit 2: Sulphur metabolism (10 Lectures)

Overview of sulfate assimilation, sulfur chemistry and function, sulfate uptake and transport, reductive sulfate assimilation pathway, synthesis and function of sulfur containing amino acids, glutathione and its derivatives, role of sulfated compounds in metabolism.

V. Practicals

- Estimation of nitrite content,
- Estimation of nitrate content,
- *In vivo* assay of nitrate reductase activity,
- *In vitro* assay of nitrate reductase activity,
- *In vitro* assay of nitrite reductase activity,
- *In vitro* assay of glutamine synthetase activity,
- *In vitro* assay of glutamate synthase and glutamate dehydrogenase activity,
- Estimation of ureides and amides,
- Assay of nitrogenase activity by acetylene reduction method,
- Estimation of hydrogen evolution by legume nodules,
- Estimation of cysteine, methionine, pyruvate and glutathione,
- Assay of APS activity.

VI. Suggested Reading

- Bothe, H. and Trebst, A. (eds.). 1981. *Biology of Inorganic Nitrogen and Sulfur*. Conference proceedings. Springer-Verlag
- De Kok *et al.* 2012. *Sulfur Metabolism in Plants*. Part of the Proceedings of the International Plant Sulfur Workshop book series. Springer
- Bray CM. 1983. *Nitrogen Metabolism in Plants*. Longman.
- Bidwell, R.G.S. 1983. *Plant Physiology: A Treatise*, Vol. 8: Nitrogen Metabolism. Academic Press
- Foyer. C. H. and Zhang, H. 2010. *Nitrogen Metabolism in Plants in the Post-Genomic Era*. Annual Plant Reviews, Vol.42. Wiley-Blackwell
- Buchanan B.B., Gruissem W. and James R. L. (Eds.). 2000. *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists.

I. Course Title : Biochemistry on Xenobiotics

II. Course Code : BIOCHEM 511

III. Credit Hours : 2+0

IV. Theory

Block 1: Biochemistry on Xenobiotics

Unit 1: Xenobiotics (7 Lectures)

Xenobiotics: classification and their effects on biological systems, Problems related to xenobiotics degradation, potential effects of toxic agents on immune system function, biotic metabolism of xenobiotics - biodegradation/biotransformation

Unit 2: Mode of degradation (7 Lectures)

Mode of degradation - Enzymatic and Non-enzymatic, Metabolism of toxic compounds with reference to role of detoxifying enzymes, Mechanism of xenobiotics detoxification - in animal using the enzymes of Phase I and Phase II, Role of microbes in xenobiotics degradation and co-metabolism, Biodegradation and its genetics, manipulation of xenobiotic degradative genes

Unit 3: Plant metabolism of xenobiotics (7 Lectures)

Plant metabolism of xenobiotics - transformation, conjugation and compartmentation, Metabolic responses of pesticides in plants, Impact, metabolism, and toxicity of heavy metals in plants, Regulation of xenobiotics in higher plants: signalling and detoxification.

Unit 4: Phytoremediation (7 Lectures)

Phytoremediation, Advances in development of transgenic plants for remediation of xenobiotic pollutants, safety assessment of xenobiotics

IX. Suggested Reading

- Richardson, M. 1996. *Environmental Xenobiotics*. CRC Press
- Singh, A., Prasad, S.M. and Singh, R.P.(eds). 2016. *Plant Responses to Xenobiotics*. Springer.
- Chang, Y-C. (ed). 2019. *Microbial Biodegradation of Xenobiotic Compounds*. CRC Press
- Costas Ioannides (ed). 2002. Enzyme Systems that Metabolise Drugs and Other Xenobiotics. Wiley
- Lee, P., Aizawa, H., Gan, L., Prakash, C. And Zhong, D. 2014. *Handbook of Metabolic Pathways of Xenobiotics*. –
- Emerson, M.L. 2012. Xenobiotics*: New Research*. Nova Science
- Shamaan, N.A. 2008. *Biochemistry of xenobiotics: towards a healty lifestyle and safe environment*. PenerbitUniversiti Putra Malaysia.

Course Title with Credit Load
Ph.D. in Biochemistry

Course Code	Course Title	Credit Hours
BIOCHEM 601*	Advanced Enzymology	2+1
BIOCHEM 602	Advanced Molecular Biology	3+0
BIOCHEM 603	Biochemistry Of Biotic And Abiotic Stresses	3+0
BIOCHEM 604	Frontier Topics In Biochemistry	2+0
BIOCHEM 605	Concepts And Aplication Of Omics In Biological Science	3+0
BIOCHEM 606	Biomembranes	2+0
BIOCHEM 607*	Application Of Techniques In Biochemistry	1+2
BIOCHEM 691	Doctoral Seminar I	1+0
BIOCHEM 692	Doctoral Seminar II	1+0
BIOCHEM 699	Doctoral Research	75

*Core course

Course Contents
Ph.D. in Biochemistry

I. Course Title : Advanced Enzymology

II. Course Code : BIOCHEM 601*

III. Credit Hours : 2+1

IV. Theory

Block 1: Enzymology And Enzyme Engineering

Unit 1: Enzyme catalysis and specificity (Seven Lectures)

Theory of enzymatic catalysis, Specificity and editing mechanisms, concept of active site and enzyme substrate complex, active site mapping, factors associated with catalytic efficiency, mechanism of enzyme reactions,detection of intermediates in enzymatic reactions.

Unit 2: Enzyme kinetics (7 Lectures)

Transition state theory, Arrhenius equation, Determination of energy of activation, effect of pH and temperature on enzyme kinetics, pre-steady state and steady state kinetics, single substrate kinetics, allosteric enzymes and mixed inhibition, substrate and product inhibition, numerical exercises.

Unit 3: Enzyme mechanism and regulation (7 Lectures)

Mechanism determination by radioisotope exchange, role of enzymes in regulation of metabolism, bifunctional enzymes, pseudoenzyme and enzyme promiscuity, extremozymes, catalytic nucleic acids (ribozymes, catalytic DNA).

Unit 4: Industrial enzymology (7 Lectures)

Advantages and disadvantages of biocatalysis in technology driven processes, stabilization and regeneration of enzyme systems used in biotechnology, protein engineering of enzymes, creation of chimeric, bifunctional, immobilization of enzymes, semisynthetic enzymes and their use as industrial biocatalysts, and their practical significance, modern information technologies in enzyme engineering.

V. Practicals

- Purification and characterization of some model enzymes (peroxidise, á-amylase, lipase)
- Study kinetics of inhibited and un inhibited enzyme catalysed reactions
- Determination of Km values of single substrate reactions
- Determination of enzyme activity by coupled assay
- Electrophoretic separation of isozymes
- Enzyme immobilization.

VI. Suggested Reading

- Aehle, W. 2007. *Enzymes in Industry. Production and Application*. (Third, Completely Revised Edition). Wiley-VCH Verlag GmbH & Co. KGaA
- Buchholz, K., Bornscheuer, U., Kasche, V. 2012. *Biocatalysts and Enzyme Technology*. UK: Wiley-VCH Verlag GmbH
- Fessner, W. and Anthonsen, T. 2009. *Modern Biocatalysis*. Germany: Wiley-VCH Verlag GmbH
- Frey, P.A. and Hegeman, A.D. 2007. *Enzymatic Reaction Mechanisms*. Oxford University Press
- Young Je Yoo, Yan Feng, Yong-Hwan Kim, Camila Flor J. Yagonia. 2017. *Fundamentals of Enzyme Engineering*. Springer

I. Course Title : Advanced Molecular Biology

II. Course Code : BIOCHEM 602

III. Credit Hours : 3+0

IV. Theory

Block 1: Genome Organisation and Manipulation

Unit 1: Concepts of gene and genome (5 Lectures)

Genes, their relationship with chromosomes, gene number hypothesis; Genome – definition, variation and organization in plants and animals, structure of organelle genomes; concept of epigenome, genome size and genome evolution.

Unit 2: Regulation of gene expression (6 Lectures)

Prokaryotic and eukaryotic gene regulation, transcriptional and posttranscriptional regulation; regulation at genome level, role of histones, riboswitches.

Unit 3: Techniques in genome analysis (6 Lectures)

Genome sequencing technologies, Sanger sequencing, next generation sequencing, nanopore sequencing; genome mapping – genetic map construction, physical mapping.

Unit 4: Techniques for gene transfer and genome manipulation (6 Lectures)

Methods of gene isolation and transfer in plants and animals, agrobacterium mediated and direct transfer of genes in plants and animals; gene silencing technologies: virus induced gene silencing, RNA interface; genome editing -TALENs, CRISPR/cas, ZFN and their application, site directed mutagenesis,Application of genetic engineering in different fields, gene therapy.

Unit 5: Aspects of molecular breeding (5 Lectures)

Genome browsing, primer design, marker application for breeding, application of MAS in case studies. Bioethics and bio safety guidelines, IPR in recombinant DNA research

V. Suggested Reading

- Brown, T. A. 2018. *Genomes 4*. Garland Science
- Rippe, K. 2011. *Genome Organization and Function in the Cell Nucleus*. Wiley VCH Verlag
- Primrose, S. B. and Twyman, R.2006. *Principle of Gene Manipulation and Genomics*. 7th edition. Blackwell Publishing
- Christopher Howe. 2007. *Gene Cloning and Mani*pulation. 2nd edition. Cambridge University Press
- S. Mohan Jain, D S Brar.(eds.). 2009. *Molecular Techniques in Crop Improvement*. 2nd edition. Springer
- Boopathi, N. M. 2013. Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits. Springer
- Brown, T. A. 2010. *Gene Cloning and DNA Analysis. An Introduction*. Wiley-Blackwell
- Singh, K. K. 2015. *Biotechnology and Intellectual Property Rights. Legal and Social Implications*. Springer

I. Course Title : Biochemistry of Biotic and Abiotic Stresses

II. Course Code : BIOCHEM 603

III. Credit Hours : 3+0

IV. Theory

Block 1: Biochemistry of Biotic and Abiotic Stresses

Unit 1: Plant-pathogen interaction and disease development (4 Lectures)

Molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.

Unit 2: Biochemistry of plant defence mechanisms (7 Lectures)

Role of secondary metabolites, Plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance, pathogen derived resistance.

Unit 3: Plant host-virus interaction (4 Lectures)

Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids.

Unit 4: Biochemical basis of abiotic stresses (7 Lectures)

Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants, synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation.

Unit 5: Tolerance against stress (6 Lectures)

Reactive oXygen species and biotic and abiotic stress, antioXidants, enzymes of defense system. Role of calcium, nitric oXide and salicylic acid in plant development. Molecular strategies for imparting tolerance against biotic and abiotic stress.

V. Suggested Reading

- Buchanan, Bob B., Gruisem, W. and Jones, R. 2015. *Biochemistry and Molecular Biology of Plants*, 2nd edition, Wiley Blackwell.
- Dresselhaus, T. and Hückelhoven, R. (Eds.) 2019. *Biotic and Abiotic Stress Responses in Crop Plants*. MDPI. https://doi.org/10.3390/agronomy8110267
- Rout, G.R. and Das, A.B. 2013. *Molecular Stress Physiology of Plants*. Springer. DOI 10.1007/978-81-322-0807-5
- Shanker, A.K. and Shanker, C. (Eds.) 2016. *Abiotic and Biotic Stress in Plants - Recent Advances and Future Perspectives*.InTech. http://dX.doi.org/10.5772/60477
- Ramakrishna, A. and Gill, S.S. 2018. *Metabolic Adaptations in Plants During Abiotic Stress*. CRC Press
- Khan, M.I.R. and Khan, N.A. (Eds.). 2017. *Reactive Oxygen Species and Antioxidant Systems in Plants: Role and Regulation under Abiotic Stress*. Springer
- Smirnoff, N. (ed.) 2005. *Antioxidants and reactive oxygen species in plants*, Blackwell

I. Course Title : Frontier Topics in Biochemistry

II. Course Code : BIOCHEM 604

III. Credit Hours : 2+0

IV Theory

Block 1: Frontier Topics in Biochemistry

Unit 1: Latest development in metabolic nutrition.

Unit 2: Latest development in environmental and industrial biochemistry.

Unit 3: Latest development in molecular biology techniques.

Unit 4: Latest development in metabolic engineering.

Unit 5: Latest development in regulation of gene expression.

Unit 6: Latest development in biotic and abiotic stress response in plants.

Unit 7: Latest development in protein chemistry.

Unit 8: Topics related to recent approaches concerning application of biochemical tools and techniques

VI. Suggested Reading

- Selected articles from recent issues of *Thomson Reuters and NAAS rated journals*

I. Course Title : Concepts and Application of Omics in Biological Science

II. Course Code : BIOCHEM 605

III. Credit Hours : 3+0

IV. Theory

V. Block 1: Concepts and Aplication of Omics in Biological ScienceUnit 1: Protein and nucleic acid sequencing (7 Lectures)

Various methods of sequencing including automated sequencing and microarrays, whole genome sequence analysis.

Unit 2: Genomics – methods of analysis and application (7 Lectures)

Comparative genomics, functional genomics, nutrigenomics, transcriptomics, gene identification, gene annotation, pairwise and multiple alignments, application of genomics, quantitative PCR, SAGE, MPSS, microarray, role of bioinformatics in functional genomics.

Unit 3: Proteome technology (7 Lectures)

2D-PAGE, MSMS, MALDI-TOF, comparative proteomics and structural proteomics

Unit 4: Metabolomics and ionomics (7 Lectures)

Elucidation of metabolic pathways, Sample preparation for metabolomics. Techniques involved in metabolite identification- LCMS, NMR, FTIR, MS. Metabolomics in biotic and biotic stress in crop plants, SPE, SPME, metabolic pathway engineering and its application, Concept and application of ionome and ionomics.

VI. Suggested Reading

- Lieber D.C. 2002. *Introduction to Proteomics - Tools for the New Biology*. Humana Press.
- Leung, H.E. 2012. *Integrative Proteomics*. InTech
- Lesk, A.M. 2012. Introduction to Genomics, 2nd Edition. OXford University Press
- Aizat, W.M., Goh, H-H. and Baharum, S.N. (Eds.) 2018. Omics Applications for Systems Biology. Springer International Publishing
- Arivaradarajan, P., Misra, G. (Eds.) 2018. *Omics Approaches, Technologies and Applications*. Springer Singapore
- Fan TWM, Lane AN and Higashi RM. (Eds.) 2012. *The Handbook of Metabolomics*. Humana Press, Totowa, NJ

I. Course Title : Biomembranes

II. Course Code : BIOCHEM 606

III. Credit Hours : 2+0

IV. Theory

Block 1: Biomembranes

Unit 1: Concept of biomembranes and their classification based on cellular organelles; physico-chemical properties of different biological and artificial membranes, cell surface receptors and antigen.

Unit 2: Membrane biogenesis and differentiation; membrane components-lipids, their distribution and organization; proteins, intrinsic and extrinsic, their arrangement; carbohydrates in membranes and their function.

Unit 3:

Various membrane movements; Membrane transport: Organization of transport at plant membranes, pumps, carriers, ion channels, water transport through aquaporins, transport of macro molecules: exocytosis and endocytosis, energy transduction.

Unit 4: Role of membrane in cellular metabolism, cell recognition and cell-to-cell interaction; signal transduction, recent trends and tools in membrane research.

- **Suggested Readings**

- Watson, H. 2015. *Biological membranes.* Essays Biochem. **59**, 43–70: doi: 10.1042/ BSE0590043
  Sh9783527616114
- Berk, A., Kaiser, C. A., Lodish, H., Amon, A., Ploegh, H., Bretscher, A., Krieger, M. And Martin, K. C. 2016. *Molecular Cell Biology*. Macmillan Learning
- Stillwell, W. 2013. *An Introduction to Biological Membrane: From Bilayers to Rafts.* Elsevier
- Yeagle, P. 2016. *The Membranes of Cell.* 3rd edition. Academic Press
- initzky, M. 2008. *Biomembranes: Structural and Functional Aspects.* VCH. DOI: 10.1002/

I. Course Title : Application of Techniques in Biochemistry

II. Course Code : BIOCHEM 607*

III. Credit Hours : 1+2

IV. Theory

Block 1: Application of Techniques in Biochemistry

Unit 1: Isolation, purification and analysis of metabolites (3 Lectures)

Isolation and purification of important metabolites from microbial/plant/animal source, Applications of paper, thin layer and gas liquid chromatography, PAGE, FPLC and HPLC in the separation of biomolecules. Determination of molecular weight of protein using PAGE/ gel filtration method.

Unit 2: Electrophoretic separation (3 Lectures)

Electrophoretic separation of protein, Experiments on DNA: Isolation, agarose gel electrophoresis and restriction analysis of DNA. Techniques in DNA-protein and protein-protein interaction.

Unit 3: Application of centrifugation (2 Lectures)

Isolation of chloroplast and mitochondria by differential centrifugation and their purification by density gradient centrifugation.

Unit 4: Enzyme techniques (3 Lectures)

Isolation, purification and characterization of enzymes, isozymic analysis and enzyme immobilization.

Unit 5: Molecular biology and immunochemical techniques (3 Lectures)

Application of PCR, yeast 2 hybrid system, Antigen-Antibody interaction, ELISA, Chromatin immunoprecipitation, gel based and gel free proteasome tools.

V. Suggested Reading

- Katoch, R. 2011. *Analytical Techniques in Biochemistry and Molecular Biology*. Springer
- Wilson, K. and Walker, J. 2010. *Principles and Techniques of Biochemistry and Molecular Biology*, 7th Edition. Cambridge University Press
- Hegyi, G., Kardos, J., Kovács, M., Málnási-Csizmadia, A., Nyitray, L. Pál, G., Radnai, L., Reményi, A. and Venekei, I. 2013. *Introduction to Practical Biochemistry*. EötvösLoránd University

Journals

- *Annual Review of Biochemistry*
- *Annual Review of Genetics*
- *Annual Review of Plant Physiology and Plant Molecular Biology*
- *Biochemical and Biophysical Research Communication*
- *Biochemical Journal*
- *Biochimica Biophysica. Acta*
- *Cell*
- *Current Science*
- *Federation of European Biochemical Society*
- *Food Chemistry*
- *Indian Journal of Experimental Biology*
- *Journal of Agriculture and Food Chemistry*
- *Journal of Biological Chemistry*
- *Journal of Immunology*
- *Journal of Molecular Modelling*
- *Journal of Plant Biochemistry and Biotechnology*
- *Nature*

- *Physiologia Plantarum*
- *Plant Physiology*
- *Plant Science*
- *Planta*
- *Proceedings of National Academy of Sciences, USA*
- *Protein Science*
- *RNA*
- *Science*
- *Scientific American*
- *Trends in Biochemical Sciences*
- *Trends in Biotechnology*
- *Trends in Plant Sciences*

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 2

Basic Sciences
– Microbiology

Course Title with Credit load
M.Sc. (Ag) in Microbiology

Course Code	Course Tittle	Credit Hours
MICRO 501	Techniques in microbiology	0+2
MICRO 502*	Principles of microbiology	3+1
MICRO 503*	Microbial physiology and metabolism	3+1
MICRO 504	Microbial genetics.	2+1
MICRO 505*	Soil microbiology	2+1
MICRO 506	Microbial biotechnology	2+1
MICRO 507*	Food microbiology	2+1
MICRO 508	Bacteriophages	1+1
MICRO 509	Environmental microbiology	2+1
MICRO 510	Industrial microbiology	2+1
MICRO 511	Biofertilizer technology	2+1
MICRO 512	Cyanobacterial and algal biotechnology	2+0
MICRO 591	Master's seminar	1+0
MICRO 599	Master's research	30

*Core Courses

Course Contents
M.Sc. (Ag) in Microbiology

Course Title : **Techniques in Microbiology**
Course Code : **MICRO 501**
Credit Hours : **0+2**

Practicals

- Awareness about lab safety measures
- Study of general microbiological equipment, cleaning of glassware and apparatus for laboratory use
- Methods of sterilization used in microbiology laboratory
- Use of simple techniques in laboratory (Colorimetry, Centrifugation, electrophoresis and chromatography)
- Types of culture media
- Isolation techniques and direct microscopic count
- Environmental factors affecting bacterial growth: physical chemical, temperature, pH, osmotic pressure, light (UV) and bacteriostatic agents. Bacteriology of air, water, and soil.
- Characteristics of important types of micro-organisms: major functional groups of bacteria, lactic acid, spore forming and coliforms bacteria, fungi, yeast and mold.
- Assessment of microbial quality of portable water.
- Working in microscope

Suggested Reading

- Roy A.K. 2010. *Laboratory Manual of Microbiology* (Practical Manual Series).
- Goldman E and Green LH. 2015. *Practical Handbook of Microbiology*. 3rd Edition. http/ www. CRC press life science Microbiolgy
- Brock, T.D. 2008. *Biology of microorganisms* (Ed.) Madigan MT, Martinko J M, Dunlap P V, Clark D.P., 12th ed. Pearson, New Jersey.
- Pelczar, M.J. Jr., Chan, E.C.S. and Kreig, N.R. 1997. *Microbiology, Concepts and Application*, 5th edition, Tata McGraw Hill, New York.
- Prescott, L.M., Harley and Klein. 2002. *Microbiology* 5th Edition, Tata McGraw Hill, New York.
- Bhatia, M.S. 2009. *Principles of Microbiology*. Swastik Publishers., DeIhi.
- Madigan, M.T., J.M. Martinko, P.V. Dunlap and D.P. Clark. 2001. *Brock biology of Microorganism* 10th Ed. Pearson Education lnc, USA.
- Singh, U.S. and K. Kapoor 2010. *Introductory microbiology* Oxford Book Company., Jaipur
- Tortora, G.J., B.J. Funke and C.L. Case. 2010. *Microbiology: an introduction*.10th Ed. Benjamin Cummings., New York.

Websites

- http://www.asmscience.org
- http://www.asm.org
- http://www.microbiologyonline.org.uk
- http://www.microbeworld.org

Course Title : **Principles of Microbiology**
Course Code : **MICRO 502***
Credit Hours : **3+1**

Theory

Block 1: Scope and History of Microbiology and Microscopy

Unit 1: Scope of microbiology

Scope of microbiology, microbes and microbiologist. Emergence of Special Fields of Microbiology.

Unit 2: History Routes

The Germ Theory of Disease, Early Studies: Pasteur's Further Contributions, Koch's Contributions, Work Toward Controlling Infections, spontaneous generation theory.

Unit 3: Staining and microscopy

Microscopy; Bright field, Dark field, Phase contrast, Confocal, Fluorescence, TEM, SEM – Working Principles and applications; Properties of light; Simple staining, differential and special staining.

Block 2: Evolutionary Link of Prokaryotes

Unit1: Phylogenetic classification

Evolutionary relationship among prokaryotes. Prokaryotes and Eukaryotes, Phylogenetic and numerical taxonomy. Species concept.

Unit2: Methods of sequencing

Use of DNA and r-RNA sequencing in classifications.

Unit1: Microbial growth and reproduction

Microbial growth and reproduction-communication, bacteria, yeast and virus growth, Replication, Cultivation methods, Normal micro flora of Human body; Immune response- specific and non-specific host resistance.

Unit 2: Sterilization techniques

Physical and chemical methods of sterilisation.

Unit 3: Nutritional requirements for microbial growth

Classification of microbes: electron, energy and carbon sources.

Practicals

- Working principles and handling of different types of microscopes – Bright and Dark field microscopy
- Working principles and handling of different types of microscope- SEM and TEM
- Methods of isolation from different environments – soil, water, milk and food
- Use of selective media for isolation
- Purification techniques of bacteria and fungi
- Enumeration and Quantification techniques
- Maintenance and preservation of cultures
- Assessment of microbial quality of portable water.
- Morphological characterization of Bacteria
- Morphological characterization of fungi
- Biochemical characterization of bacteria
- Biochemical characterization of fungus

Suggested Reading

- Brock TD. 2008. *Biology of microorganisms* (Ed.) Madigan MT, Martinko J M, Dunlap P V, Clark DP, 12th ed. Pearson, New Jersey.
- Pelczar MJ. Jr., Chan, ECS and Kreig NR. 1997. *Microbiology, Concepts and Application*, 5th edition, Tata McGraw Hill, New York.
- Prescott, L.M., Harley and Klein. 2002. *Microbiology* 5th Edition, Tata McGraw Hill, New York.
- Bhatia, M.S.2009. *Principles of Microbiology*. Swastik Publishers., DeIhi.
- Madigan, M. T., J. M. Martinko, P.V. Dunlap and D.P. Clark.2001. *Brock biology of Microorganism* 10th Ed. Pearson Education lnc, USA.
- Singh, U.S and K. Kapoor 2010. *Introductory microbiology* Oxford Book Company., Jaipur
- Tortora, G. J., B.J. Funke and C.L. Case. 2010. *Microbiology: an introduction*.10th Ed. Benjamin Cummings., New York
- Davis BD, Dulbecco R, Eisen HN and Ginsberg HS. 1990. *Microbiology* (4th edition). J.B.Lippincott company, Newyork.
- AleXopoulus CJ and C W. Mims. 1993. *Introductory Mycology* (3rd edition).Wiley Eastern Ltd, NewDelhi.
- Elizabeth Moore-Landecker. 1996. *Fundamentals of the fungi.* (4th edition).Prentice Hall International, Inc, London.
- Heritage,J. Evans E.G.V. and Killington, R.A. 1996. *Introductory Microbiology*. Cambridge University Press.
- Webster J. 1993. Introduction to Fungi.(2nd edition).Cambridge University press,Cambridge.
- Prescott LM, Harley JP and Klein DA. 2006. Microbiology (7th edition) McGraw Hill, Newyork.
- Schaechter M and Leaderberg J. 2004. The Desk encyclopedia of Microbiology. Elseiver Academic press, California.
- Nester, E.W., Roberts, C.V. and Nester, M.T. 1995. *Microbiology: A human perspective*. IWOA, U.S.A.
- Pelczar Jr, M.J. Chan, E.C.S. and Kreig, N.R. 1993. *Microbiology*, Mc. Graw Hill. Inc, New York.
- Holt JG and Bergey DH. 1994. *Bergey's Manual of Determinative Bacteriology* (9th Edition), Williams and Wilkins, Baltimore.
- Mara D. and Horan N. 2003. *The Handbook of Water and waste water Microbiology*. Academic Press-An imprint of Elsevier.
- Madigan M T, Bender K S, Buckley HD, Sattley WM, Stahl DA 2017. *Brock Biology of Microorganisms* - 15th edition. Pearson Education, USA.

Websites

- http://www.asmscience.org
- http://www.asm.org
- http://www.microbiologyonline.org.uk
- http://www.microbeworld.org

I. Course Title : Microbial Physiology and Metabolism

II. Course Code : MICRO 503*

III. Credit Hours : 3+1

IV. Theory

Block 1: Scope of Microbial Growth and Physiology

Unit 1: Structure, function and biosynthesis of cellular components

Microbial nutrition – Chemical composition of microbial cell – Structure, function and assembly of cell membrane in prokaryotes, archaea and fungi – Macro and Micro- nutrients and their physiological functions – Transport of solutes across the membrane

Block 2: Pathways and their Significance; Growth Kinetics and Nutritional Classifications

Unit 1: Growth Kinetics, cell cycle, cell division, pathways and fermentation metabolism

Microbial growth. Cell cycle and cell division. Bioenergetics -carbohydrate utilization via EMP, HMP, ED, TCA pathways, Aerobic and anaerobic respiration. Fermentative metabolism. Assimilation of nitrogen and sulphur - Oxygenic and anoxygenic photosynthesis - Mechanisms of carbon-dioxide fixation in prokaryotes. Ethanol, lactic acid, butanol, acetone and mixed acid fermentation. Fermentation of nitrogenous organic compounds Regulation of microbial metabolism.

Unit 2: Growth and factors affecting growth and culture systems

Effects of physical, chemical and other environmental factors on growth Continuous culture, Diauxic growth and Synchronous culture. Method of growth measurement. Morphogenesis and cellular differentiation.

Unit 3: Nutritional classification and spore formation and germination

Metabolic diversity in photoautotrophs, photoheterotrophs, chemoautotrophs and chemoheterotrophs. Nutritional grouping/classification of microorganisms. Bacterial endospore-types, morphology, biochemistry and regulation of formation and germination

Block 3: Enzymes and Microbial Metabolisms

Unit 1: Kinetics and Mechanism of Enzymes

Enzyme kinetics: Michaelis Menten kinetics - mechanisms of inhibition of enzyme activity - coenzymes and prosthetic groups.

Unit 2: Microbial metabolism

Methods to determine free energy of biochemical reactions - high energy compounds. Microbial metabolism: generation of ATP, reducing power, development of proton gradient and biosynthesis of ATP.

Block 4: Synthesis of Macromolecules

Unit 1: Biosynthesis of macromolecules

Biosynthesis of macromolecules – Synthesis and assembly of cell wall components – Methods of studying biosynthesis - regulation of microbial metabolism.

V. Practicals

- Use of simple techniques in laboratory (Colorimetry, Centrifugation, electrophoresis and GLC, etc.).
- Determination of viable and total number of cells.
- Measurement of cell size.

- Gross cellular composition of microbial cell. Growth – Factors affecting growth.
- Study of bacterial spores and factors affecting germination.
- Enzyme activity and kinetics – calculating Km and V_{max} of enzyme.
- Demonstration of thermos-, meso-, and psychrophilic micro-organisms.
- Production and testing of inducible enzymes in bacteria.
- Sporulation and spore germination in bacteria.
- Protoplasts formation and regeneration.
- Estimation of generation time and specific growth rate for bacteria and yeast.
- Diauxic growth curve.
- Production of synchronous cells.
- Effect of chemicals and environmental factors on bacterial growth.
- Isolation and Identification of reserve food material (Glycogen/ polyphosphates, PHB) from bacteria (*Azotobacter*, *Bacillus megaterium*).
- Growth of microorganisms on various carbon and nitrogen sources.

VI. Suggested Reading

- Moat, A. G. and J. W. Foster. 2002. *Microbial Physiology*. John Wiley & Sons, New York, USA. 11th ed. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.
- Madigan, M.T, J.M. Martinko and J. Parker. 2006. *Brock: Biology of Microorganisms*, 11th ed. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.
- White, D. 2007. *The Physiology and Biochemistry of Prokaryotes*, 3rd Edition. Oxford University Press.
- Downs, D. M. 2006. *Understanding microbial metabolism*. Annual Review of Microbiology 60, 533–559.
- Hosler *et al.* 2006. *Energy Transduction: Proton Transfer Through the Respiratory Complexes*. Annual Review of Biochemistry 75, 165-187.
- Okuno *et al.* 2008. *Correlation between the conformational states of F1-ATPase as determined from its crystal structure and single-molecule rotation*. PNAS 105(52): 20722-20727.
- Itoh et al (2004) Mechanically driven ATP synthesis by F1-ATPase. Nature 427, 465-468.
- Doelle HW. 1969. *Bacterial Metabolism*. Academic Press.
- Gottschalk G. 1979. *Bacterial Metabolism*. Springer Verlag.
- Nelson DL and Cox MM. 2017. *Lehninger, Principles of Biochemistry*, 4th Edition, W.H.Freeman & Company, 2004. (T1)
- Voet D and Voet JG. 2002. *Fundamentals of Biochemistry*, Upgrade Edition, Wiley.

Journals

- *Journal of Bacteriology*.
- *Advances in Microbial Physiology*.
- *Soil Biology and Biochemistry*.
- *Journal of Applied Bacteriology*.
- *Applied and Environmental Microbiology*.
- *Microbiology*.

Websites

- http://www.asmscience.org
- http://www.asm.org
- http://www.microbiologyonline.org.uk
- http://www.microbeworld.org
- http://www.textbookofbacteriology.net
- https://www.e-education.psu.edu
- http://www.ncbi.nlm.nih.gov/pubmed/12050002
- http://www.journals.elsevier.com/bba-bioenergetics/
- http://www.bmb.leeds.ac.uk/illingworth/oxphos
- http://www.atpsynthase.info/
- https://ocw.um.edu.my/course/view.php?id=67
- https://mic.microbiologyresearch.org/content/journal/micro/10.1099/mic.0.037143-0

I. Course Title : Microbial Genetics

II. Course Code : MICRO 504

III. Credit Hours : 2+1

IV. Theory

Block 1: Introduction to Microbial Genetics

Unit 1: Historical perspectives of microbial genetics

Introduction to Microbial genetics; Historically important events and major contributions of scientists in the field of Microbial genetics; Terminologies employed in microbial genetics and definitions; Nucleic acid – overview DNA, RNA.

Unit 2: Genome of prokaryote, eukaryote (fungi) and virus

Bacterial genome Eukaryotic genome; Viral genome; Difference between prokaryotic and eukaryotic genome; Mechanisms and role of prokaryotic genome- an overview.

Unit 3: Geneticelements - chemical structure and property, enzymes associated and replication

Structure of DNA – A form, B form, Z form; RNA- tRNA, mRNA, rRNA; Role and Replication of DNA and RNA; Enzymes involved in Replication and its role.

Unit 4: Extra-chromosomal DNA in bacteria and eukaryotic cells

Plasmids, Mitochondrial DNA, Chloroplast DNA – structure and function.

Block 2: Gene Expression and Regulation

Unit 1: Introduction to gene structure and expression

Gene structure and eXpression, principles of operon, gene eXpression in prokaryote and eukaryotes, intron and eXons, post transcriptional modifications.

Unit 2: Regulation of gene expression

Regulation of gene eXpression, negative eXpression (lac operon and trp operon), positive regulation (cAMP).

Block 3: Mutation, Genetic Recombination and Sequencing

Unit 1: Principles of mutation and types

Principles of mutation, spontaneous and induced mutation, different types of mutations, selection principles of mutants.

Unit 2: Mutagens and their mode of action

Mutagens and their mode of action, transposable elements and insertion sequences.

Unit 3: DNA damage - DNA repair mechanisms

DNA damage, DNA repair mechanisms in bacteria.

Unit 4: Genetic recombination in bacteria

Genetic recombination in bacteria, mechanisms of recombination, transformation, conjugation, transduction.

Unit 5: Gene sequencing

Gene cloning and gene sequencing. Impact of gene cloning, polymerase chain reaction, DNA sequencing, recombinant DNA technology.

V. Practicals

- Isolation of genomic DNA from pure cultures of bacteria and fungi.
- Visualization of mega plasmids of bacteria.
- Isolation of bacterial plasmids and Plasmid curring.
- Qualitative and quantitative assay of DNA by spectrometry and gel-electrophoresis.

- Inducing mutation by chemicals, physical and biological agents.
- Transformation and selection of transformants.
- Amplification of gene of interest by PCR – cloning and expression.
- Isolation of metagenomic DNA from environmental samples.

VI. Suggested Reading

- Brown TA. 2001. *Gene Cloning and DNA Analysis: An Introduction*. Fourth Edition. Blackwell Science Inc., Oxford, UK.
- Levin B. 2002. *Gene VIII*. Oxford Univ. Press, New York. p.990.
- Maloy SR, Cronan JE, Freifelder D. 2008. *Microbial Genetics* - second edition. Narosa Publising house, New Delhi. p. 525.
- Omoto CK and Lurquin PF. 2004. *Genes and DNA: a beginner's guide to genetics and its applications*. Colambia University Press, USA.
- Sambrook J, Fritsch EF, Maniatis T. 2000. *Molecular Cloning: A laboratory Manuel*. Third Edition. Cold Spring Harbor Press, New York.
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- Birge EA. 1981. *Bacterial and Bacteriophage Genetics*. Springer Verlag.
- Gardner JE, Simmons MJ and Snustad DP. 1991. *Principles of Genetics*. John Wiley& Sons.
- Lewin B.1999. *Gene*. Vols. VI-IX. John Wiley & Sons.
- Maloy SR, Cronan JE and Friedfelder D. 2008. *Microbial Genetics*. Narosa.
- Scaife J, Leach D and Galizzi A 1985. *Genetics of Bacteria*. Academic Press. William Hayes 1981. *Genetics of Bacteria*. Academic Press.
- Strips UN, Yasbin RE *2006. *Modern Microbial Genetics*. Wiley-Liss, NY.

Websites

- http://highered.mcgraw-hill.com/sites/0072552980/student_view0/chapter9/
- http://highered.mcgrawhill.com/sites/0072835125/student_view0/animations.html
- http://cwx.prenhall.com/brock/
- http://www.cliffsnotes.com/sciences/biology/microbiology
- http://plato.acadiau.ca/courses/biol/Microbiology/home.HYPERLINK "http://plato.acadiau.ca/courses/biol/Microbiology/home.html"html
- http://www.learner.org/courses/biology/index.html

I. Course Title : Soil Microbiology

II. Course Code : MICRO 505*

III. Credit Hours : 2+1

IV. Theory

Block 1: Developments in Soil Microbiology and Soil Parameters

Unit 1: Historical prospective of soil microbiology. Factors affecting soil microflora.

Landmarks in the history of soil microbiology. Abiotic factors (physical and chemical) affecting soil microflora as pH, chemicals, moisture, air, temperature etc.

Unit 2: Ecology of soil microbiology

Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Microbial interactions: unculturable soil biota.

Block 2: Microbiology and Biochemistry of Plant Parts

Unit 1: Plant parts and soil interface interaction

Microbiology and biochemistry of root-soil interface; phyllosphere, plant growth promoting rhizobacteria, soil enzyme activities and their importance.

Block 3: Role of Microorganisms in Nutrient Biocycle

Unit 1: Microbial transformation of various nutrients

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Siderophores and antimicrobials.

Unit 2: Microbial degradation of organic matter

Biochemical composition and biodegradation of soil organic matter and crop residues.

Unit 3: Microbial diversity

Endophytic microorganisms Mycorrhizae, types and role in phosphate mobilization. Potassium releasing bacterium. Microbes in biotic and abiotic stress management.

Unit 4: Role of microorganisms in biodegradation of xenobiotics and pesticides

Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures: Biotic factors in soil development.

VI. Practicals

- Determination of soil microbial population
- Determination of Soil microbial biomass
- Decomposition studies in soil, Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification
- N_2 fixation, S oxidation, P solubilization and mineralization of other micro nutrients
- Study of rhizosphere effect
- Microbial diversity Endophytic microorganisms
- Mycorrhizae, types and role in phosphate mobilization Potassium releasing bacterium
- Microbes in biotic and abiotic stress management

VII. Suggested Reading

- Paul EA. 2015. *Soil Microbiology, Ecology and Biochemistry*. Elsevier

- Jan Dirk Van Elsas, Trevors JT and Elizabeth M.H. Wellington, 1997. *Modern Soil Microbiology*. Marcel Dekker, Inc.
- Paul EA. 2007. *Soil Microbiology and Biochemistry* 3rd Edition. Academic Press.
- Cardon ZG and Whitbeck JL. 2007. *The Rhizosphere An Ecological Perspective.* Academic Press.
- Schulz BJE, Boyle CJC and Sieber TN (Edrs). 2006. *Microbial Root Endophytes*. Pub Springer.
- Magesin R and Schinner F. (Edrs). 2005. *Manual of soil analysis monitoring and assessing soil Bioremediation*. Pub: Springer.
- Pinton R, Varanini Z and Nannipiers P. The Rhizosphere Biochemistry & organic substances at the soil-plant interface. Pub: CRC Press.
- Prasad TV. 2011. *A Text Book of Soil Microbiology*. Dominant Publishers & Distributors, New Delhi.
- Mukerji KG, Manoharachary C and Singh J. 2006. *Microbial activity n the Rhizosphere.* Pub: Springer.

Journals

- *European Journal of Soil biology*.
- *Canadian Journal of Microbiology*
- *Annual Review of Microbiology*
- *Journal of the Indian Society of Soil Science.*
- *Soil Biology and Biochemistry*
- *Applied soil ecology*

Websites

- www.nature.com
- www.microbiologysociety.org
- www.sare.org

I. Course Title : Microbial Biotechnology

II. Course Code : MICRO 506

III. Credit Hours : 2+1

IV. Theory

Block 1: Scope of Microbial Technology and Fermentation Metabolism

Unit1: Microbial Biotechnology:

Introduction, Scopes, historical development, application and challenges.

Unit 2: Fermentation Metabolism

Fermentative metabolism, isolation, preservation screening and genetic improvement of industrially important microbes; Microbial growth kinetics.

Unit 3: Fermenter/bioreactor design and operation

Fermenters – types of fermenter, stirred tank reactor, bubble column reactor, airlift reactor, packed bed reactor, fluidized bed reactor and trickle bed reactor, agitation and aeration in a reactor, mass transfer. Foam formation and control.

Unit 4: Fermentation system

Types, Batch, Fed batch and continuous fermentation- multistage system. Solid state fermentation, Overproduction of primary and secondary metabolites e.g. amino acids, organic acids, alcohols, enzymes, organic solvents, antibiotics, etc. Immobilization of enzymes; and cells; Scale-up principles; Down-stream processing, etc.

Block 2: Recombinant Products

Unit 1: Production of recombinant

Current advances in production of antibiotics, vaccines, and biocides; Steroid transformation; Bioprocess engineering; Production of recombinant DNA products, Immobilization techniques.

Block 3: Microbial Conversion and their Product Formation

Unit 1: Industrial production of beverages, acid and solvent

Production of alcohol (ethanol, wine and beer) and improvement by genetic engineering. Microbial production of acids (citric, acetic and gluconic acid) solvents (glycerol acetone and butanol) aminoacids (lysine and glutamic acid).

Unit 2: New tools and recent advances in microbial biotechnology

Concept of probiotics and applications of new tools of biotechnology for quality feed/food production; Microorganisms and proteins used in probiotics; Lactic acid bacteria as live vaccines; Bioconversion of substrates, anti-nutritional factors present in feeds; Microbial detoXification of aflatoXins; Microbial polysaccharides: fermentative production of Xanthan gums. Bacterial bioplastics, genetic engineering of microorganisms for the production of poly-3 hydroXyalkanoates. Single cell protein, Bio-insecticides; Bio-fertilizers; Waste as source of energy/food Microbiologically-produced food, colours, and flavours. Retting offlaX. Recent advances in microbial biotechnology.

V. Practicals

- Isolation and maintenance of industrially important microbes
- Production of alcohol
- Production of beer

- Production of citric acid
- Production of lactic acid
- Standardization of physical factors for the higher production of citric acid
- Production and assay of antibiotics
- Production of pullulan
- SCP production
- Study of bioreactors and their operation

VI. Suggested Reading

- Cruger W and Cruger A. 2004. *Biotechnology - A Textbook of Industrial Microbiology*. 2nd Ed. Panima.
- Ward OP. 1989. *Fermentation Biotechnology*. Prentice Hall.
- Wiseman A. 1983. *Principles of Biotechnology*. Chapman & Hall
- Peppler HJ and Perlman D.1979. *Microbial Technology*. 2nd Ed. Academic Press.

Websites

- http://www.asmscience.org
- http://www.asm.org
- http://www.microbiologyonline.org.uk
- http://www.microbeworld.org

I. Course Title : Food Microbiology

II. Course Code : MICRO 507*

III. Credit Hours : 2+1

IV. Theory

Block 1: Historical Perspective and Scope of Microbiology in Relation to Food

Unit 1: Importance and significance of microorganisms in food

Introduction and scope; Food Microbiology Important microorganisms in food and their sources. Importance and significance of microorganisms in food.

Unit 2: Factors of special significance in Food Microbiology

Intrinsic and extrinsic factors influencing microbial growth in foods; Spores and their significance; Indicator organisms and Microbiological criteria.

Unit 3: Microbial spoilage of different types of foods

Microbial spoilage of meat, milk, fruits, vegetables and their products. Food-borne pathogens (bacteria, fungi and viruses) and intoxication.

Block 2: Fermentation and Food Preservation Methods

Unit 1: Food fermentation

Fermented dairy, vegetable, meat products.

Unit 2: Preservatives and preservation methods

Physical methods, chemical preservatives and natural antimicrobial compounds. Biologically based preservation systems. Foods for Specified Health Probiotic bacteria; Bifidus factor. Bacteriocins and their applications; Pre-, probiotics and symbiotics. Microbes as food single cell protein.

Block 3: Food Safety and Quality Management Systems

Unit 1: Advanced techniques in detecting food-borne pathogens and toxins

Food safety and Quality Management Systems- General principles of food safety risk management, Recent concerns on food safety- Safe food alternatives (Organic foods), Good agricultural Practices (GAP), Food Indicators of water and food safety and quality Advanced techniques in detecting food-borne pathogens and toxins. HACCP (Hurdle technology and Hazard analysis. Critical control point) CODEX, FSSAI (Food Safety and Standard Authority of India) systems in controlling microbiological hazards infoods. Food safety regulations

V. Practicals

- Statutory, recommended and supplementary tests for microbiological analysis of various foods
- Infant foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers, normal, spoiled, processed, fermented food and water
- Testing of antimicrobial agents
- Analysis of water
- HACCP Plan
- Visit to Food processing Industries

VI. Suggested Reading

- Bibek Ray. 1996. *Fundamentals of Food Microbiology*. CRC Press.
- Frazier W.C. and Westhoff D.C. 1991. *Food Microbiology*. 3rd Ed. Tata McGraw Hill.
- George J Banwart. 1989. Basic Food Microbiology. AVI. James M Jay. 1987. Modern Food Microbiology. CBS.

- Peppler H.J. and Perlman D. 1979. *Microbial Technology*. 2nd Ed. Academic Press.
- Adams, M.R., and M. O. Moss 1996. *Food Microbiology*, New Age International (Rt) Ltd., New Delhi.
- Frazier, W.C. and D.C. Westhoff, 1988. *Food Microbiology* (Reprint 1995), Tata McGraw Hill Publishing Ltd., New Delhi.
- James M. Jay., Loessner, M.J. and Golden D.A. 2005. *Modern Food Microbiology*, Seventh edition.
- Verma, L.K. and Joshi, V.K. 2000. *Post Harvest Technology of Fruits and Vegetables*, Tata McGraw Hill Publication.
- Bhunia AK. 2008. *Foodborne Microbial Pathogens- Mechanisms and Pathogenesis, Food Science text Series*, Springer International, New York, USA.
- Benwart, G.J. 1987. *Basic Food Microbiology*, CBS Publishers & Distributors, New Delhi.
- Deak, T. and Beuchat LR. 1996. *Hand Book of Food Spoilage Yeasts*, CRC Press, New York.
- Doyle, M.P. and Beuchat, L. R. 2007. *Food Microbiology- Fundamentals and Frontiers*, ASM Press.
- Garbutt, J., 1997. *Essentials of Food Microbiology*, Armold – International Students edition, London.
- Marriott, N.G. and Gravani R. B. 2006. *Principles of Food Sanitation, Food Science text Series*, Springer International, New York, USA.

Websites

- https://www.journals.elsevier.com/food-microbiology
- https://www.nature.com/subjects/food-microbiology
- https://www.frontiersin.org/journals/microbiology/sections/food-microbiology
- https://www.sciencedirect.com/journal/food-microbiology

I. Course Title : Bacteriophages
II. Course Code : MICRO 508
III. Credit Hours : 1+1

IV. Theory

V. Block 1: Bacteriophages

Unit 1: Historical prospective of bacteriophages.

Historical developments and classification of bacteriophages.

Unit 2: Biological processes of phage bacterial interaction

Physiology, biochemistry, enzymology and molecular biology of phage- bacterial interactions.

Unit 3: Life cycle of bacteriophages.

Structure, functions and life cycles of P2 phage, Lambda phage, M13 phage, ÕX174 phage.

Unit 4: Biotechnological Genetic manipulation

Phages in the development of molecular biology and genetic engineering.

VI. Practicals

- Titration of phages and bacteria.
- Absorption of phages.
- Preparation of phage stocks.
- Isolation of new phages and phage resistant bacteria.
- One step growth curve, phage bursts.
- Induction of lambda.
- Complementation of T_4*rII* mutantsetc.

VII. Suggested Reading

- Birge EA. 2000. *Bacterial and Bacteriophage Genetics*. Springer-Verlag. Mathew CK. 1972. *Bacteriophage Biochemistry*. Am. Chemical Soc.
- Mathew CK, Kutter EM, Mosig G & Berget P. 1988. *Bacteriophage T4*. Plenum Press.
- Nancy T and Trempy J. 2004. *Fundamental Bacterial Genetics*. Blackwell. Stent SG. 1963. *Molecular Biology of Bacterial Viruses*. WH Freeman and Co.
- Winkler J, Ruger W and Wackernagel W. 1979. *Bacterial, Phage and Molecular Genetics - An Experimental Course*. Narosa.
- Winkler U and Rugr W. 1984. *Bacteria, Phage and Molecular Genetics*. ALA.

Websites

- https://www.nature.com/scitable/definition/bacteriophage-phage-293
- https://www.phe-culturecollections.org.uk/news/nctc-news/the-rise-and-rise-of-bacteriophages. aspx
- https://www.khanacademy.org/science/biology/biology-of-viruses/virus-biology/a/bacteriophages

I. Course Title : Environmental Microbiology

II. Course Code : MICRO 509

III. Credit Hours : 2+1

IV. Theory

Block 1: Microbial Ecology

Unit 1: Scope of Environmental microbiology and Ecological Niche

Scope of environmental microbiology,Microbial ecology: Microbial evolution and biodiversity – Ecological niches – Definitions, biotic and abiotic environment. Environmental segments. Composition and structure of environment. Concept of biosphere, communities and ecosystems. Ecosystem characteristics, structure and function. Food chains, food webs and trophic structures. Ecological pyramids.

Unit 2: Microorganisms and their natural habitats

Microorganisms and their natural habitats: Aeromicrobiology, Astrobiology, Methane and chlorates on Mars, terrestrial analogues. Biofilms and microbial mats, Aquatic ecosystems- Public Health Microbiology.

Unit 3: Extremophiles

Extremophiles: Definition and ecological aspects. Thermophiles, Xerophiles, Psychrophiles, Piezophiles, Alkaliphiles, Acidophiles- Halophiles and Barophiles. Environmental Distribution and Taxonomic Diversity, Physiology, Adaptive mechanisms, Enzymes, Applications.

Block 2: Microbial Interaction

Unit 1: Biogeochemical cycles

Biogeochemical cycling and its consequences. Global environmental problems.

Unit 2: Waste water and solid waste treatment

Microbiology of wastewater and solid waste treatment: - Waste-types-solid and liquid waste characterization, physical, chemical, biological, aerobic, anaerobic, primary, secondary and tertiary treatments. Anaerobic processes-Bioremediation of nuclear wastes. Bioconversion of Solid Waste and utilization as fertilizer. Bioaccumulation of heavy metal ions from industrial effluents. Biomining.

Microbiology of degradation of xenobiotics in the environment, ecological considerations, decay behavio

Unit 3: Microbial upgradation in fossil fuels and interaction in rumen and gastrointestinal tract.

Microbial upgradation of fossil fuels and coal gas. Microbial interaction in rumen and gastrointestinal tract.

V. Practicals

- Determination of indices of pollution by measuring BOD/COD of different effluents.
- Analysis of natural waters.
- Quality control tests, waste treatment and anaerobic digestion; Demonstration of waste water treatment processes such as activated sludge processes, biofilter and fluidized bed process.
- Bacterial reduction of nitrate from ground waters.
- Isolation and purification of degradative plasmid of microbes growing in polluted environments.
- Recovery of toxic metal ions of an industrial effluent by immobilized cells.
- Utilization of microbial consortium for the treatment of solid waste [Municipal Solid Waste]
- Biotransformation of toxic metal ions into non-toxic metals ions.
- Microbial dye decolourization/adsorption.
- Biotrap based isolation of selective functional microbes.
- Thermophlic enzyme in biomass deconstructions.
- Halophilic microbes from salt lake-Pesticide degradation by microbes

VI. Suggested Reading

- Campbell R. 1983. *Microbial Ecology*. Blackwell.
- Hawker LE & Linton AH. 1989. *Microorganisms Function, Form and Environment*. 2nd Ed. Edward Arnold.
- Richards BN. 1987. *Microbes of Terrestrial Ecosystem*. Longman.
- Mitchell R. 1992. *Environmental Microbiology*. John Wiley & Sons.
- Baker K.H. and Herson D.S. 1994. *Bioremediation*. McGraw Hill Inc., N.Y.
- Metcalf and Eddy HP. 2004. *Waste Water Engineering - Treatment, Disposal and Re-use* Inc., Tata McGraw Hill, New Delhi.
- McEldowney S Hardman DJ and Waite S. 1993. *Pollution: Ecology and Biotreatment* Longman Scientific Technical.
- Mitchell R, and GuJi-Dong. 2010. *Environmental Microbiology*. John V, Wiley Sons. Inc.
- Waste Water Microbiology 2nd Edition. Bitton. Chemistry and Ecotoxicology of pollution. Edited by Des. W. Connell, G.J. Miller. Wiley Interscience Publications.
- Bitton G. 2010. *Waste Water Microbiology* 2nd Edition.
- Connell OW and Miller GJ. 1984. *Chemistry and Ecotoxicology of pollution*. Wiley Interscience Publications.
- Forster CF and John Wase DA. *Environmental Biotechnology*. Ellis Horwood Ltd. Publication.
- Trivedi RK. 1998. *Advances in Waste Water Treatment Technologies*. Volumes II and I Global Science Publication.
- Lawrence P, Wacekett C and Hershberger D. 2000. *Biocatalysis and Biodegradation: Microbial transformation of organic compounds*. ASM Publications.
- Hurst CJ. 2001. *A Manual of Environmental Microbiology*. 2nd Edition. ASM Publications.

Websites

- http://microbiology.ucsc.edu.
- http://www.asm.org

I. Course Title : Industrial Microbiology

II. Course Code : MICRO 510

III. Credit Hours : 2+1

IV. Theory

Block 1: Basics of Industrial Microbiology

Unit 1: Historical account of microbes in industrial microbiology

Introduction to Industrial Microbiology. Sources and characters of industrially important microbes; their isolation, purification and maintenance.
types of fermentation and fermenters. Microbial growth kinetics in batch, continuous and fed-batch fermentation process.

Unit 2: Fermented Microbial products

Bioreactors: Types and configuration. Microbiology and production of alcoholic beverages; Malt beverages, distilled beverages, wine and champagne; Commercial production of organic acids like acetic, lactic, citric, and gluconic acids Commercial production of important amino acids (glutamic acid, lysine and tryptophan), vitamins (riboflavin and vitamin A), enzymes, antibiotics and single cell proteins.

Block 2: Bioplastics, Biopolymers and Biofuels

Unit 1: Biocontrol agents and Biopesticides

Biocontrol agents and Biopesticides: Biocontrol agents and their scope in control of plant diseases, nematodes and insect pests. Role of bioagents in sustainable agriculture.

Unit 2: Industrial production of Bioplastics and biopolymers

Introduction & industrial production of Bioplastics: Microorganisms involved in synthesis of biodegradable plastics and microbial pigments and biopolymers.Biosensors: Development of biosensors to detect food contamination and environment pollution. Biofuels: Production of ethanol, biogas and hydrogen from organic residues, fuels from algae; Mushroom cultivation.

Unit 3: Production of valuable products

Genetic engineering of microbes, Role of recombinant microbes in industrial sectors for enhanced production of valuable products. Mechanisms of pesticide degradation by microbes. Biomining: Coal, mineral and gas formation, prospecting for deposits of crude, oil and gas, recovery of minerals from low-grade ores.

V. Practicals

- Isolation and purification of industrially important microbes (Bacteria, fungus and yeasts)
- Production of industrial compounds such as alcohol, beer, citric acid, lactic acid

  acetic acids gluconic acid and their recovery
- Demonstration of biogas production
- Production and assay of enzymes, organic acids and pigments
- Mass production of biocontrol agent
- Visit to industries

VI. Suggested Reading

- Sylvia DM, Fuhrmann JJ, Hartlly PT and Zuberer D. 2005. *Principles and Applications of Soil Microbiology*. 2nd Ed. Pearson Prentice Hall Edu.
- Waites, M.J., Morgan, N.L., Rockey, J.S. and Higton, G. (2002). *Industrial Microbiology: An Introduction*. Blackwell Science Publishers.

- Crueger W and Crueger A. *Biotechnology: A Text Book of Industrial Microbiology* Panima Publishing Corporation.
- Reed G. 1999. *Prescott and Dunn's Industrial Microbiology*. CBS Publishers.
- Demain AL. 2001. *Industrial Microbiology and Biotechnology* IInd Edition. ASM Press, Washington.
- Stanbury PF, Whitaker W and Hall SJ. 1997. *Principles of Fermentation Technology* Aditya Books (P) Ltd., New Delhi.
- Baltz RH, Davies JE and Demain AL. 2010. *Manual of Industrial Microbiology and Biotechnology*. 3rd Edition, ASM Press.
- Forciniti D. 2008. *Industrial Bioseparations: Principles and Practice*. 1st Edition, Wiley-Blackwell.
- OkaferN. 2007. *Modern Industrial Microbiology and Biotechnology*, Scientific Publishers, Enfield, USA.
- Nduka O and Benedict OC. 2018. *Modern Industrial Microbiology and Biotechnology*, Taylor and Francis 465p.
- ElMansi EMT, Bryce CFA, Dahhou A, Sanchez S, Demain AL, Allman AR. 2012. *Fermentation Microbiology and Biotechnology* 3rd Ed. CRC Press, Taylor and Francis, Boca Raton.
- Stanbury AF and Whitaker A. 1984. Principles of Fermentation Technology –Oxford Pergamon press New York.
- Moses V and Cape RE. 1991. *Biotechnology* - The Science and the Business Harwood Academic Publishers, USA.
- Casida LE Jr. 1989. *Industrial Microbiology* Wiley Eastern Ltd., N. Delhi.
- Miller BM and Litsky W. 1976. *Industrial Microbiology*, McGraw Hill Co.,New York 451p.
- Crueger W and Crueger A. 1984. *Biotechnology – a Text book of Industrial Microbiology*. Science Tech. Inc., Madison.
- Glazer AN and Nikaido HN. 1995. *Microbial Biotechnology: Fundamentals of Applied Microbiology*, W.H.Freeman Co., New York.
- Demain AL and Solomon MA. 1986. *Manual of Industrial Microbiology and Industrial*

Microbiology, American Society of Microbiology, Washington.
- Atkinson B and Marituna F. 1983. *Biochemical Engineering and Biotechnology* Handbook, McMillian Publishers.
- Jones DG. 1983. *Exploitation of Microorganisms*. Chapman & Hall, Oxford.
- Peppler HJ and Perlman D. 1979. Microbial technology Vol.1 Fermentation Tecnology, Vol.2, Academic Press.
- Rehm HJ and Reed G. 1995. *Biotechnology, a Comprehensive Treatise*, 8 Vols. (Reference Book) Verlag Chemie,Wienheim. Also refer Second edition, 12 vols,1995 (Rehm,H.J.: Reed, G.: Puhler,A; Stadler, P Eds)
- Moo-Young Y. 1985. *Comprehensive Biotechnology*- 5 vols. (Reference Book) Pergamon Press, Oxford.
- Arora DK. 1992. *Handbook of Applied Mycology* – 5 Vols. (Reference Book) Marcel Dekker, New York.
- Glick BR and Pasternak JJ. 2003. *Molecular Biotechnology-principles and applications of recombinant* DNA,ASM press,Washington,760 pp.

Also consult latest issues of:
- Advances in Applied Microbiology, Biotechnology Advances,
- Biotechnology & Genetic Engineering Reviews,Advances in Biochemical Engineering & Biotechnology, Advances in Microbial Physiology

Websites
- https://www.biomerieux.com/en/industrial-microbiological-control-0
- https://icar.org.in/content/food-and-industrial-microbiology

I. Course Title : Biofertilizer Technology

II. Course Code : MICRO 511

III. Credit Hours : 2+1

IV. Theory

Block 1: Agriculture Important Beneficial Microorganisms

Unit 1: Agriculturally important beneficial nitrogen fixing microorganisms.

Different agriculturally important beneficial microorganisms: Chemical Vs Biofertilizers: Current Scenario in biofertilizer technology in world-In India-List of biofertilizers-their applications in agriculture.

Brief introduction about Agriculturally beneficial microorganisms (free living, symbiotic (rhizobial, actinorhizal), associative and endophytic nitrogen fixers including phosphobacteria, cyanobacteria, their types and importance taxonomic classification, Nitrogen fixing biofertilizers: nodule formation, competitiveness and quantification of N_2 fixed and their use. Mechanism of phosphorous solubilization by photobacteria. BIS standards of biofertilizers

Unit 2: Agriculturally important beneficial microorganisms related to phosphorous, potassium, Sulphur and Zinc nutrition

Different agriculturally important beneficial microorganisms: phosphate solubilizing bacteria and fungi, including mycorrhiza; Mechanism of phosphorous solubilization by phosphobacteria. Bacteria for potassium, Sulphur and Zinc nutrition.

Unit 3: Agriculturally important beneficial microorganisms having plant growth promoting rhizobacteria.

Different agriculturally important beneficial microorganisms: plant growth promoting rhizobacteria. FCO norms and biofertilizer production and usage at national and international levels

Unit 4: Agriculturally important biocontrol microbial inoculants

Different agriculturally important beneficial microorganisms: Biocontrol microbial inoculants. Requirements for establishing bioinoculants production unit Economics of biofertilizers production Constraints in biofertilizers production and usage

Unit 5: Economics of biofertilizer production

Different agriculturally important beneficial microorganisms for recycling of organic waste and compositing, bioremediators and other related microbes.

Block 2: Production of Biofertilizer

Unit 1: Production and quality control of biofertilizer

Different agriculturally important beneficial microorganisms - selection, establishment, competitiveness, crop productivity, soil & plant health, mass scale production and quality control of bio inoculants. Biofertilizer inoculation and microbial communities in the soil. Different formulations of biofertilizers. Advantages and limitations of Liquid formulations.

V. Practicals

- Isolation of phosphate solubilizing microorganisms.
- Development and production of efficient microorganisms,
- Determination of beneficial properties in important bacteria to be used as biofertilizer, Nitrogen fixing activity, indole acetic acid (IAA), siderophore production etc,
- Bioinoculant production and quality control.

- Population dynamics in broth and carrier materials during storage.
- Development of cultures from starter.
- Preparation of broth for large scale cultivation in fermenter/ large containers. Inoculation and development of culture.
- Mass production of carrier based and liquid biofertilizers. Mass production of important two or three biocontrolagents (*Trichoderma viride, Pseudomonas fluorescens* and *Metarhiziumanisopliae*).
- Form, dose and method of application.
- Mass production of AM fungi in pot and root organ culture.
- Quality control and BIS standards.
- Mass production of Azolla and BGA.
- Visit to a biofertilizer production plant

VI. Suggested

ReadingBooks

- AleXander M. 1977. *Soil Microbiology*. John Wiley.
- Bergerson FJ. 1980. *Methods for Evaluating Biological NitrogenFixation*. John Wiley & Sons.
- Sylvia DM, Fuhrmann JJ, Hartlly PT and Zuberer D. 2005. *Principles and Applications of Soil Microbiology*. 2nd Ed. Pearson Prentice Hall Edu.
- Van Elsas JD, Trevors JT and Wellington EMH. 1997. *Modern Soil Microbiology*. CRC Press.
- Panwar JDS and Jain AK. 2016. *Organic farming scope and use of biofertilizers*. Pub: NIPA, New Delhi.
- Gaur AC. 2010. *Biofertilizers in Sustainable Agriculture*, ICAR, New Delhi.
- Chanda P and Srivathsa RSH. 2005. *Liquid Biofertilizers*. Ministry of Agriculture Department of Agriculture & Cooperation, GOI.
- DeshMukh AM, Khobragade RM and DiXit PP. 2007. *Handbook of Biofertilizers & Biopesticides*. OXford Book Company, Jaipur, India.
- Gupta RP, Kalia A and Kapoor S. 2007. *Bioinoculants a Step towards Sustainable Agriculture* .NIPA, New Delhi.
- Somani LL, Shilkar P and Shilpkar D. 2011. *Biofertilizers Commercial Production Technology & Quality Control*. AgroPublishing Acadamy, Udaipur.
- Srivastava HS and Singh RP. 1995. *Nitrogen nutrition in higher plants*. Associated Publishing Company, New Delhi.
- Kannaiyan S and Kumar K. 2005. *Azollabiofertiliser for sustainable Rice Production*. Daya Publishing House, Delhi.
- Kannaiyan S, Kumar K and Govindarajan K. 2010. *Biofertilizer Technology*. Scientific Publishers (India), Jodhpur.
- Vora MS, Shelat HN and Vyas RV. 2013. *Handbook of Biofertilizers & Microbial Pesticides*.
- Chanda JK. 2008. *Biofertilizer Statistics 2006-07*. The fertilizer Association of India, New Delhi.

Journals

- *Journal of Biofertilizer& Biopesticides*
- *Journal of Botanical Sciences*

Websites

- Biofertilizer in organic Agriculture (www.Journalphytology.com)
- Microbial biofertilizers (www.Boffinaccess.com)
- Biofertilizer as a prospective input for sustainable agriculture in India. http://www.krishisewa.com/articles/organic-agriculture/115-biofertilizers.html
- Handbook of Microbial Biofertilizers M. K. Rai, PhD Editor Pub: Food Products Press, NY.
- Bio fertilisers https://www.worldcat.org/search?q=biofertilisers&fq=dt%3Abks&dblist=638&qt =sort&se= yr&sd=desc&qt=sort_yr_desc

I. Course Title : Cyanobacterial and Algal Biotechnology

II. Course Code : MICRO 512

III. Credit Hours : 2+0

IV. Theory

Block 1: Importance of Cyanobacteria and Algae

Unit 1: Ecology and evolution of algae and cyanobacteria

Introduction to cyanobacteria and algae. Definition, occurrence and distribution, thallus structure, reproduction, life cycles, origin and evolution of cyanobacteria, molecular evolution; role of algae in evolution of land plants and horizontal transfer of genes. Brief classification of algae: different classes, occurrence and distribution.

Block 2: Physiology and Culturing of Cyanobacteria and Algae

Unit 1: Algal pigments, storage products.

Algal pigments, storage products, physiology and metabolism including photosynthesis.

Unit 2: Metabolism of carbon and nitrogen

Ecology of algae –primary colonizers and cycling in soil and water. Cellular differentiation and nitrogen fiXation, nitrogen metabolism carbon metabolism

Unit 3: Culturing methods

Algal culturing and cultivation. Culture types, culture conditions, culture vessels, culture media, sterilization, culture methods, synchronous cultures, photobioreactors, algal density and growth, seaweed cultivation.

Block 3: Role of Cyanobacteria and Algae in Agriculture and their Products of Industrial Importance

Unit 1: Importance as fuels, neutraceuticals and industrial importance.

Cyanobacterial and algal fuels, Fine chemicals (restriction enzymes etc.) and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae - seaweed biotechnology, sustainable aquaculture. Ecology of algae- distribution in soil and water; primary colonizers, carbon sequestration and cycling in soil and water. Cellular differentiation and nitrogen fiXation, nitrogen metabolism.

Unit 2: Role of algae related to environment.

Algae in pollution control - as pollution indicators, eutrophication agents and role in Bioremediation and reclamation of problem soils. Cyanobacterial and algal toXins, allelopathic interactions, Algae in global warming and environmental sustainability. Cyanobacteria and selected microalgae in agriculture – biofertilizers &algalization; soil conditioners; reclamation of problem soils.

V. Suggested Reading

- Ahluwalia AS. 2003. *Phycology: Principles, Processes and Applications*. Daya Publ.
- Barsanti L and Gualtieri P. 2006. *Algae: Anatomy, Biochemistry and Biotechnology*. Taylor & Francis, CRC Press.
- Carr NG and Whitton BA. 1982. *The Biology of Cyanobacteria*. Blackwell.
- Herrero A and Flores E. 2008. *The Cyanobacteria Molecular Biology,Genomics and Evolution*. Calster Academic Press
- Kumar HD. 2005. *Introductory Phycology*. East West Press. Linda E Graham & Lee W Wilcox. 2000. *Algae*. Prentice Hall.
- Andersen RA. 2005. *Algal Culturing Techniques*. Academic Press.
- Venkataraman LV and Becker EW. 1985. *Biotechnology and Utilization of Algae: the Indian Experience*. DST.

- Das MK. 2010. *Algal Biotechnology*. Daya Publishing House.
- Tiwari. 2014. *Cyanobacteria: Nature, Potentias and Applications*. Daya Publishing House.
- Khattar JIS, Singh DP, Kaur G. 2009. *Algal Biology and Biotechnology*. I.K. International Publishing HousePvt. Ltd.
- Bhatnagar SK, Saxena A, Kraan S. 2011. *Alga Biofuels*. Stadium Press (India) Pvt. Ltd.
- Sahoo D and Kaushik BD. 2012. *Algal Biotehcnolgoy and Environment*. I.K. International Publishing HousePvt. Ltd.

Journals

- *Journal of Phycology*
- *Journal of Applied Phycology*
- *Frontiers in Microbiology*

Websites

- Cyanbacterial and algal Biotechnology
- https://www.worldcat.org/search?q=cyanobacterial+and+algal+biotechnology&qt=results_page#%2528x0%253Abook%2Bx4%253Aprintbook%2529format
- www.cyanosite.bio.purdue.edu
- http://www.asmscience.org
- http://www.asm.org
- http://www.microbiologyonline.org.uk
- http://www.microbeworld.org
- http://www.bbsrc.ac.uk/organisation/policies/reviews/scientific-areas/1107-algal-research.aspx
- http://asulightworks.com/resources/videos/arizona-center-algae-technology-and-innovation.html

Course Title with Credit load
Ph.D. in Microbiology

Course Code	Course Tittle	Credit Hours
MICRO 601*	Improvement in fermentation Technology	2+1
MICRO 602	Microbial physiology and regulation	2+0
MICRO 603*	Recent development in soil microbiology	2+0
MICRO 604	Recent approaches in environmental microbiology	2+0
MICRO 605*	Plant microbe interactions	2+1
MICRO 691	Doctoral seminar I	1+0
MICRO 692	Doctoral seminar II	1+0
MICRO 699	Doctoral Research	75

*Core Courses

Course Contents
Ph.D. in Microbiology

I. Course Title : Improvements in Fermentation Technology
II. Course Code : MICRO 601*
III. Credit Hours : 2+1

IV. Theory

Block 1: Rise of Fermentation Technology

Unit 1: Development in Fermentation

Definition of fermentation – rise of fermentation technology –current trends in fermentation industry – scope and importance of fermentation technology.

Unit 2: Types of fermenters

Continuous, batch and fed batch culture –anaerobic fermentation - range of fermentation process – microbial growth cycle – diauXic growth – growth kinetics – substrate uptake kinetics (Jacob and Monod) - primary and secondary metabolites – future prospects of fermentation microbiology

Block 2: Fermenter

Unit 1: Components of fermenter and use

Peripheral parts and accessories – alternative vessel designs –containment in fermentation – fermenter preparation and use - aeration and agitation – instrumentation and control – biosensors in monitoring – computer applications in fermentation technology

Block 3: Fermentation Process

Unit 1: Types of Fermentation

Solid state and submerged fermentation – acidic/alcoholic fermentation - recovery of product – effluent treatment – Economics of fermentation

Block 4: Recombinant Strategies Followed

Unit 1: Strategies for isolation of industrially important microbes

New strategies for isolation of industrially important microbes and their genetic manipulations; Antibiotic fermentation research; steroid transformation; Yeast technology – classification, genetics, strain improvement for brewing, baking and distilleries

V. Practicals

- Studying the various components of fermenter
- eXposure to different types of fermenter
- sterilization and operating procedures
- designing the production medium
- isolation and purification of industrially important microbes
- Genetic manipulations in microbes
- Fermentation by improved strains of yeast for production of alcohol
- microbial production of enzymes by solid state fermentation
- Microbial production of important antibiotics

- Bioremediation of industrial effluents

VI. Suggested Reading

- Stanbury PF, Whitaker A and Hall SJ. *Principles of fermentation technology*, Second edition
- Patel AH. *Industrial Microbiology*
- ElMansi EMT and Bryce CFA. *Fermentation Microbiology and Biotechnology*
- Srivastava ML. *Fermentation Technology*
- Singh T and Purohit SS. *Fermentation Technology*
- ElMansi EMT, Bryce CFA, Demain AL and Allman AR. *Fermentation Technology – Microbiology and Biotechnology*
- Peppler HJ and Perlman D. 1979. *Microbial Technology*. 2nd Ed. Academic Press.
- Reed G. 1987. *Presscott& Dunn's Industrial Microbiology*. 4th Ed. CBS.
- Stanbury PF and Whitaker A. 1987. *Principles of Fermentation Technology*. Pergamon Press.
- Wiseman A. 1983. *Principles of Biotechnology*. Chapman & Hall.

Websites

- http://www.asmscience.org
- http://www.asm.org
- http://www.microbiologyonline.org.uk
- http://www.microbeworld.org
- http://www.scribd.com/doc/46151150/Fermentation-Technology
- http://www.chalmers.se/en/areas-of-advance/lifescience/research/Pages/Fermentation-Technology.aspx
-

I. Course Title : Microbial Physiology and Regulation

II. Course Code : MICRO 602

III. Credit Hours : 2+0

IV. Theory

Block 1: Historical Evaluation of Microbial Physiology

Unit 1: Molecular aspects of various cell component

Origin, evolution, structure, function and molecular aspects of various cell components. Differentiation in bacteria, slime molds, yeasts. Molecular biology of bioluminescence, bacterial virulence. Heat shock response. Extracellular protein secretion in bacteria.

Block 2: Regulation and Pathways

Unit 1: Regulatory Pathways

Regulation of initiation, termination and anti-termination of transcription. Global regulation and differentiation by sigma factor. Regulatory controls in bacteria - inducible and biosynthetic pathways. Oxidative stress control. Fermentative and respiratory regulatory pathways.

Unit 2: Regulatory control

Ribosomal RNA and ribosomal proteins regulation under stress condition. Specific regulatory systems; SOS regulatory control; Antisense RNA regulation of gene expression.Biosynthesis of micromolecules (Nucleotides and Aminoacids) macromolecules (DNA, RNA, Proteins) Global nitrogen control and regulation of nitrogen fixation

Unit 3: Current topics

Topics of current interest in Molecular microbiology and regulatory systems.

V. Suggested Reading

Websites

- https://www.frontiersin.org/journals/microbiology/sections/microbial-physiology-and-metabolism
- https://www.sciencedirect.com/bookseries/advances-in-microbial-physiology
- https://www.researchgate.net/journal/0065-2911_Advances_in_Microbial_Physiology
- https://bmb.psu.edu/undergraduate/courses/course-archive/2016/fall-2016/microbiology-micrb/micrb-401-fall-2016/micrb-401-microbial-physiology-and-structure
- Selected articles from journals.

I. Course Title : Recent Developments In soil microbiology

II. Course Code : MICRO 603*

III. Credit Hours : 2+0

IV. Theory

Block 1: Recent Developments in Soil Microbiology

Unit 1: Ecology and microorganisms diversity

Molecular ecology and biodiversity of soil microorganisms; Survival and dispersal of microorganisms. Interaction between agricultural chemicals, pollutants and soil microorganism

Unit 2: Role of microorganisms in soil

successions and transformation of organic matter; Role of microorganisms in soil fertility. Soil health and quality: Microbial indicators

Unit 3: Bioremediation

Bioremediation of polluted soils; Biological control. Other topics of current interest.

V. Suggested Reading

Websites

- https://www.springer.com/in/book/9789811073793
- https://www.researchgate.net/publication/322952969_Advances_in_Soil_Microbiology_ Recent_ Trends_and_Future_Prospects_Volume_2_Soil-Microbe-Plant_Interaction
- Selected articles from journals.

I. Course Title : Recent Approaches in Environmental Microbiology

II. Course Code : MICRO 604

III. Credit Hours : 2+0

IV. Theory

Block 1: Recent Environmental Issue

Unit 1: Basic concept and environmental issues

Types of environmental pollution; problems arising from high-input agricultural residues. Air and water pollution.

Unit 2: Methodology of environmental management

Waste water treatment -physical, chemical, biological and microbial processes; need for water and natural resource.

Unit 3: Microbial waste treatment

Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents, etc.; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc.); anaerobic processes: digestion, filtration, etc.

Block 2: Energy Harnessing from Organic Waste

Unit 1: Pollution through conventional fuel

Conventional fuels and their environmental impact.

Unit 2: Renewable sources of energy.

Energy from solid waste; ; biogas; land filling, microbial hydrogen production; use of agro-industrial waste, agricultural waste for sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture, etc.

Block 3: Treatment of Waste for Safe Disposal

Unit 1: Disposal of domestic and industrial wastes.

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by micro – organisms.

Unit 2: Global environmental problems

Ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; Microbial and biotechnological approaches for the management of environmental problems.

V. Suggested Reading

- Evans GM and Furlong JC. 2002. *Environmental Biotechnology: Theory and Application*. Wiley International.
- Jordening HJ and Winter J. 2006. *Environmental Biotechnology: Concepts and Applications*. Wiley-VCH Verlag.

Websites

- https://www.springer.com/series/11961
- http://microbiology.ucsc.edu.
- http://www.asm.org

I. Course Title : Plant Microbe Interactions

II. Course Code : MICRO 605*

III. Credit Hours : 1+1

IV. Theory

Block 1: Types of Ecosystem and Microbial Interaction

Unit 1: Different interfaces of interactions

Plant-microbe, microbe-microbe, soil- microbe, soil-plant-microbe interactions leading to symbiotic (rhizobial and mycorrhizal, *Azolla-Anabaena*), associative, endophytic and pathogenic interactions.

Unit 2: Ecosystem- Concept and Dynamics

Types of ecosystems: Concept and dynamics of ecosystem, Food chain and energy flow, Microbial communities in the soil. Community dynamics and population interactions employing DGGE, TGGE, T-RFLP.

Block 2: Signaling and Interaction among Microbes

Unit 1: Microbial interaction

Quorum-sensing in bacteria, flow of signals in response to different carbon or other substrates and how signals are recognized.

Block 3: Genomic and Proteomic Study in Plant Microbe Interaction

Unit 1: Methodology/resources in plant-microbe interaction

Methodology/resources to study plant-microbe interaction, biosensors, transcriptome profiling, metabolic profiling, genomics, and proteomics Induced systemic resistance against pathogens and tolerance against abiotic stress: Molecular basis; Molecular diversity of microbes, plants and their interactions including transgenic microbes and plants

V. Practicals

- Phylochip based microbial community analyses-
- Endophytic and phyllosphere microbial community
- PCR-DGGE-Rhizosecretion
- secretome -FT-IR, HPLC
- Multifunctional protein identification and characteriation-2DE, MALDI-TOF.
- Examination of mycorrhizal infection in roots of different plants.

- Characterization of PGPR; Quantification of siderophores, HCN and IAA

VI. Suggested Reading

- Kosuge T and Nester, E.W. 1989. *Plant Microbe Interactions: Molecular and Genetic Perspectives*, Vol.I-IV, McGraw Hill.
- Paul Eldor, A. 2007. *Soil Microbiology, Ecology and Biochemistry*
- Robert L. Tate III. 1995. *Soil Microbiology*, John Wiley & Sons, INC.
- Sylvia David, M., Fuhrmann, T.A., Hartel, P.G. and Zuberer, D.A. 2005. *Principles and Applications in Soil Microbiology* (II nd Edition).
- Verma, D.P.S. and Kohn, T.H. 1984. *Genes involved in Microbe-Plant Interactions*, Springer-Verlag
- Jaya Kumar Arjun, Kumarapillai Harikrishnan. 2011. Metagenomic analysis of bacterial diversity in the rice rhizosphere soil microbiome. *Biotechnol. Bioinf. Bioeng*. 1(3): 361-367
- Andrea Porras-Alfaro and Paul Bayman.2011. Hidden Fungi, Emergent Properties: Endophytes and Microbiomes. *Annu. Rev. Phytopathol.* 49: 291-315.
- Eleonora Rolli *et al*. 2014. Improved plant resistance to drought is promoted by the root-associated microbiome as a water stress-dependent trait. *Environmental Microbiology*. doi: 10.1111/1462-2920.12439
- Roeland L. Berendsen, Corne´ M.J. Pieterse and Peter A.H.M. Bakker. 2012. The rhizosphere microbiome and plant health. *Trends in Plant Science*, Vol. 17, No. 8.
- Josep Penuelas and Jaume Terradas. 2014. The foliar microbiome. *Trends in Plant Science*. http://dx.doi.org/10.1016/j.tplants.2013.12.007

Journals

- *Advances in Microbial Physiology*
- *Annual Review of Genetics/Biochemistry*
- *Annual Review of Microbiology*
- *Applied and Environmental Microbiology*
- *Biology and Fertility Soils*
- *Indian Journal of Microbiology*
- *Journal of Bacteriology*
- *Journal of Basic Microbiology*
- *Microbiology and Molecular Biology Reviews*
- *Nature/Science/EMBO Journal*
- *Reviews in Microbiology and Biotechnology*
- *Soil Biology and Biochemistry*
- *Trends in Biotechnology*
- *Trends in Microbiology*
- *Trends in Plant Sciences*

Websites

- http://testweb.science.uu.nl/pmi/
- popups.ulg.ac.be/1780-4507/index.php?id=7578
- www.researchgate.net/...The_rhizosphere_microbiome_and_plant_health...
- journal.frontiersin.org/Journal/10.3389/fpls.2013.00165/abstract
- http://www.aw-bc.com/microplace/
- http://www.personal.psu.edu/jel5/micro/index.htm
- http://microbiology.ucsc.edu/
- http://www.suite101.com/links.cfm/microbiology
- http://www.microbeworld.org/resources/links.aspx
- http://www.asm.org/
- http://www.microbiologyiworld.com/
- http://www.sciencemag.org/cgi/collection
- http://www.latrobe.edu.au/microbiology/links
- www.uwstout.edu/lib/subjects/microbi
- http://www.aemtek.com

Journal related to Microbiology

- http://www.fems-microbiology.org/website/nl/default.asp
- http://www.blackwellpublishing.com/journal
- http://www.springer.com/
- http://www.e-journals.org/microbiology/
- http://pubs.nrc-cnrc.gc.ca/
- http://www.elsevier.com/
- http://www.academicjournals.org/ajmr/
- http://www.horizonpress.com/gateway/journals.html
- http://www.scielo.br/bjm
- http://www.jmb.or.kr/
- http://microbiologybytes.wordpress.com/
- http://www.topix.net/science/microbiolog

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 2

Basic Sciences

– Plant Physiology

Course Title with Credit Load
M.Sc. (Ag) in Plant Physiology

Course Code	Course Title	Credit Hours
PP 501*	Principles of Plant Physiology-I: Plant Water Relations and Mineral Nutrition	2+1
PP 502*	Principles of Plant Physiology-II: Metabolic Processes and Growth Regulation	2+1
PP 503*	Plant Developmental Biology: Physiological and Molecular Basis	2+1
PP 504	Physiological and Molecular Responses of Plants to Abiotic Stresses	2+1
PP 505	Hormonal Regulation of Plant Growth and Development	2+1
PP 506	Physiological and Molecular Mechanisms of Mineral Nutrient Acquisition and their Functions	2+1
PP 507	Photosynthetic Processes, Crop Growth and Productivity and Concepts of Crop Modelling	2+1
PP 508	Physiology of Field Crops	2+0
PP 509	Physiology of Horticulture Crops	2+0
PP 510*	Seed Physiology	2+1
PP 511	Phenotyping Physiological Processes	2+0
PP 512	Crop Growth Regulation and Management	2+0
PP 591	Master's Seminar	1+0
PP 599	Master's Research	30

Course Contents
M.Sc. (Ag) in Plant Physiology

I. Course Title : Principles of Plant Physiology I - Plant Water Relations and Mineral Nutrition

II. Course Code : PP 501*

III. Credit Hours : 2+1

IV. Theory

Block 1: Plant Water Relations

Unit 1: Soil and Plant Water Relations

Water and its importance; Molecular structure of water; Properties and functions of water. Concept of water potential; Plant cell and soil water potential and their components; Methods to determine cell and soil water potential; Concept of osmosis and diffusion. Soil physical properties and water availability in different soils;

Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance.

Unit 2: Water Absorption and Translocation

Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation; Theories explaining water absorption and translocation; Aquaporins. Mycorrhizal association and its relevance in water mining.

Unit 3: Transpiration and Evaporative Cooling

Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance. Energy balance: Solar energy input and output at crop canopy level. Stomata- its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure. Antitranspirants and their relevance in agriculture.

Unit 4: Water Productivity and Water Use Efficiency

WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE.

Unit 5: Moisture Stress and Plant Growth

Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level. Drought indices and drought tolerance strategies. Drought tolerance traits.

Block 2: Mineral Nutrition

Unit 1: Nutrient Elements and Their Importance

Role of mineral nutrients in plant's metabolism; Essential elements and their classification; Beneficial elements; factors influencing the nutrients availability; critical levels of nutrients. Functions of mineral elements in plants. Deficiency and toxicity symptoms in plants.

Unit 2: Nutrient Acquisition

Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters; Xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels. Role of mycorrhiza, root eXudates and PGPRs in plant nutrient acquisition.

Unit 3: Concept of Foliar Nutrition

Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.

V. Practicals

- Standard solutions and preparation of different forms of solutions
- Studies on the basic properties of water
- Demonstration of surface tension of water and other solvents
- Measurement of plant water status: Relative water content and rate of water loss
- Determination of water potential through tissue volume and Chardakov's test
- Determination of water potential using pressure bomb, osmometer, psychrometer
- Determination of soil moisture content and soil water potential
- Use of soil moisture probes and soil moisture sensors
- Measurement of transpiration rate in plants; use of porometry
- Measurement of CCATD and its relevance
- Demonstration and use of anti-transpirants to reduce transpiration
- Influence of potassium and ABA on stomatal opening and closing respectively
- Deficiency and toXicity symptoms of nutrients
- Effect of water stress on plant growth and development

VI. Suggested Reading

- Vilalta JM and Forner NG. 2017. *Water potential regulation, stomatal behaviour and hydraulic transport under drought: deconstructing the iso/anisohydricconcept Plant, Cell and Environment* 40, 962–976
- Mangrich AS, Cardoso EMC, Doumer ME, Romão LPC, Vidal M, Rigol A, Novotny EH. *Improving the Water Holding Capacity of Soils of Northeast Brazil by Biochar Augmentation*. Chapter 16, pp 339–354.
- McElrone AJ, Choat B, Gambetta GA and Brodersen CR. 2013. *Water Uptake and Transport in Vascular Plants. Nature Education Knowledge* 4(5): 6
- Hodson RC and J Acuff. 2006. *Water transport in plants: anatomy and physiology*. Pages 163-183, *Tested Studies for Laboratory Teaching*, Volume 27 (M.A. O'Donnell, Editor). Proceedings of the 27th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 383 pages.
- Chater CCC, Caine RS, Fleming AJ, Gray JE. 2017. *Plant Physiology*, 174 (2) 624-638; DOI: 10.1104/pp.17.00183
- Dietrich P, Sanders D, Hedrich R. 2001. *The role of ion channels in light dependent stomatal opening, Journal of Experimental Botany*, Volume 52, Issue 363, Pages 1959–1967, https://doi.org/10.1093/jeXbot/52.363.1959
- Sreeman SM, Vijayaraghavareddy P, Sreevathsa R, Rajendrareddy S, Arakesh S, Bharti P, Dharmappa P, Soolanayakanahally R. 2018. *Introgression of Physiological Traits for a Comprehensive Improvement of Drought Adaptation in Crop Plants. Front. Chem*. 6, 92.
- Seyed Yahya Salehi-Lisar Hamideh Bakhshayeshan-Agdam, (2016). Drought Stress in Plants: Causes, Consequences, and Tolerance. Drought Stress Tolerance in Plants, Vol 1 pp 1-16
- Pandey R. 2015. *Mineral Nutrition of Plants*. 10.1007/978-81-322-2286-6_20.
- Barker AV and DJ Pilbeam. 2015. Handbook of Plant Nutrition, Second Edition. Books in Soils, Plants, and the Environment Series, the 2nd Edition, CRC Press.
- Vatansever R, Ozyigit II and Filiz E. 2017. *Essential and beneficial trace elements in plants, and their transport in roots: a review. Applied biochemistry and biotechnology* 181(1), 464-482..

- Tahat MM and Sijam K. 2012. *Arbuscularmycorrhizal fungi and plant root exudates bio-communications in the rhizosphere. African Journal of Microbiology Research*, 6(46), 7295-7301.
- Rajasekar MD, Nandhini DU and Suganthi S. 2017. *Supplementation of Mineral Nutrients through Foliar Spray – A Review. Int.J.Curr.Microbiol.App.Sci.* 6(3): 2504-2513.https://doi.org/10.20546/ijcmas.2017.603.283
- Tarek A and Hassan ER. 2017. *Foliar application: from plant nutrition to biofortification*. Environment, Biodiversity and Soil Security. 10.21608/jenvbs.2017.1089.1006.

General Source of Information

- Taiz T, Zeiger E and MaX Mller IM, 2018, *Fundamentals of Plant Physiology*
- Taiz L and Zeiger E. 2015. *Plant Physiology and development*.6th Ed
- Salisbury FB and Ross C. 1992 (4th Ed.) *Plant Physiology*
- Epstein E and Bloom AJ. 2004. *Mineral nutrition of plants: principles and perspectives*.2nd Ed.
- Hopkins WG and Huner NPA. 2004. *Introduction to Plant Physiology*
- Kramer, P. J., *Water relations of plants*
- Kirkham, M. B., *Principles of soil and plant water relations*
- Hopkins WG, 2008, *Introduction to Plant Physiology*

I. Course Title : **Principles of Plant Physiology-II: Metabolic Processes and Growth Regulation**

II. Course Code : **PP 502***

III. Credit Hours : **2+1**

Block 1: Metabolic Processes and Growth Regulation

Unit 1: Carbon Metabolism – Photochemical Processes

- Chloroplast ultrastructure with special mention of lamellar system
- Excitation, electron and proton transfers and their relevance in energy conservation
- Concepts of pigment systems and generation of powerful reductant and oxidant
- Water oxidation, Water-water cycle and other aspects of electron transfer

Unit 2: Carbon Metabolism: Biochemical Processes

- CO_2 diffusion mechanisms and diffusive conductances, concept of Ci determining Photosynthesis
- RuBisCO enzyme kinetics and Calvin cycle mechanisms, Regulation of Calvin cycle and metabolite fluxes
- Photorespiration: the advantages and inefficiencies of photosynthesis because of photorespiration
- Concepts of CO_2 concentrating mechanisms (CCM) and spatial and temporal differences in carboxylation
- Ecological aspects of C_4 and CAM photosynthesis
- Product synthesis, Starch and Sucrose biosynthesis

Unit 3: Carbon Metabolism: Respiration

- Mitochondrial organization and functions
- Aspects of Glycolysis, TCA cycle and mitETC.
- Relevance of growth and maintenance respiration
- Concepts of CN resistance respiration – Alternate and SHAM sensitive ETC

Unit 4: Product Synthesis and Translocation Leading to Crop Growth

- Phloem loading and sugar transporting, concepts of bi-directional transport of sugars and other metabolites
- Source-Sink relationship and modulation of photosynthesis
- Concepts and definitions of Growth and Differentiation
- Growth and yield parameters, NAR, CGR, HI and concepts of LAI, LAD

Unit 5: Nitrogen Assimilation and Protein Synthesis

- Developments in d-nitrgen fixation
- Nitrate reduction and assimilation GS-GOGAT process for amino acid synthesis
- Inter-Dependence of carbon assimilation and nitrogen metabolisms

Unit 6: Lipid Metabolism and Secondary Metabolites

- Storage, protective and structural lipids.
- Biosynthesis of fatty-acids, diacyl and triacyl glycerol, fatty acids of storage lipids.
- Secondary metabolites and their significance in plant defense mechanisms.

Unit 7: Hormonal Regulation of Plant Growth and Development

- Growth promoting and retarding hormones: biosynthesis, transport, conjugation
- Mode of action of these hormones and their application in plant physiology

Unit 8: Synthetic Growth Promoters

- Different synthetic hormones: Salicylic acid, strigolactones etc

- Roles and biological activities of various synthetic hormones
- Commercial application of hormones to maximize growth and productivity
- **Unit 9: Morphogenesis and Reproductive Phase**
- Photoperiodism: Phytochromes, their structure and function
- Circadian rhythms,
- Blue light receptors: Cryptochrome and morphogenesis.
- Vernalization and its relevance in germination.

IV. Practicals

- Radiant energy measurements
- Separation and quantification of chlorophylls
- Separation and quantification of carotenoids
- O_2 evolution during photosynthesis
- Anatomical identification of C_3 and C_4 plants
- Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration
- Measurement of respiration rates
- Estimation of reducing sugars, starch
- Estimation of NO_3, free amino acids in the xylem exudates, quantification of solubleproteins
- Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene
- Demonstration of photoperiodic response of plants in terms of flowering

V. Suggested Reading

- Kirchhoff H. 2019. *Chloroplast ultrastructure in plants*, New Phytologist. Doi.org/10.1111/nph.15730
- Jafari T, Moharreri E, Amin A, Miao R, Song W and Suib S. 2016. *Photocatalytic water splitting—the untamed dream: a review of recent advances. Molecules*, *21*(7), 900.
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- Pagare S, Bhatia M, Tripathi, N., Pagare, S., and Bansal, Y. K. 2015. *Secondary metabolites of plants and their role: Overview. Curr Trends Biotechnol Pharm*, 9(3), 293-304.
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- Eckardt, N. A. 2015. *The plant cell reviews dynamic aspects of plant hormone signaling and crosstalk.*
- Jiang, K., andAsami, T. 2018. *Chemical regulators of plant hormones and their applications in basic research and agriculture. Bioscience, biotechnology, and biochemistry*, 82(8), 1265-1300.
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- Song, Y. H., Shim, J. S., Kinmonth-Schultz, H. A., and Imaizumi, T. 2015. *Photoperiodic flowering: time measurement mechanisms in leaves. Annual review of plant biology*, *66*, 441-464.
- Sanchez, S. E., and Kay, S. A. 2016. *The plant circadian clock: from a simple timekeeper to a complex developmental manager. Cold Spring Harbor perspectives in biology*, *8*(12), a027748.

General Text books

- *Taiz, Lincoln, Zeiger. 2007 Plant Physiology, Eduardo Original American edition Sinauer Associates, Inc., 2006; 4th ed., XXVI, ISBN: 978-3-8274-1865-4; © Springer.*
- *Plant Physiology* Frank Boyer Salisbury and Cleon Ross.
- *Introduction to Plant Physiology* (Wie)by William G. Hopkins.

I. Course Title : Plant Developmental Biology: Physiological and **Molecular Basis**

II. Course Code : PP 503*

III. Credit Hours : 2+1

IV. Theory

Block 1: Plant Developmental Biology

Unit 1: Evolutionary Development of Plants and Role of Environment

Plant development and plasticity, evolution, Biodiversity. Novel features of plant growth and development, Concept of plasticity-evolution and biodiversity, Model plants for study; Environment and development. Developmental stages and program; Cell-cycle, totipotency and regeneration.

Unit 2: Physiological and Molecular Determinants of Seed Biology

Seed development- Physiology of seed development, role of hormones in embryo development; seed development and maturation. Seed dormancy- Physiological and molecular mechanism of seed dormancy regulation. Seed germination- seed structure and Hormonal regulation of germination, Mobilization of food reserves during seed germination.

Unit 3: Vegetative Growth and Organ Development

Regeneration and totipotency- organ differentiation and development – role of hormones- developmental control genes in crop plants. Meristems in plant development. Shoot, Leaf, Trichome and stomate development and differentiation. Axillary shoot branching; Bud dormancy and growth**.** Root development; Nodule development; Tuber development- hormonal control, signaling and molecular regulation- genes involved. Vascular bundle development- xylem and phloem differentiation

Unit 4: Physiological and Molecular Aspects of Reproductive Growth and Development

Floral Induction and Development: Molecular and physiological mechanism of transition -vegetative to reproductive phase- floral organ initiation and development their controls. Development of male and female gametophyte; gametophytic mutants: pollen-stigma interaction- Pollen germination and tube growth; role of imprinting; Male sterility: and fertility restoration; Self incompatibility; Sterility and fertility restoration, Maternal gene effects, Zygotic gene effects. Sex determination in plants, mate choice in plants. Embryo and endosperm development- fertilization, role of imprinting; Parthenocarpy and apomixes

Unit 5: Ripening and Senescence

Fruit development, enlargement, maturation and ripening; climacteric and non-climacteric fruit ripening mechanism. Hormonal, biochemical & Molecular aspects of fruit ripening. Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

Unit 6: Physiological and Molecular Regulation of Plant Development Influenced by Light and Temperature

Light control of plant development: Phytochromes and cryptochromes, phototropins, their structure, biochemical properties and cellular distribution. Molecular mechanisms of light perception, signal transduction and gene regulation. Photoperiodism and its significance, vernalization and hormonal control. Circadian rhythms-biological clocks and their genetic and molecular determinants. Thermomorphogenesis- Thermoperiodism

Block 2: Application of Morphogenesis and its Practical Application

Unit 1: Tissue culture and micro-propagation

Applications of tissue culture for plant production, callus induction, somatic embryogenesis, regeneration from different explants. Micro-propogation, tip and axillary node culture of commercially important crops, hardening and ex-vitro establishment, concept of somatic hybridization and protoplast culture.

Unit 2: Application of *in-vitro* techniques for crop improvement

Development of somoclones, identification and exploitation of somoclonal variants. Haploid production, pollen/anther, ovule/ovary culture. Production of secondary metabolites by tissue culture, concept of bio-fermenters. Plant transformation, development of transgenic plants and their characterization. Germplasm storage, cryopreservation and regulation

V. Practicals

- Studying shoot apical meristem, floral meristem development and pollen tube development
- Phenotyping photomorphogenesis: (a) Studying effect of day length (short day and long day) in regulating floral induction/ flowering time in short day/long day/day neutral plants and (b) effect of light on seed germination in light-sensitive and -insensitive seeds.
- Studying effect of temperature on– (a) thermomorphogenesis- measuring hypocotyl elongation under different temperature conditions and (b) sex determination using cucurbits/sesame plants.
- Measure physiological paramters of fruit ripening and study the expression of key genes regulating ripening.
- Study the effect of ethylene, its inhbibitor and scruber on ripening (tomato).

- Study different sterilization techniques, prepare media stocks and plant hormones.
- Inoculate explant (seed and leaf tissue) of model plant for callus induction.
- Subculture the callus and standerdize regeneration protocol for shoot and root induction using callus and leaf explant.
- Micro-propagation using meristem tip and axillary node culture.
- Standerdize anther/ pollen culture for haploid production in model/crop/horticultural plant.
- Isolation of protoplast from Arabidopsis/tobacco and its culturing
- Study about selectable marker, reporter gene, PCR, southern and northern blotting techniques.
- Transformation of tobacco callus or leaf explant by *Agrobacterium tumefacines* and *Agrobacterium rhizogenes* for production of transgenic
- Molecular characterization of transgenic- PCR, southern blotting, gene expression.

VI. Suggested Reading

- Niklas KJ. *Plant Evolution- An Introduction to the History of Life.*
- Bahadur *B et al.* (eds.), *Plant Biology and Biotechnology:* Volume I: Plant Diversity, Organization, Function and Improvement
- Jong MD and Leyser O. *Developmental Plasticity in Plants*. Cold Spring Harbor Symposia on Quantitative Biology. 63-73.
- Inze D and Veylder LD. 2006. *Cell Cycle Regulation in Plant Development*. Annu. Rev. Genet. 2006. 40: 77–105
- J. Derek Bewley *et al.*, Seeds-Physiology of Development, Germination and Dormancy.
- Kent J. Bradford and Hiroyuki Nonogaki (2007). *Seed Development, Dormancy and Germination*. Blackwell publishing.
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- Piazza *et al.* 2005. *Evolution of leaf developmental mechanisms.* New Phytologist. 167: 693–710.
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- Zheng-Hua Ye. 2002. *Vascular Tissue Differentiation And Pattern Formation In Plants.* Annu. Rev. Plant Biol. 53: 183–202.
- Maureen L. Condic (2014). *Totipotency*: *What It Is and What It Is Not. Stem Cells And Development*. 23(8). 796- 812.
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- John R. Pannel. (2017). *Plant Sex Determination. Current Biology* 27, R191–R197.
- Johnson MA *et al.* 2019. *A Fruitful Journey: Pollen Tube Navigation from Germination to Fertilization. Annu*. Rev. Plant Biol. 70: 20.1–20.29
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- Vernonica E. Franklin-Tong. *Self-Incompatibility in Flowering Plants-Evolution, Diversity, and Mechanisms*, Springer
- Thomas H. 2013. *Senescence, ageing and death of the whole plant. New Phytologist*. 197: 696–711.
- Lam E, Fukuda H and Greenberg J. *Programmed cell death in higher plants.* Reprinted from Plant Molecular Biology, Volume 44 (3).
- Pua EC and Davey MR. *Plant Developmental Biology - Biotechnological Perspectives.*

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- Fankhauser C and Chory J. 1997. *Light Control Of Plant Development Annu. Rev. Cell Dev. Biol.* 13: 203–229.
- Mieke de Wit. 2016. *Light-Mediated Hormonal Regulation of Plant Growth and Development.Annu. Rev. Plant Biol.* 67: 22.1–22.25
- Franklin KA and Wigge PA. *Temperature and Plant Development*. Wiley Blackwell.
- Franklin KA *et al.* 2014. *Interaction of light and temperature signaling. Journal of Experimental Botany*. 65(11): 2859–2871.
- Bhojwani SS and Razdan MK. *Plant tissue culture: theory and practice, a revised edition*. Elsiver publication.
- Bhojwani SS, Dantu SS and Kumar P. *Plant Tissue Culture: An Introductory Text*.
- George EF and Hall MA. *Plant Propagation by Tissue Culture* 3rd Edition.
- Krishna H, Alizadeh M, Singh D, Singh U, Chauhan N, Eftekhari M and Sadh RK. 2016. *Somaclonal variations and their applications in horticultural crops improvement. 3 Biotech*, 6(1), 54.
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General Source Information

- Eng-Chong Pua and Michael R.Davey: *Plant Developmental Biology - Biotechnological Perspectives*.
- B. Bahadur *et al.* (eds.), *Plant Biology and Biotechnology*: Volume I: Plant Diversity, Organization, Function and Improvement.
- Bewley JD *et al., Seeds-Physiology of Development, Germination and Dormancy*.
- Jong MD and Leyser O. *Developmental Plasticity in Plants. Cold Spring Harbor Symposia on Quantitative Biology*. 63-73.
- Bae G and Choi G. 2008. *Decoding of Light Signals by Plant Phytochromes and Their Interacting Proteins*. Annu. Rev. Plant Biol. 59: 281–311
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- MomokoIkeuchi *et al.* 2016. *Review- Plant regeneration: cellular origins and molecular mechanisms. Development*, 143: 1442-1451.
- Pannel JR. 2017. *Plant Sex Determination. Current Biology* 27, 191–197.
- Vernonica E. Franklin-Tong. *Self-Incompatibility in Flowering Plants -Evolution, Diversity, and Mechanisms*. Springer.
- Dijk PV and Damme JV. 2000. *Apomixis technology and the paradox of sex. Trends in Plant Sciences* 5(2): 81-84.

I. Course Title : Physiological and Molecular Responses of Plants to Abiotic Stresses

II. Course Code : PP 504

III. Credit Hours : 2+1

IV. Theory

Block 1: Abiotic Stresses

Unit 1: Introduction to Abiotic Stresses

Abiotic stresses major constraints to realize potential yields of crop plants, yield losses. Drought prone areas in India- Frequency of occurrence of drought, Rainfed-kharif, Rabi, Areas affected by salinity, heavy metals, water logging, high temperature scenario due to global warming.

Block 2: Drought Stress

Unit 1: Moisture Stress Responses in Plants

Drought-characteristic features; water potential in the soil-plant-air continuum. Physiological and biochemical processes affected by drought.Oxidative stress-generation of ROS and other cytotoxic compounds, their effect on cellular process. Effect on total carbon gain- decrease in photosynthetic area and function, protein turn over and lipid characters, phenology-reproductive aspects, critical stages.

Unit 2: Stress Perception and Molecular Responses of Plants to Drought Stress

Stress perception andsignal transduction leading to expression of regulatory genes, stress specific kinases, stress specific transcription factors, functional genes associated with adaptive mechanisms.

Unit 3: Plant Adaptive Mechanisms to Drought

(a) Escape and desiccation avoidance mechanismConcept of stress escape-exploiting genetic variability in phenology, Drought avoidance mechanisms- Maintenance of cell turgor, water mining by root characters. Moisture conservation- Regulation of transpiration- traits reducing heat load, Stomatalfactors guard cell metabolism, moisture conservation by waxes. Water use efficiency (WUE) and concept of water productivity- regulation of transpiration efficiency-stomatal conductance, mesophyll efficiency, relevance of WUE and Passioura's model.

(b) Desiccation tolerance- Concept of acquired tolerance

Decreased turgor mediated upregulation of cellular tolerance mechanisms, Osmolytes, managing cytotoxic compounds, ROS, RCC, scavenging - enzymatic and non-enzymatic, protein turnover, stability, chaperones, membrane stability, photo-protection of chlorophylls.

Unit 4: Approaches to Improve Drought Tolerance

Development of genetic resources- donor genotypes for specific traits, Genomic resources- genes, QTL's regulating adaptive mechanisms, Conventional, transgenic and molecular breeding approaches to improve relevant adaptive traits, concept of trait introgression.

Block 3: Salt, Heavy Metal, Water Logging, Temperature and Light Stress

Unit 1: Salt Stress

Soil salinity-Effect of salt stress, ionic and osmotic effects; species variation in salt

tolerance; glycophytes and halophytes, Salt tolerance mechanisms - exclusion, extrusion and compartmentalization, Signaling during salt stress – SOS pathway, Approaches to improve salt tolerance.

Unit 2: Heavy Metal Stress and Water Logging

Heavy metal toxicity in plants (eg., Al, Cd), tolerance mechanisms and approaches to improve. Plant response to water logging, role of hormones- ethylene, mechanism of tolerance and approaches to improve.

Unit 3: Temperature and Light Stress

High and low temperatures; effect on plants; adaptive mechanisms, evaporation cooling, concept of cellular tolerance, protein stability, chaperones, HSPs, HSFs, membranes. High light and high ionizing radiation- photo oxidation and photo-inhibition; mechanisms of tolerance, plant adaptation to low light, concept of shade avoidance response (SAR).

V. Practicals

- Measurement of soil and plant water status.
- Drought stress imposition and measurement of physiological and biochemical changes in plants under stress –gas exchange and fluorescence measurements.
- Determination of water use efficiency as a drought resistant trait.
- Drought Susceptibility Index (DSI) -precise field technique to identify productive genotypes under stress.
- Approaches to quantify root characters
- Determination of stomatal parameters and canopy temperature as a reflection of transpiration and root activity.
- Determination of Salinity Tolerance Index.
- Studying acclimation response - Temperature induction response.
- Heat tolerance and membrane integrity- Sullivans heat tolerance test.
- Quantification of osmolytes – proline under stress.
- Oxidative stress imposition- Quantification of oxidative stress
- Quantification of ROS under stress.
- Estimation of ABA content in leaf and root tissues under stress.
- Determination of Sodium and Potassium in plant tissue grown under salt stress.
- Estimation of antioxidant enzymes.

VI. Suggested Reading

- *Plant Physiology Book by Eduardo Zeiger and Lincoln Taiz.*
- Plant Physiology Book by Frank B. Salisbury, Cleon W. Ross Salisbury, Frank B
- Pereira A. 2016. *Plant Abiotic Stress Challenges from the Changing Environment. Front. Plant Sci.* 7: 1123. doi: 10.3389/fpls.2016.01123
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- Abid M, Ali S, Qi LK, Zahoor R, Tian Z, Jiang D, Snider JL and Dai T. 2018. *Physiological and biochemical changes during drought and recovery periods at tillering and jointing stages in wheat (Triticum aestivum L.). Scientific Reports*, 8(1), p.4615.
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- Khan, A., Pan, X., Najeeb, U., Tan, D.K.Y., Fahad, S., Zahoor, R. and Luo, H., 2018. *Coping with drought: stress and adaptive mechanisms, and management through cultural and molecular alternatives in cotton as vital constituents for plant stress resilience and fitness. Biological research* 51(1), p.47.
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- Kumar S, Muthappa (Ed.) 2017. *Plant Tolerance to Individual and Concurrent Stresses*
- Fernando VD and Schroeder DF. 2016. *Role of ABA in Arabidopsis salt, drought, and desiccation tolerance. In Abiotic and Biotic Stress in Plants-Recent Advances and Future Perspectives*. IntechOpen.
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I. Course Title : Hormonal Regulation of Plant Growth and Development

II. Course Code : PP 505

III. Credit Hours : 2+1

IV. Theory

Block 1: Plant Growth and Development: Hormonal Regulation

Unit 1: Introduction to Plant Hormones

Growth, differentiation and development regulated by plant growth substances, Definition and classification of growth regulating substances: Classical hormones, Definition and classification of growth regulating substances: Endogenous growth substances other than hormones, Synthetic chemicals.

Unit 2: Plant Hormones – Discovery and Metabolism

Discovery, biosynthetic pathways and metabolism of Auxin, Discovery, biosynthetic pathways and metabolism of Gibberellins, Discovery, biosynthetic pathways and metabolism of Cytokinins, Discovery, biosynthetic pathways and metabolism of Abscisic acid, Discovery, biosynthetic pathways and metabolism of Ethylene, Discovery, biosynthetic pathways and metabolism of Brassinosteroids, Discovery, biosynthetic pathways and metabolism of Strigolactones.

Unit 3: Physiological Role of Hormones in Plant Growth and Development

Physiological functions of Auxin and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Gibberellins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Cytokinins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Abscisic acid and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Ethylene and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Brassinosteroidsand Strigolactones and use of mutants and transgenic plants in elucidating the physiological functions, Discovery, biosynthetic pathways metabolism and physiological roles of Salicylic acid and Peptide hormones.

Unit 4: Endogenous Growth Substances other than Hormones

Discovery, biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins, Discovery, biosynthetic pathways metabolism and physiological roles of Jasmonates and Tricontanol, Discovery, biosynthetic pathways metabolism and physiological roles of systemins Concept of death hormone, Recent developments in elucidating responses of Salicylic acid, Peptide hormones and Polyamines at physiological and molecular level, Recent developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricontanol at physiological and molecular level.

Unit 5: Hormone Signaling

Hormone signal perception, transduction - Receptors, components and mechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid), Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones), Advances in elucidating the structure and function of receptors and signaling components of important hormones.

Unit 6: Key Genes Regulating Hormone Levels and Functions

Genomics approaches to regulate hormone metabolism and its effect on plant growth

and development – case studies.

Unit 7: Crosstalk of Hormones in Regulation of Plant Growth and Development Processes

Crosstalk of Hormones in Regulation of Plant Growth and Development Processes: Floral transition, reproductive development, Shoot and root apical meristem development

Unit 8: Practical Utility of Growth Regulators in Agriculture and Horticulture

Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings, Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits, Practical Utility of Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop.

V. Practicals

- Extraction of Auxins from plant tissue
- Separation and detection of Auxins by GC / GC-MS / HPLC / Immunological technique
- Bioassay of auxin- effect on rooting of cuttings
- Extraction of abscisic acid (ABA) from plant tissue
- Separation and detection of ABA by HPLC/Immunological technique
- ABA bioassays- effect on stomatal movement
- Preparation of samples for ethylene estimation in plant tissue
- Estimation of ethylene in plant tissues using gas chromatography
- Ethylene bioassays, estimation using physico-chemical techniques- effect on breaking dormancy in sunflower and groundnut
- Extraction of Gibberellins from plant tissue- GC / GC-MS / HPLC
- Separation and detection of GA by GC / GC-MS / HPLC/Immunological technique
- GA bioassays- effect on germination of dormant seeds
- Cytokinin- extraction from plant tissue
- Separation and detection of cytokinin by GC / GC-MS / HPLC
- Cytokinin bioassays- effect on apical dominance and senescence / stay green

VI. Suggested Reading

- Davies P.J. 2004, *Plant Hormones: Biosynthesis, Signal Transduction and Action*, 2nd Edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Hedden, P. and Thomas, S.J. 2006. *Plant Hormone Signalling*, Blackwell Publishing Ltd., Oxford, UK.
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- Buchanan B B, Gruissem W and Jones R L. *Biochemistry and Molecular biology of Plants*, 2nd Edition
- Lincoln Taiz and Eduardo Zeiger. *Plant Physiology and Development*, 6th Edition.
- *Teaching Tools in Plant Biology*, The American Society of Plant Biologists
- *The Arabidopsis* Book(http://www.arabidopsisbook.org/)

I. Course Title : Physiological and Molecular Mechanisms of Mineral Nutrient Acquisition and their Functions

II. Course Code : PP 506

III. Credit Hours : 2+1

IV. Theory

Block 1: Mineral Nutrient: Classification, Function, Availability, Deficiency and Toxicity

Unit 1: Mineral Elements: Classification, Function, Deficiency and Toxicity

Classification based on mobility and characteristic features; physiological role in regulating plant growth, metabolism, development and human health- Regulatory Dietary Allowance (RDA), Deficiency and toxicity of macro, micro and beneficial elements, Tolerance of plants to nutrient toxicity, hyper-accumulators of nutrients: Concept of phytoremediation.

Unit 2: Nutrient Availability at Rhizosphere

Biological and chemical reactions influencing nutrient availability near the root system, interaction between ions in the rhizosphere, Rhizosphere chemistry in relation to plant nutrition- chemical reactions, root exudates to mobilize nutrients.

Block 2: Nutrient Uptake, Translocation and Acquisition

Unit 1: Ion Uptake Mechanisms

Mineral salt absorption- chemical potential of solute- Nernst equation- passive uptake- diffusion, ion exchange-Donnan Equilibrium, mass flow of ions, Mediated transport- Facilitated diffusion-ionophores; membrane transport proteins- active transport-ion channels, Primary and secondary transport- carriers and pumps.

Unit 2: Ion Transport to Shoot and Grains

Long distance transport in plants - Mechanism of xylem and phloem transport, Radial movement of ions across the root, Mechanism of phloem transport, remobilization of mineral nutrients - phloem loading, phloem unloading.

Unit 3: Physiological and Molecular Mechanism of Nutrient Acquisition and Transport: Macronutrients

Molecular structures of LAT and HAT, their localization and regulation by various external factors, Nitrate transporters and their functional regulation - Nitrate transporters (NRT1, NRT2, dual-affinity nitrate transporter NRT1.1/CHL1), Phosphate transporters and their functional regulation - PT1/PHT1, PHT2, PHT3, PHT4, Potassium transporters and their functional regulation - KT/HAK/KUP family Ion transporters involved in transport of multiple elements, for example, sulphate transporter for Selenate transport, phosphate transporter for Arsenate transport, etc.

Unit 4: Physiological and Molecular Mechanism of Nutrient Acquisition and Transport: Micro and Beneficial Nutrients

Plant Strategies: Different Strategies I & II adopted by plants for uptake of Fe under Fe deficient condition, Transporters and genes regulating uptake and transport of micronutrients, genes encoding transport/channel proteins, Examples of genes encoding mineral ion transporters for Zn, Fe, Mn, Cu, B, Mo, Ni, Cl, Na, Si, Se, Beneficial nutrients and their role in plant growth and development – Sodium, Silicon, and Cobalt.

Unit 5: Microbes, Fungal Association for Nutrient Acquisition

Microbes to improve nutrient availability – Bio-inoculation technology- P solubilizers and Zinc solubilizers in nutrient absorption, Microbial systems for biological nitrogen fixation – process of nodulation, biochemistry of N2-fixation, Endophytes to improve nutrient availability, Mycorrhiza- Mycorrhizal symbiosis on nutrient uptake by root. Role of AMF on nitrogen, phosphorus and zinc uptake.

Unit 6: Nutrient Delivery

Foliar application of nutrients, absorption and their compartmentation, Concept of slow release fertilizers and chelates (organic and inorganic), Soil less cultures- aeroponics, hydroponics, fertigation.

Block 3: Nutrient Efficiency of Crop

Unit 1: Improving Nutrient Acquisition and Efficiency of Crops

Concept of nutrient uptake and use efficiency- Genotypic differences- physiology and molecular mechanisms, Nutrient use efficiency in selected crops, Root system architecture (RSA), root characters associated with nutrient acquisition, Genes and QTLs to improve nutrient acquisition and efficiency for important nutrients in few crop species, Transgenic and molecular breeding approaches to improve traits associated with acquisition and efficiency – Case studies, Biofortification strategies – for micronutrients, agronomic approaches, Influence of nutrition status on plant response to biotic and abiotic stresses.

V. Practicals

- Techniques to develop the deficiency symptoms of nutrients –Hydroponics/ Aeroponics- diagnosis of deficiency symptoms in agriculturally important crop plants
- Physiological and biochemical markers to identify nutrient deficiency levels
- Biochemical markers for essential elements: Assay of nitrate reductase activity for N
- Estimation of chlorophyll concentration in leaves of N deficient and N sufficient plants
- Collection of acid phosphatase from root exudates and enzyme assay for P
- Measuring anthocyanin and chlorophyll pigments concentration in leaves for P
- Collection of organic acid in root exudates, characterization and quantification for P
- Assay of carbonic anhydrase activity for Zn
- Assay of SOD Activity for Cu, Zn and Mn
- Estimation of nitrogen concentration in plant tissue - Kjeldhal and Dumas method
- Estimation of phosphorus concentration in plant tissue – colorimetric method
- Estimation of potassium, magnesium and sodium concentration in plant tissue – flame photometer
- Estimation of micronutrients (Zn, Cu, Fe, Mn, Co etc) concentration in plant tissue – atomic absorption spectrometer/ ICP-OES
- Measurement of simple root traits such as root length, angle, volume, surface area, etc. (using conventional methods or root scanner and WinRhizo)
- 'Shovelomics' in the field grown crops (for measuring root architecture) and using 'ImageJ' for analysis
- Non-invasive techniques to quantify nutrients – XRF (X-Ray Fluorescence) and hyper spectral reflectance.
- **X. Suggested Reading**

- *Recommended Dietary Allowances*: 10th Edition (https://www.ncbi.nlm.nih.gov/books/NBK234932/pdf/Bookshelf_NBK234932.pdf)
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- Marschner H. *Mineral Nutrition of Higher Plants* 3rdEdn
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- *Mineral Nutrition of Plants, In: Plant Biology and Biotechnology*. B. Bahadur *et al.* (eds.), Volume I: *Plant Diversity, Organization, Function and Improvement*, DOI: 10.1007/978-81-322-2286-6_20, Springer India, Pp. 499-538.
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- Mitra GN. *Regulation of Nutrient Uptake by Plants: A Biochemical and Molecular Approach*
- Uraguchi, S., Kamiya, T., Sakamoto, T., Kasai, K., Sato, Y., Nagamura, Y., Yoshida, A., Kyozuka, J., Ishikawa, S. and Fujiwara, T., 2011. *Low-affinity cation transporter (OsLCT1) regulates cadmium transport into rice grains. Proceedings of the National Academy of Sciences*, 108(52), pp.20959-20964.
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I. Course Title : Photosynthetic Processes, Crop Growth and Productivity and Concepts of Crop Modelling

II. Course Code : PP 507

III. Credit Hours : 2+1

IV. Aim of the Course

The course provides a comprehensive theoretical and hands on experience and expertise to students on various aspects of photosynthesis including biophysical, biochemical and molecular regulations. While canopy photosynthesis drives crop growth rates, factors associated with sink activity and partitioning determine productivity. Hence, adequate emphasis would be given to canopy photosynthesis, translocation and its feedback regulation, Crop growth and yield structure analysis and their responses to environmental factors. Growth and yield prediction models and their relevance will be adequately discussed.

The course is organized as follows:

No.	Blocks	Units
1.	Photosynthetic Processes	1. Canopy Architecture and Energy Utilization 2. Photochemical Processes 3. Biochemical Processes 4. Product Synthesis and Translocation 5. Growth and Yield forming Mechanisms
2.	Yield Improvement and Modelling	1. Molecular Options to Improve Photosynthesis, Growth and Productivity 2. Fundamentals of Dynamic Simulation Models 3. Description of Well-established Yield Models 4. Examples of Robust Models Extensively Used

V. Theory

Block 1: Photosynthetic Processes

Unit 1: Canopy Architecture and Energy Utilization

Parameters associated with canopy architecture that determine radiation interception and absorption, Energy absorption by primary and accessory pigments and energy utilization efficiency, Light distribution inside the canopy and concepts of light extinction coefficient.

Unit 2: Photochemical Processes

Ultrastructure of chloroplast: structure and composition of lamellar system, Components of electron transport, Water oxidation system and energy conservation processes, Pigment systems and the generation of a powerful oxidant and a powerful reductant, Chlorophyll fluorescence and fluorescence quenching: qN, qP, NPQ.

Unit 3: Biochemical Processes

CO_2 diffusion and resistances (g_s and g_m). Concept of Ci determining CO_2 diffusion. RuBisCO activation state, kinetics and catalytic properties, Carboxylation processes in C_3, C_4 and CAM plants and their relevance, CO_2 concentrating mechanisms and their importance in improving carbon assimilation, Ecological significance of C_4 and CAM photosynthesis, Photorespiration and Mitochondrial respiration and net carbon gain, Carbon isotope discrimination and its importance as a surrogate of Ci.

Unit 4: Product Synthesis and Translocation

Triose phosphate utilization and regulation of Calvin cycle mechanisms, Product synthesis and partitioning between starch and sucrose, Concepts of end-product inhibition or Pi-regeneration limitation, Phloem transport and factors that regulate phloem loading and un-loading.

Unit 5: Growth and Yield forming Mechanisms

Carbon gain and the concepts of Canopy photosynthesis. Relevance of LAI and LAD in determining total carbon gain and crop growth rates, Source: Sink relationship and its relevance in governing differences in crop growth rates and productivity. Concepts of HI and partitioning coefficient and remobilization of carbon from vegetative organs to reproductive structures, Growth analysis and parameters that explain growth rates: NAR, CGR, HI and their inter-dependence.

Block 2: Yield Improvement and Modelling

Unit 1: Molecular Options to Improve Photosynthesis, Growth and Productivity

Characteristic features of the Chloroplast genome: its structure and genes associated with various photosynthetic mechanisms, coordinated expression of chloroplast and nuclear genome for maintaining photosynthetic activities. Genomic and genetic resources such as specific genes and QTL associated with photosynthetic processes Transgenic options to enhance photosynthetic performance such as transferring genes to mitigate oxidative stress damage (SOD, APX, AKR etc), Theoretical concepts of crop improvement through inducing CCM in C_3 plants and reducing photorespiration.

Unit 2: Fundamentals of Dynamic Simulation Models

Collection of crop specific genetic coefficient, Crop, soil and historic weather data

Unit 3: Description of Well-established Yield Models

Application and limitations of modeling, Yield prediction models such as APSYM, PeanutGrowetc, Machine learning approaches and IoT for making informed on-

farm decisions.

Unit 4: Examples of Robust Models Extensively Used

Duncan'syield prediction model, Passioura'smodelfor growth maximising.

VI. Practicals

- Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA portioning efficiency, HI.
- Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized.
- Gas exchange: principles and uses to assess variations in CO_2 and water vapourtransfer, determination of A/gs and intrinsic WUE
- Quantification of chlorophyll content by various methods: colorimetric and SPAD meter. The concept of SLN
- Chlorophyll fluorescence and quenching coefficients
- Theoretical aspects of carbon isotope fractional and its use in determining WUE
- Quantification of RuBisCO content by ELISA (if possible)
- Determination of RuBisCO activity and activation state using radioactive CO-$_2$
- CO_2 and light response curves and computation of carboxylation efficiency, quantum efficiency, relative limitations of photosynthesis at single leaf level.
- Adoption of crop models: Growth and yield prediction by Duncan's and Passioura's models

X. Suggested Reading

- Goyne, P.J., Milroy, S.P., Lilley, J.M., and Hare, J.M. (1993). Radiation interception, radiation use efficiency and growth of barley cultivars. *Australian Journal of Agricultural Research*, 44(6), 1351-1366.
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- https://www.researchgate.net/publication/38051229,_The_photochemical_reaction_in_photosynthesis.
- Wang, Y., Stessman, D.J., and Spalding, M.H. (2015). The CO_2 concentrating mechanism and photosynthetic carbon assimilation in limiting CO_2: how Chlamydomonas works against the gradient. *The Plant Journal*, 82(3), 429-448.
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- Hay, R.K.M. (1995). Harvest index: a review of its use in plant breeding and crop physiology. *Annals of Applied Biology*, 126(1), 197-216.
- Irving, L. (2015). Carbon assimilation, biomass partitioning and productivity in grasses. *Agriculture*, 5(4), 1116-1134.
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- vonCaemmerer, S., and Evans, J. R. (2010). Enhancing C3 photosynthesis. *Plant Physiology*, *154*(2), 589-592.
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- https://www.mdpi.com/1424-8220/18/8/2674/pdf
- http://ijid.informaticspublishing.com/indeX.php/ijid/article/download/111838/78332
- https://www.mdpi.com/1424-8220/18/8/2674/pdf
- Splinter, W.E. (1974). Modelling of plant growth for yield prediction. *Agricultural Meteorology*, 14(1-2), 243-253.

General Source Information

- Blankenship RE. 2014. *Molecular mechanisms of Photosynthesis* 2nd Edition
- *Canopy Photosynthesis: From Basics to Applications*. 2016 Ed Hikosaka, Kouki, Niinemets, Ülo, Anten, Niels P.R.
- Adams III, William W., Terashima, Ichiro. 2018. *The Leaf: A Platform for Performing Photosynthesis*.
- Pessarakli M. 2016. *Handbook of Photosynthesis* 3rd Edition.

I. Course Title : Physiology of Field Crops

II. Course Code : PP 508

III. Credit Hours : 2+0

IV. Theory

Block 1: Physiology of Field Crops

Unit 1: Introduction

Origin- Variability in physiology of crop plants between wild species and cultivated. Adaptability to growing environments (ecosystems), Importance in food grain contribution.

Unit 2: Crop Establishment, Crop Growth and Development

Seed characteristic features, dormancy, viability, concept of seed priming seedling establishment and crop stand. Different crop growth stages, concept of source establishment and optimum LAI, Canopy architecture, light interception/radiation use efficiency, thermal time, heat units, GDD, determining growth duration.

Unit 3: Reproductive Growth

Photo and thermo-periodic response for flowering, sink development, sink source relationship, partitioning efficiency, improvement in HI, yield determining factors, genetic gain in yield over years, structuring of ideal plant type, limitations to improve source to sink size, options to improve yield potential.

Unit 4: Seed Nutrient Quality

Seed quality, seed as a source of nutrients, seed constituents and their improvement, concept of pathway engineering to improve seed quality.

Unit 5: Plant Nutrition

Nutrient requirement, genetic variability in nutrient acquisition under constraint conditions, specific nutrient disorders.

Unit 6: Abiotic Stress Response

Response to different abiotic stresses, plant traits/mechanics to improve adaptation to realize potential yields. Global warming responses, thermomorphogenesis, approaches to overcome the constraints.

Unit 7: Crop Specific Physiological Processes and Importance

Choosing location specific crop species exposure will be given on physiological process as described above. Besides, emphasis is on providing information on crop specific features/productivity constraints.

Suggested Reading

- *Grain Legumes*: Ed De Ron, Antonio M. (Ed.) 2015. Springer
- *Legumes under Environmental Stress: Yield, Improvement and Adaptations*. Eds MM Azooz P Ahmad and Hoboken, NJ: John Wiley and Sons, Ltd., 328 pages. ISBN: 978-1-118-91708-4
- *Pulse Crops: Biotechnological Strategies to Enhance Abiotic Stress Tolerance*. Ganeshan S, Gaur PM, Chibbar RN, Tuteja N, Gill SS, Tuteja R. chapter 17
- *Climate Change and Management of Cool Season Grain* Legume *Crops*. Eds Yadav GS, McNeil DL, Redden R, Patil SA. Springer
- *Nature's pulse power: legumes, food security and climate change.* Considine MJ, Siddique

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- Ram B, RajulaShanthy T, Viswanathan R, Hemaprabha G and Palaniswami C. 2016. *Handbook on sugarcane.* ICAR-Sugarcane Breeding Institute. ISBN 978-93-85267-03-1
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- Singh, C.B.andKhare, D. 2015.. *Genetic Improvement of Field Crops*. Scientific Publishers, Jodhpur.
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- Fahad S, Bajwa AA, Nazir U, Anjum SA, Farooq A, Zohaib A, Sadia S, Nasim W, Adkins S, Saud S and Ihsan MZ. 2017. *Crop production under drought and heat stress: plant responses and management options. Frontiers in Plant Science* 8(1147): 1-16.
- Pandey V and Shukla A. 2015. *Acclimation and Tolerance Strategies of Rice under Drought Stress. Rice Science* 22(4): 147-161.
- Kole C. 2006. *Cereals and millets. Genome Mapping and Molecular Breeding in Plants. Springer.*
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- Rinki, Mamrutha HM, Sareen S, Tiwari V, Singh GP. 2018. *Dissecting the physiological and anatomical basis for high yield potential in HD 2967. Vegetos*. 31: 121-124.
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- Reynolds *M. Wheat Physiological Breeding volume I and II (CIMMYT): Wheat Physiological Breeding: A Field Guide to Wheat Phenotyping*.
- Mamrutha HM *et al.* 2019. *Physiological and Molecular Basis of Abiotic Stress Tolerance in Wheat*. In: Rajpal V., Sehgal D., Kumar A., Raina S. (eds) *Genetic Enhancement of Crops for Tolerance to Abiotic Stress: Mechanisms and Approaches*, Vol. I. Sustainable Development and Biodiversity, vol 20. Springer, Cham
- Tiwari V. *et al.* 2017. *Managing Abiotic Stresses in Wheat*. In: Minhas P., Rane J., Pasala R. (eds) *Abiotic Stress Management for Resilient Agriculture*. Springer, Singapore

I. Course Title : Physiology of Horticulture Crops

II. Course Code : PP 509

III. Credit Hours : 2+0

IV. Theory

Block 1: Physiology of Horticultural Crops

Unit 1: Introduction

Origin, distribution and adaptability of crops to different agro-climatic conditions

Unit 2: Crop growth and Development

Internal factors (hormone, etc.) influencing various physiological processes linked to vegetative growth or growth of specific organ, correlative and algometric growth External factors (water, nutrition, temperature, etc.) influencing various physiological processes linked to vegetative growth or growth of specific organ, correlative and algometric growth, Propagation methods, grafting, cutting, budding, air layering. Physiology of pruning, dwarfing, branch bending, canopy management etc., Physiological and biochemical aspects of scion and root stock interaction and compatibility.

Unit 3: Reproductive Growth

Physiology of flowering, photo- and thermo-periodism and response to vernalization, Factors influencing reproductive growth, fruit and seed set/retention, physiology of flower sex ratio, Physiological processes governing source-sink relationship and productivity.

Unit 4: Pre and Post Harvest Physiology

Preharvest factors influencing postharvest physiology, Physiological and molecular mechanisms of ripening, Physiological and molecular mechanisms of senescence, Hormonal and chemical control of postharvest deterioration of fruits/vegetable/ flowers. Regulation of ripening at physiological and molecular levels, Regulation of senescence at physiological and molecular levels, Approaches to improve shelf life and storability. Approaches to improve postharvest management, Approaches to improve processing and value addition.

Unit 5: Plant Nutrition and Abiotic Stress Responses

Nutrient acquisition and requirement, plant phenology and nutrient requirement; Role of rootstocks in nutrient acquisition and in abiotic stress tolerance, Adaptive mechanisms and approaches to improve performances under drought and high temperature, Adaptive mechanisms and approaches to improve performances under frost, chilling and nutrient deficient conditions, Root physiology in abiotic stress tolerance.

Unit 6: Specific Aspects and Unique Crop Features

Specific aspects

Polyhouse cultivation, Hormones/PGRs for improving crop performance, Major and micronutrients for improving crop performance, Light interception, shade regulation, dwarfing root stocks, Chilling requirement for flowering, photoperiodic response, pollen viability, stigma receptivity, Flower (blossom) and fruit drop.

Unique crop features

Maturity and maturity indices, Source-sink relations, Vegetative propagation, Physiology of tuberization and rhizome initiation and formation, Virus free planting material, Bulbs/tubers dormancy, bud break, Physiological disorders, Storage, Packaging, Quality.

IX. Suggested Reading

- Sethuraj MR and Raghavendra AS. 2012. *Tree Crop Physiology*. ISBN-13: 978-0444428417, ISBN-10: 0444428410, Elsevier Science Publishers.
- Bhatnagar P. *Physiology of Growth and Development of Horticultural Crops*, ISBN-10: 817754666X, ISBN-13: 978-8177546668
- Singh A. *Fruit Physiology and Production*, ISBN-10: 8127211788, ISBN-13: 978-8127211783, Kalyani Publishers; 5th edition (March 28, 2003).
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- Durner EF. 2013. *Principles of Horticultural Physiology*, ISBN-13: 978-1780643069, ISBN-10: 1780643063, CABI.
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- Urban L, Jegouzo L, Damour G, Vandame M and François C. 2008. *Interpreting the decrease in leaf photosynthesis during flowering in mango. Tree physiology*, 28(7), 1025-1036.
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X. *Symposium on Mineral Nutrition of Fruit Crops* 984 (357-363).

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Grapes

- Keller M. 2015. *The science of grapevines: anatomy and physiology*. Academic Press.
- Williams LE. 2017. *Grape. In Photoassimilate Distribution Plants and Crops Source-Sink*

Relationships (pp. 851-882). Routledge.
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Guava

- Rodrigues AAM, Silva SDM, Dantas AL, Silva AFD, Santos LDS and Moreira DDN. 2018. *Physiology and postharvest conservation of 'Paluma'guava under coatings using Jack fruit seed-based starch. RevistaBrasileira de Fruticultura*, 40(2).
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- Adhikari S. 2012. *Guava Pruning and Its Physiology*

Tomato

- Aivalakis G and Katinakis P. 2008. *Biochemistry and molecular physiology of tomato and pepper fruit ripening. Eur J Plant SciBiotechnol, 2*(special issue 1), 145-155.
- Peet MM. 2008. *Physiological disorders in tomato fruit development. In International Symposium on Tomato in the Tropics 821* (151-160).
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- Fentik DA. 2017. *Review on genetics and breeding of tomato (Lycopersicon esculentum Mill.). Adv Crop Sci Tech, 5*(5), 306.

Onion

- Brewster JL. 2018. *Physiology of crop growth and bulbing. In Onions and allied crops* (53-88). CRC Press.

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- Coolong TW. 2007. *Physiological Factors Affecting Onion* (*Allium Cepa L.) Storability: Cultural Methods for Improving Postharvest Quality*, University of Georgia.
- Khokhar, K.M., 2017. *Environmental and genotypic effects on bulb development in onion–a review. The Journal of Horticultural Science and Biotechnology* 92(5): 448-454.
- Khokhar KM. 2014. *Flowering and seed development in onion—A review*. Open Access Library 1(07).

Brinjal

- Sharma SP and Brar JS. 2008. *Nutritional requirements of brinjal (Solanum melongena L.)-A review. Agric. Rev*, 29(2), pp.79-88.
- Byari, S.H. and Al-Rabighi, S.M., 1995. *Morphological and physiological responses of egg plant cultivars (Solanum melongena L.) to drought.* J. KAU: *Met. Env, Arid Land Agric. Sci*, *6*, pp.41-47.

I. Course Title : Seed Physiology

II. Course Code : PP 510*

III. Credit Hours : 2+1

IV. Theory

Block 1: Physiology of Seed Development

Unit 1: Introduction to Seed Physiology

Importance of seed as a propagule, seed structure and functions; chemical composition of seeds. Embryogenesis: pollination and fertilization, pollen and pistil interaction, signal for interaction; pollen load hypothesis; genetical and environmental influence on seed development. Source-Sink relationship affecting seed yield and quality. Concept of seed viability and seedling vigour and their relevance; approaches to improve the storability of seeds. Physiological and molecular mechanisms of seed germination; approaches to improve seed germination; seed size and its influence on seed germination.

Unit 2: Seed Development

Physiology and molecular mechanisms of embryo, endosperm and seed coat development; cellularization during endosperm development; morphological and cellular changes during seed coat development, anatomy and function of seed coat, programmed cell death (PCD) in seed coat, Deposition of seed storage reserves during development.

Unit 3: Seed Maturation

Seed maturation and maturation indices; physiological and anatomical changes during seed maturation; Seed drying and acquisition of desiccation tolerance in seeds; mechanisms of desiccation tolerance; role of ABA LEA's, HSP's, dehydrins and other stress proteins during seed maturation and drying, Seed abortion and approaches to reduce it.

Unit 4: Metabolism in Developing Seed

Chemical composition of seeds (carbohydrates, proteins, fats etc.), source of assimilates for seed development, pathways of movement of assimilates to developing seed, approaches to increase the chemical composition of seeds. Seed respiration and mitochondrial activity; seed respiration rate and storability of seeds. Seed ageing, Mobilization of stored resource in seeds; Chemistry of oXidation of starch, proteins and fats; Utilization of breakdown products by embryonic aXis.

Block 2: Physiology of Seed Germination and Dormancy

Unit 1: Seed germination

Seed germination, types of germination, imbibition kinetics of germinating seed; Physiological events during germination: seed respiration, mitochondrial activity, mobilization of food reserve; energy utilization by the germinating seed.

Environmental regulation of germination: hydro-time, thermal time and hydrothermal time models; Influence of environmental factors on germination; Role of plant hormones/PGR's during seed germination.

Unit 2: Seed Dormancy and Viability

Physiological and molecular basis of seed dormancy, hormonal regulation of dormancy, After ripening, dormancy breaking treatments; Ecological perspective of seed dormancy. Seed viability: concept and physiology of seed viability, theories of seed ageing, seed storage and regulation of storage life of seeds; methods to prolong seed viability; Conservation of orthodoX and recalcitrant seeds. Seed vigour: concept, importance,

measurement; Physiological, biochemical and molecular basis of seed vigour.

V. Practicals

- Determination of seed reserves: carbohydrates, proteins and lipids
- Study of different seed structures
- Kinetics of seed imbibition; Seed germination test, enzymatic activities and respiration during germination and vigour testing methods etc.
- Accelerated ageing test to know the seed vigour and storability
- Measurement of seed moisture content
- Determination of amylase activity in germinating seeds
- Measurement of electrical conductivity in seed leachate
- Measurement of seed viability using tetrazolium chloride
- Determination of dehydrogenase activity
- Seed germination study- Determination of Germination Index and seedling growth
- Measurement ofseed vigour index
- Dormancy breaking treatments
- Seed priming techniques
- Effect of environmental stresses on seed germination and seedling growth
- Effect of hormones on seed germination

IX. Suggested Reading

- Bewley, JD, Bradford K, Hilhorst H, Nonogaki H. (2013). *Seeds: Physiology of Development, Germination and Dormancy*, Springer-Verlag.
- Larkins BA and Vasil IK (Ed), *Cellular and Molecular Biology of Plant Seed Development*, 2010, Springer.
- Vanangamudi K, Natarajan K and Vanangamudi M *et al.* 2017. *Seed Physiology*. Associated Publishing Company.
- Bewley JD and Black M. 1994. *Seeds: Physiology of Development and Germination*, Springer
- Pammenter NW and Patricia Berjak. 2000. *Aspects of recalcitrant seed physiology*. R.Bras. Fisiol. Veg., 12: 56-69.
- Prakash. M. 2011. *Seed physiology of crops*.(ed). Satish Serial Publishing house, New Delhi.
- Roberto Benech-Arnold, Rodolfo Sanchez. 2004. *Handbook of Seed Physiology: Applications to Agriculture*. CRC Press.
- Vijayakumar A. 2001. *Seed Dormancy an overview*. *In: Recent techniques and Participatory Approachs in Quality seed production* (eds. K. Vanangamudi *et al.*) TNAU, Coimbatore. 287-396.
- Padmavathi SM, Prakash S, Ezhil Kumar G, Sathianarayanan and Kamaraj A. 2012. *A Text Book of Seed Science and Technology*. New India Publishing Agency, New Delhi.
- Tina Steinbrecher Gerhard Leubner-Metzger. 2017. *The biomechanics of seed germination*. *Journal of Experimental Botany*, 68(4): 765–783.
- http://sbc.ucdavis.edu/Research_pages/Seed_physiology_and_technology/.
- Bench ALR and Sanchez RA. 2004. *Handbook of Seed Physiology*. Food Product Press.

I. Course Title : Phenotyping Physiological Processes

II. Course Code : PP 511

III. Credit Hours : 2+0

IV. Theory

Block 1: Phenotyping Physiological Processes

Unit 1: Concept of Phenotyping

Phenotyping technologies are essential component for assessing plant responses, identify superior trait donors, mitigation responses, trait introgression and trait based breeding.

Unit 2: Phenotyping for Traits for Crop Establishment

Seed viability, seed dormancy, seed hydration rates, seed density and weight, Seedling vigour in normal and adverse conditions.

Unit 3: Concept and Approaches to Identify Genotypes with Superior Growth Rate

Phenotyping for leaf expansion, leaf area index, light interception and crop extinction coefficient. Pigment quantification for nitrogen and chlorophyll status - SPAD, anthocyanin and flavonoids – Duolex. Growth rates by non-invasive techniques like NDVI, Concept of Net assimilation rate and DM/LAD; surrogates for photosynthetic traits; stomatal characteristic.

Unit 4: Identifying Photo-insensitive Genotypes-options and Approaches

Exposing to longer and shorter photoperiod by staggered sowing; extending the day length- light interception by red light; days to heading/ anthesis, approaches for synchronization of flowering.

Unit 5: Identifying Thermo-insensitive Genotypes-options and Approaches

Altering total degree days- staggered sowing at lower latitudes or by growth chambers; quantifying heading, anthesis, maturity and grain filling days, grain number and weight, grain filling rate.

Unit 6: Yield Structure Analysis- Relevant Yield Attributes

Pollen biology, stigma receptivity, spikelet sterility (cereals), floral abscission (other crops), fruiting points / productive tillers, number of grains/ fruits per panicle/ inflorescence and grain characteristic. Phenotyping for lodging- culm traits, intermodal length, lignification, Phenylalanine ammonia lyase (PAL) and Tyrosine ammonia lyase(TAL). Approaches to identify genetic resources with traits to improve yield potential.

Unit 7: Source-sink Relationship- Assessment of Limitation

Phenotyping for source-sink size, Concept of sink-source limitation- defloration and defoliation. Remobilization of stored metabolites and concept of stay green; estimation of water soluble carbohydrates; partitioning coefficient and harvest index.

Unit 8: Identify Genetic Resources for Abiotic Stress Constraints

Approaches for precise stress imposition to diverse stresses, Identify trait donor lines for different stresses: approaches by Stress Susceptibility Index (SSI), Stress Induction Response (SIR), Capturing variability for adaptive traits: root traits,stomatal factors/wax, osmolyte, surrogate approach for acquired tolerant traits,Flowering response, Spikelet fertility, Abscission and Senescence, Screening high density response-based on SSI – root adaptation and Shade Avoidance Response (SAR).

V. Suggested Reading

- Kumar J, Pratap A and Kumar S. 2015. *Plant Phenomics: An Overview*. 10.1007/978-81- 322-2226-2_1.
- Pratap A, Gupta S, Nair RM, Gupta SK, Schafleitner R, Basu PS, Singh CM, Prajapati U, Gupta AK, Nayyar H, Mishra AK, Baek KH. 2019. *Using Plant Phenomics to Exploit the Gains of Genomics. Agronomy* 9, 126.
- AOSA. 2009. *Seed Vigor Testing Handbook. Contribution No. 32 to the Handbook on Seed Testing*.
- Finch-Savage WE and Bassel GW. 2015. *Seed vigour and crop establishment: extending performance beyond adaptation. Journal of experimental botany, 67*(3), 567-591.
- Muñoz-Huerta R, Guevara-Gonzalez R, Contreras-Medina L, Torres-Pacheco I, Prado-Olivarez J and Ocampo-Velazquez R. 2013. *A review of methods for sensing the nitrogen status in plants: advantages, disadvantages and recent advances. sensors*, 13(8), 10823-10843.
- Xue, J and Su B. 2017. *Significant Remote Sensing Vegetation Indices: A Review of Developments and Applications, Journal of Sensors*, 2017: 17 https://doi.org/10.1155/2017/1353691.
- Ouzounis, T., Rosenqvist, E., and Ottosen, C., 2015. *Spectral Effects of Artificial Light on Plant Physiology and Secondary Metabolism: A Review American Society Horticulture Science*. 50(8); 1128–1135 doi.org/10.21273/HORTSCI.50.8.1128
- *The Flowering Response of the Rice Plant to Photoperiod: A Review of The Literature* Fourth Edition.
- Sehgal A, Sita K, Siddique KH, Kumar R, Bhogireddy S, Varshney RK and Nayyar H. 2018. *Drought or/and Heat-Stress Effects on Seed Filling in Food Crops: Impacts on Functional Biochemistry, Seed Yields, and Nutritional Quality. Frontiers in Plant Science*, 9.
- Prasad, P. V., Bheemanahalli, R., andJagadish, S. K. 2017. *Field crops and the fear of heat stress—Opportunities, challenges and future directions. Field Crops Research* 200, 114-121.
- Gómez JF, Talle B and Wilson ZA. 2015. Anther and pollen development: a conserved developmental pathway. *Journal of Integrative Plant Biology* 57(11), 876-891.
- Khobra R, Sareen S, Meena BK, Kumar A, Tiwari V and Singh GP. 2019. *Exploring the traits for lodging tolerance in wheat genotypes: A review. Physiology and Molecular Biology of Plants*, 1-12.

  Hirano K, Ordonio RL and Matsuoka M. 2017. *Engineering the lodging resistance mechanism of post-Green Revolution rice to meet future demands. Proceedings of the Japan Academy, Series B*, 93(4), 220-233.

  White, A. C., Rogers, a., Rees, M and Osborne, C.P., 2016. *How can we make plants grow faster? A source–sink perspective on growth rate Journal of Experimental Botany*, 67(1): 31–45.

  Ragheba, A., El-Shimyb, H and Raghebb, G. 2016. *Green architecture: a concept of sustainability, Procedia - Social and Behavioral Sciences* 216: 778 – 787.
- Wang H, Wu G, Zhao B, Wang B, Lang Z, Zhang C and Wang H. 2016. *Regulatory modules controlling early shade avoidance response in maize seedlings*, *BMC Genomics***17**: 269, https://doi.org/10.1186/s12864-016-2593-6.
- Carriedo, L., Maloof, J and Brady, S. 2016. *Molecular control of crop shade avoidance. Current Opinion in Plant Biology*. 30. 151-158. 10.1016/j.pbi.2016.03.005.

I. Course Title : Crop Growth Regulation and Management

II. Course Code : PP 512

III. Credit Hours : 2+0

IV. Theory

Block 1: Propagation - Crop Establishment

Unit 1: Seed as a Propogule

Concept of improving seed characteristics for crop establishment. Mechanisms of regulating seed dormancy, precocious germination, ways to control pre-harvest sprouting in crop plants. Seed viability and its regulation, factors to minimize loss of viability and improve seedling vigour. Concept of seed priming, techniques of priming, seed priming to induce tolerance to stresses. Role of media, nutrition and PGPR's on seedling vigour and subsequent crop establishment.

Unit 2: Vegetative Propogule

Chemical and hormonal regulation of vegetative propagation. Regulation of rooting, bud sprouting, Bulb/tuber dormancy. Chemical regulation of graft union. Concept of *in vitro* micropropogation.

Block 2: Regulation of Plant Growth Processes

Unit 1: Regulation of Plant Growth and Flowering

Chemical and hormonal regulation of plant architecture, tillering, branching, bud breaking, Regulation of flowering by photo and thermoperiod, nutrients, chemicals and hormones, concept of speed breeding, Flowering synchrony in hybrid seed production, Sex ratio alteration, flower and fruit thinning, Pollen viability in relation to environment, harvesting, storage and transportation, Prevention of abscission, flower and fruit drop, seed and fruit growth regulation- role of hormones.

Unit 2: Fruit Ripening and its Regulation

Approaches to improve shelf life – storage environment, water loss, respiration, Modified atmosphere, gaseous environment for storage, storage disorders, chilling injury.

Unit 3: Concept of Senescence and its Retardation

Physiology of senescence and options to regulate, Chemical regulation of senescence, maintenance of chlorophyll during storage, role of hormones/micronutrients in reducing senescence, Concept of stay green, advantages and limitations. Relevance of stay green traits in plant breeding for crop improvement.

Block 3: Protective Cultivation–Stress Mitigation

Unit 1: Protective Cultivation Interventions to Alter Physiological Processes and Growth

Spectral characteristics of light in polyhouse, light regulation to optimize plant photosynthetic and photomorphogenic processes and plant growth, LED sources of monochromatic light to regulate growth, etiolating and flowering, High temperature induced thermomorphogenic processes, Artificial growing media, soilless cultures, aeroponics, fogoponics, Concept of CO_2 fertilization. Effect of humidity on leaf expansion and growth.

Unit 2: Drought Mitigation Options and Approaches

Moisture conservation options at soil and plant level, Concept of increasing water holding capacity, role of Hydrogels – water and mineral nutrients release pattern. Approaches to improve transpiration over evapo-transpiration, stomatal and non-

stomatal regulation of water loss, antitranspirants, Osmoprotectants, ROS scavengers, plant nutrients, Root stocks in improving tolerance, Chemical regulation of flower drop due to temperature, Chemicals to improve pollen viability during abiotic stress.

Unit 3: Specific Plant Processes Regulated by Chemicals and Growth Hormones

Rooting of cuttings, Wine brewing industry, Promotion of gynoecious flower, Hybrid rice production, Induction of flowering in pine apple, cucurbits, Delaying of senescence and ripening, Production of dwarf plant for ornamental purpose, Reduction in flower and fruit drop, Increase in berry size in grapes.

V. Suggested Reading

- Wu X, Ning F, Hu X and Wang W. 2017. *Genetic Modification for Improving Seed Vigor Is Transitioning from Model Plantsto Crop Plants. Front. Plant Sci.* 8: 8. doi: 10.3389/ fpls.2017.00008
- William E. Finch-Savage and Steven Footitt. 2017. *Seed dormancy cycling and the regulation of dormancy mechanisms to time germination in variable field environments Journal of Experimental Botany*, 68, (4), 843 856, https://doi.org/10.1093/jxb/ erw477
- Afzal I, Ur Rehman H, Naveed M and ShahzadMaqsood, Basra A. 2016. *Recent Advances in Seed Enhancements* Intech.
- *Techniques and Experiments Plant Tissue Culture Techniques and Experiments* Elsevier Inc. 2013.
- Nanda AK and Melnyk CW. 2018. *The role of plant hormones during grafting. Plant Res.* 131(1): 49–58. doi: 10.1007/s10265-017-0994-5PMCID: PMC5762790
- Casa JJ and Balasubramanian. SK 2019. *Thermomorphogenesis, Annual Review of Plant Biology*, 70: 321-346 https://doi.org/10.1146/annurev-arplant-050718-095919
- Halevy AH. 2018. *Handbook of Flowering*. V*CRC press*
- Watson A, Ghosh S, Lee T. Hickey. 2018. *Speed breeding is a powerful tool to accelerate crop research and breeding. Nature Plants* 4, 23–29.
- Kusumaningrum D, Lee SH, Lee WH, Mo C., and Cho, B. K. 2015. *A review of technologies to prolong the shelf life of fresh tropical fruits in Southeast Asia. Journal of Biosystems Engineering* 40(4), 345-358.
- Sandarani, MDJC, Dasanayaka DCMCK and Jayasinghe CVL. 2018. *Strategies Used to Prolong the Shelf Life of Fresh Commodities. J AgriSci Food Res* 9: 206.
- Falagán, N and Terry LA. 2018. *Recent advances in controlled and modified atmosphere of fresh produce. Johnson Matthey Technology Review* 62(1), 107-117.
- Kim, J., Kim, J. H., Lyu, J. I., Woo, H. R., and Lim, P. O. 2017. *New insights into the regulation of leaf senescence in Arabidopsis. Journal of experimental botany* 69(4), 787-799.
- Luche, H. D. S., Silva, J. A. G. D., Maia, L. C. D., and Oliveira, A. C. D. 2015. *Stay-green: a potentiality in plant breeding. Ciência Rural*, *45*(10), 1755-1760.
- Bian, Z., Jiang, N., Grundy, S. and Lu, C., 2017. *Uncovering LED light effects on plant growth: new angles and perspectives-LED light for improving plant growth, nutrition and energy-use efficiency*. In *International Symposium on New Technologies for Environment Control, Energy-Saving and Crop Production in Greenhouse and Plant* 1227. 491-498.
- Barrett, G.E., Alexander, P.D., Robinson, J.S. and Bragg, N.C., 2016. *Achieving environmentally sustainable growing media for soilless plant cultivation systems–A review. Scientia horticulturae*, 212: 220-234.
- Raviv, M., Lieth, J.H. and Bar-Tal, A. (eds), 2019. *Soilless Culture: Theory and Practice: Theory and Practice*. Elsevier.
- Wang, P., Deng, Y., Li, X.Y., Wei, Z., Hu, X., Tian, F., Wu, X., Huang, Y., Ma, Y.J., Zhang, C. and Wang, Y. 2019. *Dynamical effects of plastic mulch on evapotranspiration partitioning in a mulched agriculture ecosystem: Measurement with numerical modeling. Agricultural and Forest Meteorology*, 268: 98-108.
- GernotBodner, Alireza, Hans-Peter *Management of crop water under drought: A review. Agronomy for sustainable development*. 2: 401-442

Course Title with Credit Load
Ph.D. Plant Physiology

Course Code	Course Title	Credit Hours
PP 601	Functional Genomics and Genes Associated with a Few Physiological Processes	2+0
PP 602*	Signal Perceptions and Transduction and Regulation of Physiological Processes	2+0
PP 603	Molecular Approaches for Improving Physiological Mechanisms Through Trait Introgression	2+1
PP 604	Plant Phenomics – Next Generation Phenomics Platforms	2+0
PP 605	Experimental Techniques to Characterize Plant Processes for Crop Improvement	0+2
PP 606	Global Climate Change and Crop Response	2+0
PP 607*	Physiological and Molecular Aspects of Source-sink Capacity for Enhancing Yield	3+0
PP 608	Seed and Fruit Growth and their Quality Improvement	2+0
PP 609	Plant-microbe Interactions	2+1
PP 610	Weed Biology and Physiology of Herbicide Action	2+0
PP 691	Doctoral Seminar I	1+0
PP 692	Doctoral Seminar II	1+0
PP 699	Doctoral Research	75

*Core courses

Course Contents
Ph.D. in Plant Physiology

I. Course Title : Functional Genomics and Genes Associated with a Few Physiological Processes

II. Course Code : PP 601

III. Credit Hours : 2+0

IV. Theory

Block 1: Functional Genomics And Genes: Physiological Processes

Unit 1: Gene Discovery

Finding genes in complex plant system, Constructing gene-enriched plant genomic libraries, Recent advancements in genome sequencing, RNA sequencing and expression, In Silico prediction of plant gene function, Quantitative Trait Locus analysis as a gene discovery tool, Gene expression analysis –micro-array and deep sequencing, small RNA and Degradome, Study of methylome and its significance

Unit 2: Genetic Tools for Plant Development

Understanding the importance of mutants in unrevealing the physiological processes, genome wide insertional mutagenesis – T-DNA insertion mutants, Gain in function, Transposon mutagens, Transposition, Physical and Chemical mutagenesis, Gene and Enhancer Traps for Gene Discovery, High-Throughput TAIL-PCR as a Tool to identify DNA Flanking insertions, High-Throughput TILLING for functional Genomics, Genome editing approaches for functional analysis of genes.

Unit 3: Gene Knock Out Approaches

PTGS-Antisense technology, Virus induced gene silencing (VIGS), Custom Knock-outs with Haripin RNA-mediated Gene Silencing and other silencing tools, Complementation studies.

Unit 4: Chemical Genomics

Reverse chemical genomic approaches for functional validation of genes, Protein structure prediction, homology modelling and virtual screening by using bioinformatic approaches to identify the small molecules and their validation through phenotyping assessment.

Unit 5: Gene Over Expression Approaches

Vector Construction for Gene Overexpression as a Tool to Elucidate Gene Function Transient expression, Transgenics, Targeted and conditional expression of transgene**.** Multiple gene expression by Nanostring technology, Co-expression analysis and gene networking to identify potential genes in the pathway (informatics), Epigenetics.

Unit 6: Synthetic Biology and Interaction Studies

Engineering microbial pathways in plants (eg, photosynthesis), DNA-protein & Protein-protein interaction studies, yeast hybrid system, Correlating the data from genome, transcriptome, proteome, metabolome and ionome with phenome, Multivariate analysis and identification of metabolite as biomarkers.

Unit 7: Case Studies

Functional characterization of genes associated with important cellular processes influencing crop growth and development: genes controlling photosynthesis and

nutrient uptake, Functional characterization of genes associated with important cellular processes influencing crop growth and development: genes controlling respiration and photorespiration, Functional characterization of genes associated with important cellular processes influencing crop growth and development: fatty acid biosynthesis, seed protein quality and quantity, Functional characterization of genes associated with important cellular processes influencing crop growth and development: genes controlling flowering.

***Regulation of Gene Expression in Plants*. Gatehouse JA. 1997. *Plant Biochemistry*.**

Plant genome sequencing, Fleury D, Langridge P. 2012. *Plant Biotechnology and Agriculture*. Baxevanis, A. D. and Ouellette, B. F. F. (eds). 2001. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Methods of Biochemical Analysis*, vol. 43, 2nd ed., New York: John Wiley and Sons, Inc.

Gene Expression Analysis: Methods and Protocols, Raghavachari N, Garcia-Reyero, N (Eds.) 2018. ISBN 978-1-4939-7834-2, Springer

Transcriptome Data Analysis: Methods and Protocols. Wang Y, Sun, M (Eds.), 2018. ISBN 978-1-4939-7710-9; Springer

Comparative Genomics: Methods and Protocols. Setubal, J C., Stoye, Stadler P (Eds.) ISBN 978-1-4939-7463-4; Springer

- Rosenberg E. 2017. *It's in Your DNA*. 2017
- *Recombinant DNA Technology and Genetically Modified Organisms*. 2017. Nambisan P. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology.
- He F, Zhang F, Sun W, Ning, and Wang GL. 2018. *A Versatile Vector Toolkit for Functional Analysis of Rice Genes* 11: 27.doi: 10.1186/s12284-018-0220-7.
- Kamburova VS, Nikitina EV, Shermatov SE, Buriev ZT, Kumpatla SP, Emani C and Abdurakhmonov EY. *Genome Editing in Plants: An Overview of Tools and Applications International Journal of Agronomy*. https://doi.org/10.1155/2017/7315351
- Bhardwaj R, Singh R. 2014. *Gene Silencing in Emerging Technologies and Management of Crop Stress Tolerance*, Volume 1.
- Norambuena L, Raikhel NV, Hicks GR. 2009. *Chemical genomics approaches in plant biology*. *Methods Mol Biol.* 553: 345-54. doi: 10.1007/978-1-60327-563-7_18.
- Dejonghe W and Russinova E. *Plant Chemical Genetics: From Phenotype-Based Screens to Synthetic Biology*. *Plant Physiol.* 2017 May; 174(1): 5–20.doi: 10.1104/pp.16.01805
- Fiers M, Hoogenboom J, Brunazzi A, Wennekes T, Angenent GC and Immink RGH. 2017. *A plant-based chemical genomics screen for the identification of flowering inducers*, Plant Methods 201713: 78, https://doi.org/10.1186/s13007-017-0230-2
- *Gene Overexpression in Cereals for Functional Genomics and Discovery of Useful Genes*, Abe K and Ichikawa H. 2016. *Front Plant Sci.* 7: 1359. doi: 10.3389/fpls.2016.01359
- *Gene Overexpression: Uses, Mechanisms, and Interpretation*, Prelich G. 2012. 190 no. 3 841-854; https://doi.org/10.1534/genetics.111.136911
- Wusheng Liu C. Neal Stewart Jr *Plant synthetic biology* https://doi.org/10.1016/j.tplants.2015.02.004, REVIEW| 20, 5, P309-317, 2015
- *Plant Synthetic Biology*: Quantifying the "Known Unknowns" and Discovering the "Unknown Unknowns" R. Clay Wright, Jennifer Nemhauser, 2019. DOI: https://doi.org/10.1104/pp.18.01222
- *Plant synthetic biology for molecular engineering of signalling and development*. Nemhauser JL and Torii KU. 2016. *Nat Plants* 2: 16010.doi: 10.1038/nplants.2016.10

Of Physiological Processes

II. Course Code : PP 602*

III. Credit Hours : 2+0

IV. Theory

Block 1: Signal Perceptions and Transduction: Regulation of Physiological Processes

Unit 1: Concept of Receptor and Ligands

Signal, signal types, long (diffusible) and short (contact) range signaling and components of signaling. Types of receptors, nature of ligands, downstream components like primary, secondary signaling components.

Unit 2: Receptors – Signal Perception and Transfer

Cell surface trans-membrane receptors- GPCRs, Receptor Tyrosine Kinases (RTKs), Receptors Serine Threonine kinases (RSTKs), Receptor-Like Kinases (RLKs), receptor two component systems. Signal transfer phosphor-relay and generation of secondary signaling components and activation of TFs or enzymes. Downstream components- G-proteins, second messengers-Cyclic AMP, Adenylate cyclase cascade, cyclic GMP, calcium-calmodulin-kinases; effector molecules (transcription factor).

Unit 3: Hormone Signaling

Hormone binding receptors-Transduction process. Effector molecules and gene expression. Specific signaling pathways of Auxins, Cytokinin, Gibberellins, Ethylene, ABA, Brassinosteroids, Salicylic Acid, Strigolactone, polyamines, Jasmonic acid, etc. which leads to formative effects. Cross talk in the signaling of different hormones-significance of studies with hormone action mutants.

Unit 4: Light Signaling

Perception of light-pigments involved- activation of phytochrome/cryptochrome (study of mutants). Light signal transduction. Multiple signaling cascades-identification of signaling components through mutant analysis-changes in gene expression.

Unit 5: Abiotic Stress Signaling and Nutrient Signalling

Sensing of environmental factors (Temperature-Osmotic-Ionic stress), Activation of specific molecules and secondary messengers, activation of downstream components-leading to stress gene expression, Case studies with different abiotic stresses, Retrograde signaling, Nitrogen fixation, nitrogen and phosphorus uptake, nutrient translocation.

Unit 6: Signaling Cascade during Developmental Events

Leaf senescence/fruit development and ripening, Tuberization, Sugar signaling. Signaling during seed germination.

Unit 7: Signal Perception and Transduction in Plant Defense Responses

General mechanisms to pathogen response, Role of salicylic acid and active oxygen species, Cross Talk Signaling- Stress matrix under field conditions, cross talk between abiotic-abiotic stress, biotic-abiotic stress signaling networks.

V. Suggested Reading

- He, Y., Zhou, J., Shan, L. and Meng, X., 2018. *Plant cell surface receptor-mediated signaling–a common theme amid diversity*. J Cell Sci, 131(2), p.jcs209353.
- Hall, M.A., Smith, A.R., Novikova, G.V. and Moshkov, I.E., 1999. *Perception and transduction of ethylene. New Comprehensive Biochemistry*, 33, 475-490.
- Huber, A.E. and Bauerle, T.L., 2016. *Long-distance plant signaling pathways in response to multiple stressors: the gap in knowledge. Journal of Experimental Botany*, 67(7), 2063-2079.

- Pollard, T.D., Earnshaw, W.C., Lippincott-Schwartz, J. and Johnson, G., 2016. *Cell Biology* E-Book. Elsevier Health Sciences.
- Braun, Y., Smirnova, A.V., Weingart, H., Schenk, A. and Ullrich, M.S., 2007. *A temperature sensing histidine kinase—function, genetics, and membrane topology*. Methods In Enzymology: 423: 222-249. Academic Press.
- Unden, G., Wörner, S. and Monzel, C., 2016. *Cooperation of secondary transporters and sensor kinases in transmembrane signalling: the DctA/DcuS and DcuB/DcuS sensor complexes of Escherichia coli. In Advances in Microbial Physiology* (Vol. 68, 139-167). Academic Press.
- Ortiz-Urquiza, A. and Keyhani, N.O., 2016. Molecular genetics of *Beauveria bassiana* infection of insects. *Advances in Genetics* 94: 165-249). Academic Press.
- Snijders, L. and Naguib, M., 2017. *Communication in animal social networks: a missing link. Adv Study Behav*, 49, pp.297-359.
- Hedden, P. and Thomas, S.G. (eds.), 2008. *Annual Plant Reviews, Plant Hormone Signaling* 24. John Wiley and Sons.
- Eckardt, N.A., 2015. *The plant cell reviews dynamic aspects of plant hormone signaling and crosstalk*.
- Chow, B. and McCourt, P., 2006. *Plant hormone receptors: perception is everything. Genes and development*, 2015, 1998-2008.
- Leduc, N., Roman, H., Barbier, F., Péron, T., Huché-Thélier, L., Lothier, J., Demotes-Mainard, S. and Sakr, S., 2014. *Light signaling in bud outgrowth and branching in plants. Plants*, 3(2), 223-250.
- Kami, C., Lorrain, S., Hornitschek, P. and Fankhauser, C., 2010. *Light-regulated plant growth and development. Current Topics in Developmental Biology* (91: 29-66). Academic Press.
- Coureux, P.D. and Genick, U.K., 2007. *Triggering and Monitoring Light Sensing Reactions in Protein Crystals. Methods in Enzymology* (422: 305-337). Academic Press.
- Wang, C.S., Hsu, S.W. and Hsu, Y.F., 2013. *New insights into desiccation-associated gene regulation by Lilium longiflorum ASR during pollen maturation and in transgenic Arabidopsis. International Review of Cell and Molecular Biology* (301: pp. 37-94). Academic Press.
- Ben-Ari, G. and Lavi, U., 2012. *Marker-assisted selection in plant breeding. Plant Biotechnology and Agriculture* (163-184). Academic Press.
- Peleg, Z.V.I., Walia, H. and Blumwald, E. 2012. *Integrating genomics and genetics to accelerate development of drought and salinity tolerant crops. Plant Biotechnology and Agriculture* 271-286. Academic Press.
- Zhu, J.K., 2016. *Abiotic Stress Signaling and Responses in Plants*. Cell, 167(2): 313-324.
- Pandey, G.K., Pandey, A., Prasad, M. and Böhmer, M., 2016. *Abiotic stress signaling in plants: functional genomic intervention. Frontiers in Plant Science*, 7, p.681.
- Inaba, T., Yazu, F., Ito-Inaba, Y., Kakizaki, T. and Nakayama, K., 2011. *Retrograde signaling pathway from plastid to nucleus. International Review of Cell and Molecular Biology* (Vol. 290, pp. 167-204). Academic Press.
- Khan, M.I.R., Reddy, P.S., Ferrante, A. and Khan, N.A. (eds.). 2019. *Plant Signaling Molecules: Role and Regulation Under Stressful Environments*. Woodhead Publishing.
- Sparks, E., Wachsman, G. and Benfey, P.N., 2013. *Spatiotemporal signalling in plant development. Nature Reviews Genetics*. 14(9), p.631.
- Becraft, P.W., 2002. *Receptor Kinase Signaling in Plant Development. Annual Review of Cell and Developmental Biology*, 18(1) 163-192.
- Sparks, E., Wachsman, G. and Benfey, P.N. 2013. *Spatiotemporal signalling in plant development. Nature Reviews Genetics* 14(9): p.631.
- Rabellino, D., Boyd, J.E., McKinnon, M.C. and Lanius, R.A. 2019. *The Innate Alarm System: A Translational Approach. Stress: Physiology, Biochemistry, and Pathology* 197-212. Academic Press.
- Newton, A.C., Torrance, L., Holden, N., Toth, I.K., Cooke, D.E., Blok, V. and Gilroy, E.M., 2012. *Climate change and defense against pathogens in plants. Advances in Applied Microbiology* (81: 89-132). Academic Press.
- Reverchon, S., Muskhelisvili, G. and Nasser, W., 2016. *Virulence program of a bacterial plant pathogen: the Dickeya model. Progress in Molecular Biology and Translational*

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- Signaling and Communication in Plants, ISBN-10: 3540892273Springer; 2009 edition (March 18, 2009)
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- *Developmental and Cell Biology Series: Hormones, Signals and Target Cells in Plant Development Series* Number 41, Osborne DJ, McManus MT, Cambridge University Press, ISBN-13: 9780521330763
- *How Plants Communicate* Machajewski S. 2018, Rosen Education Service, ISBN-13: 9781538301852
- *Signal Transduction in* Plants Aducci P (Ed), 2011, ISBN-13: 9783034899383
- *Reactive Oxygen Species: Signaling Between Hierarchical Levels in Plants.* Schmitt FJ. Allakhverdiev SI (Eds), 2017, Wiley-Scrivener ISBN-13: 9781119184881
- *Biocommunication: Sign-Mediated Interactions Between Cells and Organisms* Gordon R and Seckbach J (Ed). 2017. World Scientific Publishing Europe Ltd ISBN-13: 9781786340443
- *Annual Plant Reviews: Intracellular Signaling in Plants* Hedden P, Napier R, Yang Z (Ed) 2008, Wiley-Blackwell (an imprint of John Wiley and Sons Ltd) ISBN-13: 9781405160025

I. Course Title : Molecular Approaches for Improving Physiological Mechanisms through Trait Introgression

II. Course Code : PP 603

III. Credit Hours : 2+1

IV. Theory

Block 1: Trait Introgression through Molecular Breeding

Unit 1: Physiological Traits Relevant for Crop Improvement and their Phenotyping

Physiological traits with relevance to growth, development, biotic/abiotic stress tolerance, nutrient acquisition, Concept of complex, multi-gene control of physiological traits, Concepts of trait introgression to augment crop productivity and/or stress adaptation.

Unit 2: Identification of QTL by Bi-parental Mapping Approach

Concepts of developing trait-specific mapping population and identification of contrasting parental lines through phenotyping, Mapping populations and their developments – F_2, RIL, doubled haploid populations, Accurate phenotyping of bi-parental mapping populations, Conventional Genotyping strategies using SNP and SSR markers, other rapid approaches like GBS, RADseq, QTLseq etc., Composite interval mapping and other approaches for QTL discovery.

Unit 3: Identification of QTLs by Association Mapping Approach

Concepts of assembling a "Panel" of germplasm amenable for association mapping based on molecular and phenotypic diversity, Concepts of linkage disequilibrium, LD decay and population structure, Concepts QTL discovery in structured populations. Phenotyping of the association mapping populations, Concepts of Genome wide association studies (GWAS).

Unit 4: Trait Introgression by Molecular Breeding Approaches

Strategies for QTL introgression and Marker Assisted Selection (MAS), Various breeding methods for trait introgression: Marker assisted backcross breeding (MABC), Marker assisted recurrent selection (MARS), Marker assisted phenotypic selection (MAPS), etc.

Block 2: Trait Introgression through Transgenic Technology

Unit 1: Gene Discovery and Gene Constructs for Relevant Plant Traits/ Adaptive Mechanisms

Map-based cloning to identify novel genes and their allelic variants, Identification of differentially expressed genes through transcriptome, metabolome and proteome analysis in contrasting genotypes, Gene identification through forward (inducing mutations with radiation, chemicals, or insertional mutagenesis)and reverse genetic approaches (site-directed mutagenesis, gene knockout or knockdown), Cloning full-length candidate genes, inducible promoters, Concepts of "codon optimization" to make constructs for specific crops.

Unit 2: Trait Improvement or Pyramiding through Transgenic Technology

Introduction to GMOs and its application in crop improvement, Gene stacking strategies for trait improvement, *Agrobacterium* and other methods of plant transformation including gene gun, *in planta*, etc.

Unit 3: Genome Editing, a Potential Option for Gene Regulation by Transgenic Approach

Genome editing techniques: CRISPR/Cas9, Zinc finger nucleases, etc, CRISPR as tool to generate loss-of-function and gain-of-function transgenics.

Unit 4: Characterization of Transformed Plants and Event Selection Strategies

Molecular analysis bySouthern, qRT-PCR/Northern analysis, and immunoassays, Concepts of copy number and desirable number of independent events, Evaluation of transgenics based on empirical/physiological/biochemical processes under specific conditions – containment and confined field trials, Generation of T1 populations, event characterization, Molecular data as per regulatory requirements, Biosafety and Regulatory aspects of GMO.

Block 3: Other Approaches for Trait Introgression

Unit 1: Trait Introgression through Tissue Grafting and Asexual Propagation

Concept of identifying root stocks with superior traits, grafting, scion root stock interaction, compatibility, concept of chimeric grafting in transgenic technology involving a non-transgenic shoot to a transgenic root.

Unit 2: Doubled haploids for Trait Introgression

Concept of crossing trait donor lines and developing doubled haploids from the F1 anthers, Screening and identifying trait introgressed doubled haploids.

V. Practicals

- Phenotyping approaches for the different physiological traits. Development of SSR, SNP and SCAR markers, resolution of polymorphism on agarose gels and PAGE, genotyping options for SSR markers using capillary and chip based fragment analysis systems. scoring of gels and assessment of polymorphism
- Statistical approaches to assess genetic variability, heritability and other parameters. Phylogenetic analysis and principle component analysis and construction of dendrograms. Construction of Linkage map, QTL maps, population structure, LD decay etc leading to identification of QTLs.
- Bioinformatics – sequence analysis, structure analysis, designing primers for SSR regions, SNP2CAPS approaches of genotyping.
- Molecular biology - genomic/plasmid DNA isolation, RNA isolation. Full-length gene cloning, vector construction with specific promoter, gene stacking and transient assays. Transformation in model system
- Crop transformation - *Agrobacterium* mediated transformation (in-planta and invitro), particle-gun transformation.
- Evaluation of transgenics – semiquantitative and quantitative RT-PCR, southern blot, northern blot, western blot and ELISA, biochemical/physiological assay based on the function of gene and testing LOD.
- Improvement of traits based on grafting options.
- Techniques in developing doubled haploids and characterization.

VI. Suggested Reading

Reynolds MP. 2012. *Physiological Breeding I: Interdisciplinary Approaches to Improve Crop Adaptation* Chapters 2, 3, 5: 153

Reynolds M and Langridge P. 2016. *Physiological Breeding*. Current Opinion in Plant Biology, 31: 162–17.1

Sheshshayee MS, Preethi NV, Rohini S, Sowmya HR, Smitharani A, Pooja B, Prathibha MD and Soolanayakanahally R. 2018. *Introgression of Physiological Traits for a Comprehensive Improvement of Drought Adaptation in Crop Plants. Front. Chem*., 10.

Cossani M and Reynolds M. 2012. *Physiological Traits for Improving Heat Tolerance in Wheat. Plant Physiology*, Vol. **160**: 1710–1718

Payne T, Reynolds M and Skovmand B. *Searching genetic resources for useful variation in*

physiological traits Chapter 5. *Physiological Breeding* I: Interdisciplinary Approaches to Improve Crop Adaptation Reynolds, M.P. (ed).
Bonnett D. *Optimizing marker-assisted selection (MAS) strategies for crop improvement*.

Chapter 14: 153 Physiological Breeding I: Interdisciplinary Approaches to Improve Crop Adaptation Reynolds, M.P. (ed).

- Breeding Rice for Drought-Prone Environments Edited by K.S. Fischer, R. Lafitte, S. Fukai, G. Atlin, and B. Hardy. 2003, IRRI. Section 4. What molecular tools are available for selection for drought tolerance?
- Collard BCY, Jahufer MZZ, Brouwer JB and Pang ECK. *An introduction to markers, quantitative trait loci (QTL) mapping and marker-assisted selection for crop improvement: The basic concepts.Euphytica* 142: 169–196
- Lipka AE, Kandianis CB, Hudson ME, Yu J, Drnevich J, Bradbury PJ and Gore MA. 2015. From association to prediction: statistical methods for the dissection and selection of complex traits in plants. *Current Opinion in Plant Biology* 2015, 24: 110–118
- Yang Xu, Pengcheng Li, Zefeng Yang, Chenwu Xu. 2017. *Genetic mapping of quantitative trait loci in crops*. The Crop Journal 5 175–184
- Nguyen KL, Grondin A, Courtois B and Gantet P. 2019. *Next-Generation Sequencing Accelerates Crop Gene Discovery*. *Trends in Plant Science* Vol. 24, No. 3
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- Assefa T, Mahama AA, Brown AV, Cannon EK, Rubyogo JC, Rao IM and Cannon SB. 2019. *A review of breeding objectives, genomic resources, and marker-assisted methods in common bean* (Phaseolus vulgaris L.). *Molecular Breeding*, 39(2), 20.
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- Arya KV and Shylaraj KS. 2019. *Introgression of Sub1 QTL (Submergence tolerant QTL) into the elite rice variety Jaya by Marker Assisted Backcross Breeding*. *Journal of Tropical Agriculture* 56(2).
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- Hee JY, Choi PS, Kwon SY and Harn CH. 2015. *Plant Transformation Methods and Applications*. *In Current Technologies in Plant Molecular Breeding*, 297-343. Springer, Dordrecht, 2015.
- Thomas G, Gersbach CA and Barbas CF III. 2013. *ZFN, TALEN, and CRISPR/Cas-based methods for genome engineering*. *Trends in biotechnology* 31 (7) : 397-405.
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- Prabhu KV. *Use of GMOs Under Containment, Confined and Limited Field Trials and Post-Release Monitoring of GMOs*. *Biosafety of Genetically Modified Organisms: Basic concepts, methods and issues* (Chowdhury MKA, Hoque MI, Sonnino A, (eds). Food and Agriculture Organization of the United Nations, Rome: 157-220.
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- Rui W, Wang X, Lin Y, Ma Y, Liu G, Yu X, Zhong S and Liu B. 2013. *Inter-species grafting caused extensive and heritable alterations of DNA methylation in Solanaceae plants*. PLoS One 8 (4) : e61995.
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- Forster BP and Thomas WT. 2005. *Doubled haploids in genetics and plant breeding. Plant Breed Rev*, 25, 57-88.

I. Course Title : Plant Phenomics-next Generation Phenomics

Platforms

II. Course Code : PP 604

III. Credit Hours : 2+0

IV. Theory

Block 1: Concepts of High throughput Phenotyping and its Requirement

Unit 1: Concepts of Phenotyping

The concepts of "phene and trait" analogous to gene and allele. Genome-phenome relationship, definition of phenotyping, GxE interaction on phenome.

Unit 2: Physio-Morphological Traits Associated with Crop Performance

Overview of phenotyping needs to complement genomic resources, specific traits associated with yield potential, stress adaptation (both biotic and abiotic stresses). Need for high throughput precision phenotyping approaches for basic studies and to generate genetic and genomic resources.

Unit 3: Features of Phenomic Platforms

Precision growth conditions, maintenance of light, temperature/VPD and RH to realize the potential crop growth response, Controlled environmental facilities for simulating challenging climatic conditions to phenotype diverse plant traits, Concept of sensors, diverse sensors and their utility in precise quantification of environmental variables, soil moisture sensors, Imaging to capture plant traits, image acquisition. Automated big data access, processing, etc.

Unit 4: Trends in Phenomics

Types of phenomic platforms- Laboratory, Greenhouse and the field-based platforms. Platforms designed for specific needs i.e., root phenotyping, drought studies etc.,

Crop specific phenotyping, mobile and stationary platforms, Global trends in establishing major phenomics platforms, and their characteristic features and impact.

Unit 5: Non-invasive Phenotyping Approaches

The concept of non-invasive capturing of plant growth and health, Imaging technologies - image acquisition, segmentation and data analysis, Critical aspects of Visual, IR Thermal, Fluorescence, NIR, Hyperspectral imaging, Development and validation of models for deriving relevant physiological traits from image phenome. Concepts of Plants to sensors and sensors to plants, Stationary and ground based tractor mounted sensors/imaging tools, Unmanned aerial vehicle (UAV) sensors, Machine learning and its integration to analyze ground and aerial based images.

Block 2: Applications of the Phenomics Platforms

Unit 1: Basic Studies to Assess the Crop Response

Functional validation of genes, chemicals and other interventions, Characterize the growth and stress response in contrasts to identify the relevance of adaptive trait.

Unit 2: Applied Studies Focused on Crop Improvement Programs

Characterizing the pre-released promising lines for productivity under defined environmental variables. Phenotyping germplasm accessions, mapping populations for specific traits for mapping, Concept of Phenome Wide Association Studies (PWAS). Genomic selection, gene-based crop models to predict complex traits, Impact of phenomics platform, progress made, case studies.

VII. Suggested Reading

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- Noah F, Gehan MA and BaXter I. 2015. *Lights, camera, action: high-throughput plant phenotyping is ready for a close-up. Current Opinion in Plant Biology* 24 2015: 93-99.
- Singh AK, Ganapathysubramanian B, Sarkar S and Singh A. 2018. *Deep learning for plant stress phenotyping: trends and future perspectives. Trends in Plant Science.*
- Lobos GA, Camargo AV, del Pozo A, Araus JL, Ortiz R and Doonan JH. 2017. *Plant Phenotyping and Phenomics for Plant Breeding. Frontiers in Plant Science*, 8, 2181.
- Walter A, Liebisch F and Hund A. 2015. *Plant phenotyping: from bean weighing to image analysis. Plant Methods*, 11(1): 14.
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- Okono R. 2010. *Practical measurement of generic drought adaptation-related traits. Drought phenotyping in crops: From theory to practice. Generation Challenge Programme,* Cornell, USA, 451-457.
- Chen D, Neumann K, Friedel S, Kilian B, Chen M, Altmann T and Klukas C. 2014. *Dissecting the phenotypic components of crop plant growth and drought responses based on high-throughput image analysis. The Plant Cell,* 26(12), 4636-4655.
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- Jeudy C, Adrian M, Baussard C, Bernard C, Bernaud E, Bourion V and Lamboeuf M. 2016. *RhizoTubes as a new tool for high throughput imaging of plant root development and architecture: test, comparison with pot grown plants and validation. Plant Methods,* 12(1), 31.
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- Costa C, Schurr U, Loreto F, Menesatti P and Carpentier S. 2018. *Plant Phenotyping Research Trends, a Science Mapping Approach. Frontiers in Plant Science*, 9.
- Das Choudhury S, Samal A and Awada T. 2019. *Leveraging Image Analysis for High-Throughput Plant Phenotyping. Frontiers in Plant Science*, 10, 508.
- Golzarian MR, Frick RA, Rajendran K, Berger B, Roy S, Tester M and Lun DS. 2011. *Accurate inference of shoot biomass from high-throughput images of cereal plants. Plant Methods*, 7(1), 2.
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spectrometers applied to crop trait monitoring in organic potato production. Sensors, 17(6), 1428.
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- Li, L, Zhang Q and Huang D. 2014. *A review of imaging techniques for plant phenotyping. Sensors* 14(11) 20078-20111.
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- Campbell MT, Knecht AC, Berger B, Brien CJ, Wang D and Walia H. 2015. *Integrating image-based phenomics and association analysis to dissect the genetic architecture of temporal salinity responses in rice. Plant physiology* 168(4): 1476-1489.
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- Campbell ZC, Acosta-Gamboa LM, Nepal N and Lorence A. 2018. *Engineering plants for tomorrow: how high-throughput phenotyping is contributing to the development of better crops. Phytochemistry Reviews*. 17(6), 1329-1343.
- Araus JL, Kefauver SC, Zaman-Allah M, Olsen MS and Cairns JE. 2018. *Translating high-throughput phenotyping into genetic gain. Trends in Plant Science* 23(5): 451-466.

General Source Information

- Montes JM, Melchinger AE and Reif JC. 2007. *Novel throughput phenotyping platforms in plant genetic studies. Trends in Plant Science*, 12(10): 433-436.
- Development of high throughput plant phenotyping facilities at aberystwyth (ppt)
- Zhou J, Reynolds D, Websdale D, Le Cornu T, Gonzalez-Navarro O, Lister C and Clark M. 2017. *CropQuant: An automated and scalable field phenotyping platform for crop monitoring and trait measurements to facilitate breeding and digital agriculture*. BioRXiv, 161547.
- Bradshaw JE. 2017. *Plant breeding: past, present and future. Euphytica*, 213(3), 60.
- Lee U, Chang S, Putra GA, Kim H and Kim DH. 2018. *An automated, high-throughput plant phenotyping system using machine learning-based plant segmentation and image analysis*. *PloS one*, 13(4), e0196615.
- Furbank RT and Tester M. 2011. *Phenomics–technologies to relieve the phenotyping bottleneck. Trends in Plant Science* 16(12): 635-644.

I. Course Title : **Experimental Techniques to Characterize Plant Processes for Crop Improvement**

II. Course Code : **PP 605**

III. Credit Hours : **0+2**

IV. Theory

Block 1: Characterization of Plant Processes: Experimental Techniques and Crop Improvement

Unit 1: Stress Responses

Thermal (reflectance) characters as a measure of water status and root characteristics, Oxidative stress induction and assessing the response on lipid peroxidation and quantification of ROS, RCC's, RNS, Fluorescence to assess the stress response, Water use efficiency quantification at leaf, plant level, surrogates for WUE, Tissue localization of ROS, RNS by qualitative staining and fluorescence-based methods.

Unit 2: Photosynthetic processes

Concept and approaches to assess of radiation utilization efficiency (RUE), Quantification of mesophyll and other diffusive resistances regulating photosynthesis. Carboxylation efficiency (light and CO_2 response curves), RuBiSCO activation status

Unit 3: Hormonal Response on Specific Plant Growth Processes and Quantification

Bioassays to assess the biological process regulated by hormones – new in-vivo assays, Promoter assays for hormone response- GUS/YFP/GFP based assays-expression of hormone responsive genes, Recent analytical tools and techniques to quantify hormones – GC-MS, LC-MS, Capillary electrophoresis.

Unit 4: Nutrient Response Acquisition and Quantification

Recent advances in soil less cultures to study the nutrient response- Hydroponics/ Aeroponics/Fogoponics, Noninvasive techniques to quantify nutrients – XRD (X-Ray Diffraction analysis) and hyper spectral reflectance.

Unit 5: Photo and Thermo Morphogenesis

Photo receptors, light and temperature regulation of plant growth and flowering, Thermal time, heat units, GDD, Concept and approaches for speed breeding.

Unit 6: Recent Approaches for Functional Genomics

In silico prediction of gene function, Flanking sequence identification in insertional (T-DNA/transposon) mutants, Concept of insertional mutagenesis and mutant experiments, Utilization of genetic resources for functional genomics – mutants and tilling, eco tilling, VIGS, RNAi, miRNA, Genome editing –CRISPR, Concept of chemical genomics for functional validation, Relevant molecular tools to assess gene expression or (to regulate the process and assign a function to gene), Multiple gene expression by Nano String technology, Cap analysis gene expression (CAGE) – to identify start point of transcription, Yeast hybrid interaction, Immunoprecipitation, Chip-PCR.

V. Suggested Reading

- Costa, Miguel and Grant, Olga and Chaves M. 2013. *Thermography to explore plant-environment interactions. Journal of Experimental Botany* **64**. 10.1093/jxb/ert029.
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I. Course Title : Global Climate Change and Crop Response

II. Course Code : PP 606

III. Credit Hours : 2+0

IV. Theory

Block 1: Climate Change: Crop Response and Mitigation

Unit 1: Fundamentals of Climate Change

Definition of climate change, history and evidences of climate change and its implications. Natural and anthropogenic climate change. Sources of Greenhouse Gas (GHG) emission, Global Warming Potential of GHGs, accumulation of GHGs in the atmosphere and science behind climate change, industrial revolution and GHG build-up in the atmosphere, Energy-Emission-Economy Interactions, carbon intensity of economy, carbon equity/justice.

Unit 2: Manifestations of Climate Change

Impact on monsoons, occurrence of extreme weather events, hydrological cycle and water availability, effect on crop growing period in tropics, subtropics and temperate regions, shifts in distribution of flora and fauna, effects on biodiversity and migration of tropical plant species to higher latitudes and altitudes.

Unit 3: Major GHGs (CO_2, Methane, NO_2, etc.), their Production Rates, Monitoring and their Influence on Climate Change

GHGs: An Overview, - role of CO_2, methane and major uncertainties. Mechanism of their production and emission from various, source and sinks of GHGs; and contribution of GHGs to global warming. Techniques used in monitoring GHGs.

Unit 4: Agricultural Practices on GHG Production

Carbon footprint analysis of agriculture and various agricultural practices contribute to climate change. Impacts of natural factors and farming practices on greenhouse gas emissions. Sources of agricultural GHG emission- Agricultural Soil Management, enteric fermentation, manure management, other sources. Opportunities to reduce GHG emission from Agriculture.

Unit 5: Direct and Indirect Effects of Climate Change on Plant Processes

Problems and Prospects of Crops with changing temperature: Growth and Development of Crop plants, Thermo-morphogenesis, phenology, Physiological processes such as photosynthesis, Net carbon assimilation, C_3 and C_4 plants adaptation,Respiration, Nutrient acquisition and metabolisms, Plant water relations and Heat shock proteins, Grain/seed development: Grain Quality parameters and yield.

Unit 6: Climate Change Scenario and Impact on Crops

Different scenarios for temperature, rainfall in different agro-climatic zones of India and their impact on crop growth and productivity. Major climate change (temperature, CO_2, and rainfall) impact quantification using field or controlled environment experiments, meta-analysis and simulation models. Some examples of crop simulation models calibration and their application in short-term and long-term predictions.

Unit 7: Ozone Depletion leading to Increased Ionizing Radiations and its Implications on Crop Growth

Role of CFCs in ozone depletion, penetration of ionizing UV radiations and its implications on crop growth.

Unit 8: Long-term and Short-term Projections of Climate Change: Effects

on Natural Vegetation and Ecosystems

Response of natural ecosystems to increasingatmospheric CO_2 concentration and climate warming, effect of climate change on quality of feed i.e leaf and stored grains/seeds, its implications on pollinators and pests

Unit 9: Technologies for Climate Change Mitigation in Agriculture

Agricultural biotechnology to produce crop varieties with enhanced carbon uptake.
Nutrient management: Management of nitrogenous fertilizers.
Tillage/residue management: 1.Conservation tillage CO_2 mitigation technology; 2. Biochar: A potentialtechnique for carbon sequestration.
Methane mitigation using reduced tillage technology, change in methanogenic bacterial activity using electron acceptors.
Carbon sequestration potential, concept and measurement.

Unit 10: Climate-resilient Agriculture

Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of "Genome wide mutants" to identify genes/processes for improved adaptation to changing environments.

Unit 11: Climate Change: Technologies for Crop response studies

Temperature Gradient Chambers, Temperature Gradient Greenhouses, Soil plant atmosphere research system (SPAR), Infra-red warming Technology, Free Air temperature enrichment technology, Soil Warming system etc.

Unit 12: Politics of Climate Change Negotiations

IPCC, Major International conventions/treaties, Kyoto Protocol, Paris Agreement, Global initiatives on Carbon sequestration, carbon trading.

VIII. Suggested Reading

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- Lipper L, McCarthy N, Zilberman D, Asfaw S, Branca. 2018. *Climate Smart Agriculture: Building Resilience to Climate Change.* Springer, FAO.
- *Handbook of Climate Change and Agroecosystems: The Agricultural Model Intercomparison and Improvement Project* (AgMIP) in 2 parts Kindle Editionby Rosenzweig Cynthia and Hillel Daniel (Author), Cynthia Rosenzweig (Editor), 2015
- Climate Smart Agriculture FAO source book, 2013
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- Uprety, D.C., Baruah, K.K. and Borah, L. 2011. *Methane in rice agriculture. J. Sci. and Indust. Res.* **70** (6): 401-411
- IPCC AR5 Reports WG I 2013
- IPCC AR5 Reports WG II and III 2014
- IPCC Special Reports
- UNFCCC website
- IPCC website
- NOAA website
- CCAFS website
- India's Second National Communication to UNFCCC
- INCCA Report, MoEF and CC
- MoEF and CC website

I. Course Title : **Physiological and Molecular Aspects of Source-sink Capacity for Enhancing Yield**

II. Course Code : **PP 607***

III. Credit Hours : **3+0**

IV. Theory

Block 1: Source Size and Function–Basic Concepts, Physiological and Molecular Mechanisms, Genomic Resources to Regulate Source Characters

Unit 1: Source Establishment

Maximize energy capture by improved light interception, light distribution and its utilization efficiency, concepts of shade avoidance response (SAR) and option to increase, Increase canopy size by vertical expansion – concept of increasing optimum LAI levels, Concepts of semi-tall varieties with resistance to lodging: traits associated with lodging resistance, Sustain net carbon gain with age – the relevance of stay green character, photon capture and achieve high CO_2 reduction to photon ratio under low light, Options for increasing canopy photosynthesis, Relevance of maintaining cell turgor and nutrient status.

Unit 2: Source Function- Photochemical Reactions

Maximize conversion efficiency of intercepted radiation by improving net carbon gain - Emerging solutions to increase carbon fixation rate, Improve efficiency of photochemical reaction by - Engineering the pigments to expand PAR spectrum into IR range; reduce antenna size, optimize energy dissipation mechanisms; optimize components of ETC and downstream acceptors; accelerate adaptation for shifting light intensities.

Unit 3: Source Function- CO_2 Diffusion and Concentration

Enhance stomatal conductance (g_s) and mesophyll conductance (g_m) – guard cell metabolism; concepts of leaf mesophyll tissue thickness (SLW), Concepts of VPD responses of g_s to enhance duration of photosynthesis during the day, Bicarbonate transports and aquaporins; achieve higher CCM - Engineering C4 cycle, CAM, cyanobacteria, carboxysomes, algal pyrenoids.

Unit 4: Source Function- Metabolic Engineering of CO_2 Fixation

RuBisCO carbon fixation activity - Increase and optimize kinetics of RuBisCO with enhanced specificity to CO_2, Engineer RuBisCO to minimize feedback regulation by metabolite inhibitors, Increased activation state by improving stability and function of RuBisCOactivase; optimize RuBp regeneration – modulate specific enzyme levels. New concepts on photorespiratory synthetic bypass.

Unit 5: Case Studies to Improve Source Capacity

Genetic and genomic resources, genes/QTLs associated with specific yield potential traits and/or photosynthetic mechanisms, Genetic resources to improve source traits-case studies.

Block 2: Improving Sink Size and Capacity

Unit 1: Sink Establishment

Optimise duration of phenological stages related to sink establishment, genetic and environmental factors, GDD and phenology.

Unit 2: Increase the Sink Size by Enhancing the Relevant Constituent

Traits

Role of hormones in regulating molecular mechanisms of yield structure development, Genomic and genetic resources developed for regulation/improvement of such traits. – Sink Size: Tillering associated traits, branching patterns/fruiting points, spikelet number, pod number, fruit number. – Sink development: Basic concepts and molecular mechanisms associated with pollination, fertilization, ovary development in determining the spikelet fertility/sterility components and strategies for engineering seed/fruit size in crop plants.

Unit 3: Genetic and Genomic Resources, Genes/ QTLs, Genetic Resources to Improve

Sink Traits- Case Studies. Progress and status in developing genomic and genetic resources of validated genes/ QTLs to improve sink traits- Specific case studies.

Unit 4: Source to Support the Sink Capacity

Canopy architecture to support sink requirements in cereals: plant height, tillering, leaf area, shading or senescence of lower canopy leaves, canopy photosynthesis, Canopy architecture to support sink requirements in Pulses: Leaf senescence, abscission, mobilization of N and other nutrients, Symbiotic N fiXation to support sink size and capacity in pulses.

V. Suggested Reading

- Ray DK, Mueller ND, West PC, Foley JA. 2013. *Yield Trends Are Insufficient to Double Global Crop Production* by 2050. PLoS ONE 8(6): e66428. doi: 10.1371/journal.pone.0066428
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- Zhu G, Li G, Wang D, Yuan S, Wang F. 2016. *Changes in the Lodging-Related Traits along with Rice Genetic Improvement in China. PLoS ONE* 11(7): e0160104. doi: 10.1371/journal.pone.0160104
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- Christophera M, Chenub NK, Jenningsa R, Fletchera S, Butlera D, Borrellc A, Christopher J. 2018. *QTL for stay-green traits in wheat in well-watered and water-limited environments. Field Crops Research* 217 (2018) 32–44
- Thomas H and Ougham H. 2014. *The stay-green trait. Journal of Experimental Botany*, Vol. 65, No. 14, pp. 3889–3900, 2014
- Kusaba M, Tanaka A, Tanaka R. *Stay-green plants: what do they tell us about the molecular*

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- Yi Xiao, Xin Guang Zhu. 2017. *Components of mesophyll resistance and their environmental responses: A theoretical modelling analysis. Plant Cell Environ*. 40: 2729–2742.
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- South PF, Cavanagh AP, Liu HW, Ort DR. 2019. *Synthetic glycolate metabolism pathways stimulate crop growth and productivity in the field. Science.* DOI: 10.1126/science.aat9077
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- Paul *et al.* 2018. *The Role of Trehalose 6-Phosphate in Crop Yield and Resilience, Plant Physiology* 177: 12–23.
- Narnoliya *et al. Transcriptional Signatures Modulating SAM Morphometric and Plant Architectural Traits Enhance Yield and Productivity in Chickpea, The Plant Journal.*

I. Course Title : Seed and Fruit Growth and their Quality Improvement

II. Course Code : PP 608

III. Credit Hours : 2+0

IV. Theory

Block 1: Physiological and Molecular Aspects of Seed and Fruit Growth: Quality Improvement

Unit 1: Physiology of Seed Growth and Development

Mechanism of seed development and different developmental stages; synthesis, mobilization and accumulation of stored reserves, Forms of stored reserves and their localization, Sink drawing ability (SDA) and its relevance in seed growth and development, Role of plant hormones in seed growth and development and SDA.

Unit 2: Seed as a Propagule

Seed as a propagation material; seed size and seed chemical composition and their relevance in seed germination, Physiological, biochemical and molecular mechanisms and approaches to regulate seed germination, seedling emergence and establishment and seedling vigour, Physiological, biochemical and molecular mechanisms and approaches to regulate seed priming and crop establishment: seed dormancy, precocious germination and controlling pre-harvest sprouting in crops, Physiological, biochemical and molecular mechanisms and approaches to regulate seed viability, improving the viability and storability of seeds.

Unit 3: Seed as a Source of Nutrition

Seed as a source of nutrition to humans: approaches to improve the quality of seeds through synthesis of seed storage reserves and other constituents, Genes/ QTL's regulating these processes and concept of pathway engineering to improve the quantity and quality of seed constituents, Carbohydrates- Amylose and amylopectin ratios for glycemic index, resistant and digestable starch, improving dietary fibre, alter gelatinisation, Protein content, modified proteins, essential amino acids, Oil content, fatty acid composition, Omega 3 fatty acids. Carotenoids and vitamins, Biofortification strategies to enhance the grain zinc, iron, other minerals and other essential compounds, Engineering for low protease inhibitors, phytic acid, tannins, phenolic substances, lectins, oxalates as anti-nutritional factors, Case studies of improving seed nutrition components by molecular breeding and transgenic approaches.

Unit 4: Quality Deterioration during Storage

Changes in chemical composition during storage; factors influencing the deterioration of nutritional quality of seeds during storage; approaches to minimize nutritional quality deterioration, Effect of quality deterioration on human and animal health

Unit 5: Fruit Growth and Development

Flower and fruit development; concept of parthenocarpy, Physiological and biochemical changes during fruit development and chemical composition, Molecular approaches to regulate flower and fruit drop/ abscission; Role of hormones.

Unit 6: Fruit as a Source of Phytochemicals: Nutraceuticals

Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Antioxidants, Flavanoids, anthocyanins, Biosynthetic pathways and the quantification and options to improve

by hormonal and molecular pathway engineering approaches of Vitamins- Vitamin C, Tocopherol, Carotenoids, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Alkaloids, Mangiferin, tomatins, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of DigestableFiber lycopene, stillbeans, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Aroma, monoterpenoids and Fatty acid esters.

Unit 7: Fruit Ripening, Post Harvest Deterioration and Shelf life

Physiological and molecular mechanisms of fruit ripening, Postharvest deterioration of fruits; factors regulating fruit deterioration; hormonal and environmental aspects of reducing post harvest deterioration of fruits, Physiological and Molecular approaches to regulate fruit ripening and shelf life: Role of Ethylene and Ethylene response factors regulating specific processes of fruit ripening; Approaches to regulate specific shelf life characters, Improving fruit ripening and shelf life by molecular approaches-Case studies.

V. Suggested Reading

- Bewley, JD, Bradford K, Hilhorst H, Nonogaki H. (2013). *Seeds: Physiology of Development, Germination and Dormancy*, Springer-Verlag
- Larkins BA and Vasil IK (Ed). 2010. *Cellular and Molecular Biology of Plant Seed Development*, Springer
- Vanangamudi K, Natarajan K and Vanangamudi M, *Seed Physiology*, Associated Publishing Company.
- Pammenter NW and Berjak P. 2000. *Aspects of recalcitrant seed physiology*. *R.Bras. Fisiol. Veg*., 12: 56-69.
- Prakash M. 2011. *Seed Physiology of Crops*.(ed). Satish Serial Publishing house, New Delhi..
- Lee KR, Chen GQ and Kim HU. 2015. *Current progress towards the metabolic engineering of plant seed oil for hydroxy fatty acids production. Plant Cell Reports*, 34(4): 603-615.
- Zhu Y, Xie L, Chen GQ, Lee MY, Loque D and Scheller HV. 2018. *A transgene design for enhancing oil content in Arabidopsis and Camelina seeds. Biotechnology for biofuels*, 11(1), p.46.
- Patil G, Mian R, Vuong T, Pantalone V, Song Q, Chen P, Shannon GJ, Carter TC and Nguyen HT. 2017. *Molecular mapping and genomics of soybean seed protein: a review and perspective for the future. Theoretical and Applied Genetics* 130(10): 1975-1991.
- Tien Lea D, Duc Chua H. and Quynh Lea N. 2016. *Improving nutritional quality of plant proteins through genetic engineering. Current Genomics*, 17(3): 220-229.
- Mene-Saffrane, L. and Pellaud, S. 2017. *Current strategies for vitamin E biofortification of crops. Current opinion in biotechnology* 44: 189-197.
- Jiang, L., Wang, W., Lian, T. and Zhang, C. 2017. *Manipulation of metabolic pathways to develop vitamin-enriched crops for human health. Frontiers in Plant Science*, 8, 937.
- Bohra A, Jha UC, Jha R, Naik SJS, Maurya AK and Patil PG. Chapter-1. *Genomic Interventions for Biofortifcation of Food Crops*, A. M. I. Qureshi *et al*. (eds.), *Quality Breeding in Field Crops*, https://doi.org/10.1007/978-3-030-04609-5_1
- Finkelstein JL, Haas JD and Mehta S. 2017. *Iron-biofortified staple food crops for improving iron status: a review of the current evidence, Current Opinion in Biotechnology* 44: 138–145
- Sperotto RA, Ricachenevsky FK, Waldow VdA, Fett JP. *Iron biofortification in rice: It's a long way to the top, Plant Science* 190 (2012) 24–39
- Lee J, Nou IS, Kim HR. 2012. *Current status in calcium biofortification of crops, J Plant Biotechnol* 39: 23–32, DOI: http://dx.doi.org/10.5010/JPB.2012.39.1.023
- Sharma D, Jamr G, Singh UM, Sood S and Kumar A. 2017. *Calcium Biofortification: Three Pronged Molecular Approaches for Dissecting Complex Trait of Calcium Nutrition in Finger Millet (Eleusine coracana) for Devising Strategies of Enrichment of Food Crops*, doi: 10.3389/fpls.2016.02028
- Gemede HF and Ratta N. 2014. *Antinutritional factors in plant foods: Potential health benefits*

and adverse effects. International Journal of Nutrition and Food Sciences, 3(4), pp.284-289.
- Vasconcelos IM and Oliveira JTA. 2004. *Antinutritional properties of plant lectins. Toxicon*, 44(4), pp.385-403.
- Kumar D and Kalita P. 2017. *Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries*. Foods, 6(1), p.8.
- Kawakatsu T, Hirose S, Yasuda H and Takaiwa F. 2010. *Reducing rice seed storage protein accumulation leads to changes in nutrient quality and storage organelle formation. Plant Physiology* 154(4), pp.1842-1854.
- Afzal I, Rehman HU, Naveed M and Basra SMA. 2016. *Recent advances in seed enhancements. In New Challenges in Seed Biology-Basic and Translational Research Driving Seed Technology*. *IntechOpen*.
- Probert R, Adams J, Coneybeer J, Crawford A and Hay F. 2007. *Seed quality for conservation is critically affected by pre-storage factors. Australian Journal of Botany*, 55(3), pp.326-335.
- Gillaspy G, David HB and Gruissem W. *Fruits: A Developmental Perspective, The Plant Cell*, Vol. 5, 1439-1451
- Nitsch JP. 1953. *The Physiology of Fruit Growth. Annual Review of Plant Physiology*, 4(1), 199–236.doi: 10.1146/annurev.pp.04.060153.0012
- Kumar R, Khurana A and Sharma AK. 2014. *Role of plant hormones and their interplay in development and ripening of fleshy fruits, Journal of Experimental Botany*, 65: 4561–4575, https://doi.org/10.1093/jxb/eru277
- Robert HS. 2019. *Molecular Communication for Coordinated Seed and Fruit Development: What Can We Learn from Auxin and Sugars? Int. J. Mol. Sci. 20*, 936.
- Golubkina N, Zamana S, Seredin T, Poluboyarinov P, Sokolov S, Baranova H, Krivenkov L, Pietrantonio L and Caruso G. 2019. *Effect of Selenium Biofortification and Beneficial Microorganism Inoculation on Yield, Quality and Antioxidant Properties of Shallot Bulbs. Plants*, 8(4), p.102.
- Lovat C, Nassar AM, Kubow S, Li XQ and Donnelly DJ. 2016. *Metabolic biosynthesis of potato (Solanum tuberosum L.) antioxidants and implications for human health. Critical reviews in food science and nutrition*, 56(14), pp.2278-2303.
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- Kasote DM, Katyare SS, Hegde MV and Bae H. 2015. *Significance of antioxidant potential of plants and its relevance to therapeutic applications. International Journal of Biological Sciences*, 11(8), p.982
- Yahia EM and Carrillo-Lopez A. (eds.). 2018. *Postharvest Physiology and Biochemistry of Fruits and Vegetables. Woodhead Publishing.*
- Valero D and Serrano M. 2010. *Postharvest biology and technology for preserving fruit quality*. CRC press.
- Wills R and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*. UNSW press.
- Siddiqui MW. ed., 2015. *Postharvest biology and technology of horticultural crops: principles and practices for quality maintenance*. CRC Press.
- Corpas FJ and Palma JM. 2018. *Nitric oxide on/off in fruit ripening. Plant Biology*, 20(5), 805–807.doi: 10.1111/plb.12852

I. Course Title : Plant-Microbe Interactions

II. Course Code : PP 609

III. Credit Hours : 2+1

IV. Theory

Block 1: Plant Pathogen Interaction

Unit 1: Introduction to Plant Pathogen Interaction

Introduction to plant microbe interaction and importance, the concepts of holobiome and hologenome, Differences between endophytes/ rhizosphere/phylloplane microbes and phytopathogens, Types of endophytes/rhizosphere/phylloplane microbes, and their classifications

Unit 2: Genetic Basis of Host Pathogen Interaction

Genetics of immune response, Signal perception, Host-pathogen interaction (bacteria, fungus and virus), Nature of resistance to diseases-pathogenecity genes *(pat)* in plant pathogens-disease specific genes *(dsp), avirulence genes (avr), avr gene – coded proteins-structure of avr genes*, Transmission of the alarm signal to host defense producers: signal transduction, pathogen elicitors, protein kinases, calcium ions, phosphorylases, phospholipases, ATPases, Accumulation of Phytoalexins as a Resistance mechanism-Biosynthesis and metabolism of Phytoalexins, Modes of action of Phytoalexins, Pathogenesis-Related proteins (PR) and Disease Resistance- intro-Characterization and biological functions of PR proteins, Biosynthesis of PR proteins.

Unit 3: Growth Regulators of Plant Defense and Susceptibility

Regulation of hormones countering the pathogen infection and toxins modulating the plant physiology, ABA-SA cross talk and role of JA during plant interaction biotrophic and necrotrophic pathogens respectively.

Unit 4: Bioenergetics in Plant Pathogen Interaction

An overview of energy-capture and energy-utilization processes in higher plant, Energy-capture and utilization process as affected by pathogenic infection, Molecular basis of pathogenesis and the process of interaction- classical examples of pathogens causing necrosis, wilts, tumours and soft rots, Role of primary metabolism in plant-pathogen interaction.

Block 2: Plant-Endophytes/ Rhizosphere/ Phylloplane Microbes Interaction

Unit 1: Interaction of Endophytes/ Rhizosphere/ Phylloplane Microbes with Plants

Approaches to study endophytic/ rhizosphere/ phylloplane microbes bacteria and fungi, Intracellular bacteria 'Cytobacts', Possible mechanisms of host plant genotype influence in recruitment of endophytic microbes vertical/ seed transmission, Inter-kingdom signaling regulating endophyte/ rhizosphere/phylloplane microbes development, Adaptation with respect to colonization of endophytes/ rhizosphere/ phylloplane microbes.

Unit 2: Role of Endophyte/ Rhizospheric/ Phylloplane Microbiota in Plant Physiological Processes

Phytohormones role in beneficial endophyte/rhizospheric/phylloplanerecruitment, Hormonal regulation of assimilate partitioning in plant-microbe interactions, Plant-Fungus-Bacteria, the three fold interaction for improved plant nutrition.

Unit 3: Endophyte/ Rhizospheric/ Phylloplane Microbes in Improving Biotic and Abiotic Stress Tolerance

Importance in imparting stress (biotic and abiotic) adaptations, in the regulation

of bioactive compound (alkamide) accumulation; acclimatization of root-interacting fungi for improved plant nutrition and stress tolerance, Cultivable versus uncultivable endophytes with respect to their extent of tissue colonization and diversity, Genetic engineering of endophytes for production of industrially important bioactive compounds, endophyte-enrichment technologies in crops for traits manipulation, Role of existing microbiome on introduced endophyte, symbiotic microbes and their interaction, Modern techniques for examining plant-microbe-insect interactions.

Unit 4: Bioethics, Biosafety, Intellectual property rights and implications in plant-microbe research

DBT biosafety regulations on working with microbial organisms associated with plants, Standard operating procedure (SOP), Committees dealing with biosafety and safe release of microorganisms.

Block 3: Microbial Interaction with Plants in the Presence of Abiotic Factors

Unit 1: Disease Triangle and the Contribution of the Environmental Factors in Influencing the Plant-microbe Interaction

Disease triangle involving plant-pathogen-environment and the importance of environmental stresses (drought, heat, humidity and soil factors) in influencing the resistance or susceptibility, Role of environmental factors in influencing establishment and sustenance of introduced beneficial microbes.

Unit 2: Physiological and Molecular Basis for Predisposition or Endurance of Plant during Abiotic-biotic Stress Interaction

Plant-water relations and changes in physiology in deciding the microbe interaction with plants, Metabolites in deciding the microbe interaction with plants, Hormonal cross talk, signal transduction, role of R-genes and other defense pathways during the simultaneous exposure to abiotic stress.

V. Practicals

- *In-planta* bacterial/fungal multiplication in plant under drought stress
- Detection of plant pathogens using molecular tools
- Stomatal conductance in plants under drought stress and pathogen stress
- Apoplast isolation from plants subjected to bacterial infection
- Virus induced gene silencing in plants
- Acetylene reduction assays to check nitrogen fixation in plant (The effect of beneficial microbes in plant)
- Biochemical analyses of beneficial and pathogen-effector proteins
- Plant colonization and disease or growth promotion scoring
- In-vivo detection of plant immune responses and their inhibition by effectors
- Estimation of phytoalexins, PR proteins, ACC deaminase and growth hormones in pathogen challenged plants
- Effect of plant microbe interaction on plant physiological processes, viz. photosynthesis, chlroroplast, transpiration, etc.

VI. Suggested Reading

- Jones JDG and Dangl JL. 2006 *The plant immune system. Nature* Vol. 444, Pages 323–329
- Dodds PN and Rathjen JP. 2010. *Plant immunity: towards an integrated view of plant–pathogen interactions. Nature Reviews. Genetics.* Vol. 11, Pages 539–548
- Baker B, Zambryski P, Staskawicz B, Kumar SPD. 1997. Science. *Signaling in Plant-Microbe Interaction*. Vol. 276
- *The role of abscisic acid in plant–pathogen interactions.* Mani BM and Felix Mauch. *Current Opinion in Plant Biology*. 2005 8: 409-414 2005.

- Loake G and Grant M. 2007. *Salicylic acid in plant defence—the players and protagonists. Current Opinion in Plant Biology*.10: 466-472
- Kent AD and Triplett EW. 2002. *Microbial Communities and Their Interactions in Soil and Rhizosphere Ecosystems. Annual Review of Microbiology*. 56: 211-236
- Whipps JM. 2001. *Microbial interactions and biocontrol in the rhizosphere. Journal of Experimental Botany*. 52: 487–511.
- Vandenkoornhuyse P, Quaiser A, Duhamel M, Van AL, Dufresne A. 2015. *The importance of the microbiome of the plant holobiont. New Phytologist*. 206: 1196-1206 .
- Suzuki N, Rivero RM, Shulaev V, Blumwald E and Mittler R. 2014. *Abiotic and biotic stress combinations. New Phytologist*. 203: 32-4.
- Atkinson NJ and Urwin PE. 2012. *The interaction of plant biotic and abiotic stresses: from genes to the field. Journal of Experimental Botany*, 63: 3523–3543.

General Source Information

- Matveeva T, Provorov N, Valkonen JPT. *Cooperative Adaptations and Evolution in Plant-Microbe Systems.* Frontiers Media SA.
- Maheshwari, Dinesh K, Annapurna K. (Eds.). 2017. *Endophytes: Crop Productivity and Protection*, Ed. ISBN 978-3-319-66544-3; Springer.
- *Signaling in the Phytomicrobiome* Smith DL, Gravel V, Yergeau E. Frontiers Media SA
- Verma, Vijay C, Gange, Alan (Eds.) *Advances in Endophytic Research*. 2014, Eds: ISBN 978-81-322-1575-2; Springer
- Schulz, Barbara JE, Boyle, Christine JC, Sieber, Thomas N. (Eds.) *Microbial Root Endophytes*, Eds: 2004, ISBN 978-3-540-33526-9; Springer
- Choudhary, Devendra K, Varma, Ajit, Tuteja, Narendra (Eds.). 2016. *Plant-Microbe Interaction: An Approach to Sustainable Agriculture* Eds: ISBN 978-981-10-2854-0; Springer
- Miller, James R., Miller Thomas A. (Eds.) *Insect-Plant Interactions*, 1986, Eds.
- Ahmed S, Brattsten LB. *Molecular Aspects of Insect-Plant Associations*, ISBN 978-1-4613-1865-1 (Springer).
- Chandrakanth Emani. 2018. *The Biology of Plant-Insect Interactions: A Compendium for the Plant Biotechnologist* 1st Edn, ISBN 9781498709736 - CAT# K25008, CRC Press.
- Tejesvi MV, Pirttilä AM, Frank AC. *Emerging Tools for Emerging Symbioses—Using Genomics Applications to Studying Endophytes* by Frontiers Media SA
- Jyoti Shah, Linda Walling. *Advances in Plant-Hemipteran Interactions*, by Frontiers Media SA.
- Huang JS. 2009. *Plant Pathogenesis and Resistance* (*Biochemistry and Physiology of Plant-Microbe Interactions)*, Kluwer Academic Publishers.
- Day PR. 1973. *Genetics of Host Parasite Interaction*,W.HFreeeman and Company.
- Sharma PD. 2006. *Plant Pathology*, Narosa Publishing House Pvt. Ltd.
- Mahadevan A. 1979. *Physiology of Host-Pathogen Interaction*, Today and Tomorrow Printers and Publishers.
- Stainhaus EA. 1963. *Insect Pathology*, Academic Press, New York and London.
- Follett PA. 2017. *Insect plant interactions: host selection, herbivory, and plant resistance – an introduction. EntomolExpAppl*, 162: 1-3. doi: 10.1111/eea.12524.
- Ryan RP, Kieran G, Ashley F, David JR and David ND. 2007. *Bacterial endophytes: recent developments and applications.* FEMS Microbiol. Lett.,278: 1–9.
- Bringel F and Couée I. 2015. *Pivotal roles of phyllosphere microorganisms at the interface between plant functioning and atmospheric trace gas dynamics. Front. Microbiol.* 6: 486. doi: 10.3389/fmicb.2015.00486.
- Lugtenberg B. (Ed.). 2015. *Principles of plant-microbe interactions***.** doi: https://doi.org/10.1007/978-3-319-08575-3.
- Velmourougane K, Saxena G, Prasanna R. 2017. *Plant-microbe interactions in the rhizosphere: mechanisms and their ecological benefits*. Singh D., Singh H., Prabha R. (eds) *Plant-Microbe Interactions in Agro-Ecological Perspectives*. Springer, Singapore. doi: https://doi.org/10.1007/978-981-10-6593-4_7.
- Schikora, A. (Ed.). 2018. *Plant-microbe interactions in the rhizosphere.* Caister academic press. doi: https://doi.org/10.21775/9781912530007.

I. Course Title : Weed Biology and Physiology of Herbicide Action

II. Course Code : PP 610

III. Credit Hours : 2+0

IV. Theory

Block 1: Weed Biology

Unit 1: Weed Biology and its Importance in Weed Management

Introduction to weeds, Classification of weeds, Yield losses caused by weeds, Environmental impacts of invasive weed species, Aspects of Weed biology, Germination, Dormancy and growth behaviour of weed species, Effect of environmental factors on weeds, Adaptation of weeds to different ecologies

Unit 2: Life Cycle and Population Dynamics of Weeds

Growth duration and reproductive potential of weed species, Population dynamics, Weed Shift due to weed management, weed Seed Bank,

Unit 3: Crop Weed Competition

Understanding the nature of crop-weed competition, critical stages of crop weed competition, growth stages of weeds for improved control by herbicides

Block 2: Physiology of Herbicide Action

Unit 1: Introduction to Herbicides

Introduction, Chemistry and classification of herbicides by mechanism of action, HRAC Classification, Site of Actions, Application techniques, doses, active ingredients, formulations, Absorption and translocation of soil and foliar applied herbicides, Methods to increase the efficiency of soil and foliar applied herbicide – role of membranes, adjuvants, surfactants, synergists,

Unit 2: Mechanism of Action of Herbicides

Physiological and biochemical effects of herbicides: Effects on membrane structure and functions, cell division and cell development, Effects on chloroplast, photosynthesis, respiration, protein synthesis, synthesis of lipids, Molecular mechanism of action, Molecular mechanisms of herbicide resistance in relation to chloroplast gene expression,

Unit 3. Herbicide Resistance and its Management

Herbicide resistance-Definition, history, magnitude; Mechanisms of resistance: Target site and non-target site, cross and multiple resistances, Role of management practices on resitance development, Resistance management: Strategies; HR crops, Super weeds,

V. Suggested Reading

- Inderjit (Ed). 2004. *Weed Biology and Management*. Springer Netherlands
- Monaco, TJ, Weller SC, Ashton FM. 2002. *Weed Science: Principles and Practices*. John Wiley and Sons Inc., New York
- De Prado R, Jorrin J, and Garcia-Torres L. 1997. *Weed and Crop Resistance to Herbicides*. Kluwer academic Publishers, The Netherlands.
- Heap I. (2018.). *The International Survey of Herbicide Resistant Weeds*. www.weedscience.com
- *Herbicide Handbook of the Weed Science Society of America*, 9th Edition. 2008. http://wssa.net.
- Devine, M.D., Duke S.O. and Fedtke C. 1993. *Physiology of Herbicide Action*. Prentice-Hall, Inc. Englewood, NJ. 441 pp
- Zimdahl, R L .2007. *Fundamentals of Weed Science* (Third Edition). Academic Press-Elsevier, USA.

Course Title with Credit Load
M.Sc. in Molecular Biology and Biotechnology

Course Code	Course Title	Credit Hours	Semester
MBB 501	**Major: 20 credits** (**12 credits of core + 8 credits of optional**) Principles of Biotechnology	3+0	**I**
MBB 502	Fundamentals of Molecular Biology*	3+0	I
MBB 503	Molecular Cell Biology*	3+0	I
MBB 504	Techniques in Molecular Biology I*	0+3	I
MBB 505	Omics and Systems Biology*	2+1	II
MBB 506	Plant Genetic Engineering	3+0	II
MBB 507	Techniques in Molecular Biology II	0+3	II
MBB 508	Introduction to Bioinformatics	2+1	I
MBB 509	Plant Tissue culture	2+1	II
MBB 510	Microbial and Industrial Biotechnology	2+1	II
MBB 511	Molecular Plant Breeding	2+1	I
MBB 512	IPR, Bio-safety and Bioethics	2+0	II
MBB 513	Immunologyand Molecular Diagnostics	3+0	I/II
MBB 514	Nano Biotechnology	2+1	II
MBB 515	Environmental Biotechnology	3+0	I
MBB 516	Bio-entrepreneurship#	1+0	II
MBB 517	Stress Biology and Genomics#	2+0	II
MBB 518	Gene Regulation#	2+0	II
	Minor (8 credits) – from one of the related disciplines Biochemistry Genetics and Plant BreedingMicrobiology Plant Physiology Plant Pathology Entomology Bioinformatics Plant Genetic Resources Any other related discipline		

Course Code	Course Title	Credits (L+P)
	Basic Supporting (6 credits) from the following disciplines	
	Biochemistry	
	Microbiology	
	Genetics and Plant Breeding	
	Statistics	
	Bioinformatics	
	Computer Applications	
	Common courses	5
MBB	Seminar	0+1
MBB500	Research	0+30
	Total	**70**

*Core Courses; # New Courses

Course Contents
M.Sc. in Molecular Biology and Biotechnology

I. Course Title : Principles of Biotechnology

II. Course Code : MBB 501

III. Credit Hours : 3+0

IV. Aim of the course

- To understand the basics of Molecular biology, plant and microbial Biotechnology
- Importance and applications in agriculture, case studies and success stories
- Public education, perception, IPR and related issues

V. Theory

Unit I (12 Lectures)

History, scope and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology etc. Basics of Biotechnology, Primary metabolic pathways, Enzymes and its activities.

Unit II (16 Lectures)

Structure of DNA, RNA and protein, their physical and chemical properties. DNA function: Expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research, Plant transformation: Gene transfer methods and applications of GM crops.

Unit III (8 Lectures)

Molecular analysis of nucleic acids -PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP etc, and their applications; DNA sequencing, different methods; Plant cell and tissue culture techniques and their applications.Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics. Plant cell and tissue culture techniques and their applications.

Unit IV (12 Lectures)

Introduction to Emerging topics: Genome editing, gene silencing, Plant microbial interactions,Success stories in Biotechnology, Careers and employment in biotechnology. Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

VI. Suggested Reading

- Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R. 2014. *Molecular Biology of the Gene*, 7th edition, Cold Spring Harbor Laboratory Press, New York
- Brown T A. 2010. *Gene Cloning and DNA analysis an Introduction* 6th edition, Wiley Blackwell
- Primrose SB and Twyman R. 2006. *Principles of gene Manipulation* 7th edition, Wiley Blackwell

• Singh BD. 2012. *Biotechnology: Expanding Horizons* 4th edition, Kalyani publisher, New Delhi, India

I. Course Title : Fundamentals of Molecular Biology

II. Course Code : MBB 502

III. Credit Hours : 3+0

IV. Aim of the course

- To understand the basics of DNA, RNA, structure, types and chromatin assembly.
- To get insights into the Central Dogma, basic cellular processes, role of mutation and recombination.
- To understand different levels of gene regulation and the pathways involved.

V. Theory

Unit I (8 Lectures)

Historical developments of molecular biology, Nucleic acids as genetic material, Chemistry and Nomenclature of nucleic acids; Structure of DNA: primary structure; secondary structure, Forms of DNA: A,B, Z and their function; Structure andTypes of RNA Genome organization in prokaryotes and eukaryotes; DNA Topology; DNA re-association kinetics, Types of repeat sequences.

Unit II (10 Lectures)

Central dogma of Molecular Biology; DNA replication- Classical experiments, Models of DNA replication; DNA replication, Origin and Steps in DNA replication - initiation, elongation and termination; Enzymes and accessory proteins and its mechanisms; Eukaryotic DNA replication in brief. Types of DNA damages and mutations; DNA repair mechanisms, Recombination: Homologous and non-homologous, Genetic consequences.

Unit III (8 Lectures)

Prokaryotic transcription, initiation, elongation and termination, promoters, Structure and function of eukaryotic RNAs and ribosomal proteins. Eukaryotic transcription – RNA polymerase I, II and III, Elongation and Termination, Eukaryotic promoters and enhancers, Transcription factors,Post transcriptional processing, Splicing: Catalytic RNAs, RNA stability and transport, RNA editing.

Unit IV (10 Lectures)

Genetic code and its characteristics,Universal and modified genetic code and its characteristics,Wobble hypothesis; Translational machinery; Ribosomes in prokaryotes and Eukaryotes. Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes,Elongation: translocation,transpeptidation and termination of translation; Co- and Post-translational modifications of proteins; Translational control; Protein stability -Protein turnover and degradation.

Unit V (12 Lectures)

Gene regulation in prokaryotes, Constitutive and Inducible expression, small molecule regulators; Operon concept: *lac* and *trp* operons, attenuation, anti-termination, stringent control.Gene regulation in eukaryotes– regulatory RNA and RNA interference mechanisms,Silencers, insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors:turn- Helix-helix, helix-loop-helix etc. Epigenetic regulations

VI. Suggested Reading

- Nelson DL and Cox M.M. 2017. *Lehinger's Principles of Biochemistry*, 7th edition, W H Freeman Publication New York.
- Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. 2017. *Lewin's Genes* XII 12th edition, Jones & Bartlett Learning publisher, Inc.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M and Losick R. 2014. *Molecular Biology of the Gene*, 7th edition, Cold Spring Harbor Laboratory Press, New York.
- Alberts, B. 2017. *Molecular Biology of the Cell* 5th edition, WW Norton & Co, Inc.
- Allison, L.A. 2011. *Fundamentals of Molecular Biology*. 2nd Edition, John Wiley and Sons.

I. Course Title : Molecular Cell Biology

II. Course Code : MBB 503

III. Credit Hours : 3+0

IV. Aim of the course

- To understand the basics structure and function of plant and animal cell
- To get insights into the basic cellular processes, transport, signalling, cell movement, cell division and general regulation mechanisms.

V. Theory

Unit I (8 Lectures)

Origin of life, History of cell biology, Evolution of the cell: endo-symbiotic theory, treeof life, General structure and differences between prokaryotic and eukaryotic cell; Similarities and distinction between plant and animal cells; different kinds of cells inplant and animal tissues.

Unit II (8 Lectures)

Cell wall, cell membrane, structure and composition of bio-membranes, Structure and function of major organelles: Endoplasmic reticulum Ribosomes, Golgi apparatus, Mitochondria, Chloroplasts, Lysosomes, Peroxisomes, Micro-bodies, Vacuoles, Nucleus, Cyto-skeletal elements.

Unit III (12 Lectures)

Membrane transport; Diffusion, osmosis, ion channels, active transport, mechanism of protein sorting and regulation of intracellular transport, transmembrane and vesicular transport - endocytosis and exocytosis; General principles of cell communication: hormones and their receptors,signaling through G-protein coupled receptors, enzyme linked receptors; signal transduction mechanisms and regulation, Cell junctions, Cell adhesion, Cell movement; Extracellular matrix.

Unit IV (10 Lectures)

Chromatin structure, Cell division and regulation of cell cycle; Mechanisms of cell division, Molecular eventsat M phase, mitosis and cytokinesis, Ribosomes in relation to cell growth and division, Extracellular and intracellular Control of Cell Division; abnormal cell division: cancer- hall marks of cancer and role of oncogenes and tumor suppressor genes in cancer development - Programmed cell death (Apoptosis).

Unit V (10 Lectures)

Morphogenetic movements and the shaping of the body plan, Cell diversification, cellmemory, cell determination, and the concept of positional values; Differentiated cells and the maintenance of tissues and organ development; Stem cells: types and

applications; Basics of Animal development in model organisms (*C. elegans*; *Drosophila*); Plant development.

VI. Suggested Reading

- Alberts, B. 2017. *Molecular Biology of the Cell* 5th edition, WW Norton & Co, Inc.
- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin, K.C., 2016. *Molecular Cell Biology* 8th Edition. W.H. Freeman & Co. New York.
- Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Hopkin, K., Johnson, A., Walter, P., 2013 *Essential of Cell Biology*, WW Norton & Co, Inc.
- Cooper, G.M. and Hausman, R.E. 2013. *The cell: A Molecular Approach* 6th edition, Sinauer Associates, Inc.

I. Course Title : Techniques in Molecular Biology I

II. Course Code : MBB 504

III. Credit Hours : 0+3

IV. Aim of the course

- To get a basic overview of molecular biology techniques, good lab practices and recombinant DNA technology
- To get a hands on training in chromatography, protein analysis, nucleic acid analysis, bacterial and phage genetics

V. Practicals

- Good lab practices, preparation of buffers and reagents.
- Principle of centrifugation and spectrophotometry.
- Growth of bacterial culture and preparation of growth curve, Isolation of Genomic DNA from bacteria.
- Isolation of plasmid DNA from bacteria.
- Growth of lambda phage and isolation of phage DNA.
- Isolation and restriction of plant DNA (e.g. Rice / Moong / Mango / Merigold).
- Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry
- PCR using isolated DNA.
- PAGEGel electrophoresis.
- Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNA construction.
- Transformation of *E. coli* and selection of transformants
- Chromatographic techniques
  a. TLC
  b. Gel Filtration Chromatography,
  c. Ion exchange Chromatography,
  d. Affinity Chromatography
- Dot blot analysis, Southern hybridization,Northern hybridization.
- Western blotting and ELISA.
- Radiation safety and non-radio isotopic procedure.

VI. Suggested Reading

- Sambrook, J., and Russell, R.W. 2001. *Molecular Cloning: A Laboratory Manual* 3rd Edition, Cold spring harbor laboratory press, New York.
- Wilson, K., and Walker, J., 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th edition, Cambridge University Press.
- Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA and Struhl K. 2002. *Short Protocols in Molecular Biology* 5th edition, Current Protocols publication.

I. Course Title : Omics and Systems Biology

II. Course Code : MBB 505

III. Credit Hours : 2+1

IV. Aim of the course

- To get a basic overview of genomics, proteomics, ionomics and metabolomics
- To get a primary information on the application of omics science across the industry

V. Theory

Unit I (8 Lectures)

Different methods of genome sequencing, principles of various sequencing chemistries, physical and genetic maps, Comparative and evolutionary genomics, Organelle genomics, applications in phylogenetics, case studies of completed genomes, preliminary genome data analysis, basics of ionomics analysis, different methods

Unit II (6 Lectures)

Protein-basics: primary-, secondary- and tertiary structure, Basics of X-ray crystallography and NMR, Principal and Applications of mass spectrometry, Proteomics: Gel based and gel free, Basics of software used in proteomics, MASCOT, PD-Quest, etc., Study of protein interactions, Prokaryotic and yeast-based eXpression system and purification

Unit III (6 Lectures)

Metabolomics and its applications, Use of 1D/2D NMR and MS in metabolome analysis, Multivariate analysis and identification of metabolite as biomarkers, Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), X-Ray Fluorescence (XRF), Neutron activation analysis (NAA), Data integration using genome, transcriptome, proteome, metabolome and ionome with phenome.

Unit IV (6 Lectures)

Introductory systems Biology - The biochemical models, genetic models and systems model, Molecules to Pathway, Equilibrium binding and cooperatively – Michaelis-Menten Kinetics, Biological oscillators, Genetic oscillators,Quorum Sensing, Cell-cell communication, *Drosophila* Development, Pathways to Network, Gene regulation at a single cell level, transcription network, REGULATORY CIRCUITS, Negative and positive auto-regulation, Alternative Stable States, Bimodal Switches, Network building and analysis

VI. Practical (12)

- Isolation of HMW DNA and brief overview of sequencing, Primary information on genome data analysis.
- BSA Standard curve preparation, EXtraction of protein and estimation methods.
- Quantification of proteins from different plant tissues using spectrophotometry.
- 2-D Gel Electrophoresis, 2-D Image analysis.
- EXperiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitin system).
- Demonstration on MALDI-TOF.
- Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods.

VII. Suggested Reading

- Primrose, S.B. and Twyman, R. 2006. *Principles of Gene Manipulation* 7th edition, Wiley Blackwell
- Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th Edition, Cambridge University Press.

I. Course Title : Plant Genetic Engineering

II. Course Code : MBB 506

III. Credit Hours : 3+0

IV. Aim of the course

- To get a basic overview of molecular cloning, vectors and genomic library construction.
- To get anoverview of PCR and its applications, sequencing, gene knockouts, transgenics etc.

V. Theory

Unit I (10 Lectures)

Historical background, Restriction Enzymes; DNA Modifying enzymes, ligase, T4 DNA polymerase, Polynucleotide kinaseetc, Cohesive and blunt end ligation; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions: Electromobility shift assay.

Unit II (14 Lectures)

Plasmids; Bacteriophages; M13, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; Expression vectors; pMal,pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag, etc.; Baculovirus vectors system, Plant based vectors, Ti and Ri plasmids as vectors, Yeast vectors, Shuttle vectors. Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning, Jumping and hopping libraries, Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression; Codon optimization for heterologous expression. Introduction of DNA into mammalian cells; Transfection techniques

Unit III (12 Lectures)

Principles of PCR, Primer design,DNApolymerases, Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T- vectors; Applications of PCR in gene recombination, Site specific mutagenesis, in molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay.

Unit IV (12 Lectures)

Genetic transformation of plants: DNA delivery – *Agrobacterium* mediated method. Direct DNA delivery – chemical mediated electroporation and particle bombardment. Vectors and transgene design - Promoters and Marker genes. Chloroplast transformation. Development of marker-free plants. Analysis of transgenic plants – molecular and Biochemical assays, genetic analysis - Identification of gene

integration site - Advance methods – *cis* genesis, intragenesis and targeted genome modification – ZFN, TALENS and CRISPR. Application of transgenic technology.

VI. Suggested Reading

- Brown, T.A. 2010. *Gene Cloning and DNA Analysis an Introduction.* 6th edition, Wiley Blackwel.
- Primrose, S.B. and Twyman, R. 2006. *Principles of Gene Manipulation* 7th edition, Wiley Blackwell.
- Sambrook, J., and Russell, R.W. 2001. *Molecular cloning: A laboratory manual* 3rd Edition, Cold spring harbor laboratory press, New York.
- Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th Edition, Cambridge University Press.

I. Course Title : Techniques in Molecular Biology II

II. Course Code : MBB 507

III. Credit Hours : 0+3

IV. Aim of the course

- To get a basic overview of molecular biology techniques, good lab practices and molecular markers.
- To get a hands on training in RNAi, microarrays, yeast2 hybrid and immunological techniques.

V. Practicals

Construction of gene libraries (cDNA and Genomics).

- Synthesis and cloning of cDNA.
- Real time PCR and interpretation of data.
- Molecular markers
  i. RAPD.
  ii. SSR.
  iii. AFLP / ISSR and their analysis.
- Case study of SSR markers - construction of linkage map.
- QTL analysis using genotypic data based on SSR.
- SNP identification and analysis.
- Microarray studies and use of relevant software.
- Proteomics
  i. 2D gels,
  ii. Mass spectrometry
- RNAi - designing of construct, phenotyping of the plant.
- Yeast 1 and 2-hybrid interaction.
- Generation and screening of mutants.
- Transposon mediated mutagenesis.
- Immunology and molecular diagnostics: Ouchterlony double diffusion, Immunoprecipitation, Radiation Immunodiffusion, Immunoelectrophoretic, Rocket Immunoelectrophoretic, Counter Current Immunoelectrophoretic,ELISA, Latex Agglutination, Immunohistochemistry.

VI. Suggested Reading

- Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th Edition, Cambridge University Press
- Bonifacino, J. S., Dasso, M., Harford, J. B., Liipincott-Schwartz, J., and Yamada, K. M. 2004. *ShortProtocols in Cell Biology*. John Wiley & Sons, New Jersey

- Hawes, C., and Satiat-Jeunemaitre, B. 2001. *Plant Cell Biology: Practical Approach*. OXford University Press, OXford
- Sawhney, S.K., Singh, R. 2014. *Introductory Practical Biochemistry*, Alpha science international limited

I. Course Title : Introduction to Bioinformatics

II. Course Code : MBB 508

III. Credit Hours : 2+1

IV. Aim of the course

- To get a basic overview of computational techniques related to DNA, RNA and protein analysis.
- To get a hands on training in software's and programs used to analyse, assemble or annotate genomes, phylogenetics, proteomics etc.

V. Theory

Unit I (8 Lectures)

Bioinformatics basics, scope and importance of bioinformatics; Biological databases for DNA and Protein sequences -PIR, SWISSPROT, GenBank, DDBJ, secondary database, structural databases –PDB,SCOP and CATH, Specialized genomic resources, Microarray database.

Unit II (10 Lectures)

Bioinformatics Tools Facilitate the Genome-Wide Identification of Protein-Coding Genes, Sequence analysis, Sequence submission and retrieval system-SEQUIN, BANKit, SAKURA, Webin, Sequence alignment, pair wise alignment techniques, multiple sequence alignment; Tools for Sequence alignment- BLAST and its variants; Phylogenetic analysis- CLUSTAL X, CLUSTAL W, Phylip, Tcoffee

Unit III (10 Lectures)

Sequencing of protein; Protein secondary structure prediction- Chousfasman, GOR Method, Protein 3DStructure Prediction: Evaluation of models- Structure validation and refinement - Ramachandran plot, Force field calculations, SAVES. Protein function prediction- sequence and domain based, Primer designing- principles and methods.Drug discovery**,** Structure Based Drug Design- Rationale for computer aided drug designing, basic principles, docking, QSAR.

VI. Practical (12 Lectures)

- Usage of NCBI resources
- Retrieval of sequence/structure from databases and submission
- Different Databases, BLAST exercises.
- Assembly of DNA and RNA Seq data
- Annotation of assembled sequences,Phylogenetics and alignment
- Visualization of structures, Docking of ligand receptors
- Protein structure analysis and modeling

VII. Suggested Reading

- Attwood, T.K., and Parry-Smith, D. J. 2004. *Introduction to Bioinformatics*, Pearson Education (Singapore) Pvt. Ltd.
- David Edwards (Ed.) 2007. *Plant Bioinformatics: Methods and Protocols*. Humana Press, New Jersey, USA.

- Mount, D.W. 2004. *Bioinformatics: Sequence and Genome Analysis.* 2nd Revised edition Cold Spring Harbor Laboratory Press, U.S.
- Pevsner J. 2009. *Bioinformatics and Functional Genomics*, 2nd edition, Wiley-Blackwell.

I. Course Title : Plant Tissue Culture

II. Course Code : MBB 509

III. Credit Hours : 2+1

IV. Aim of the course

- To provide insight into principles of plant cell culture and genetic transformation.
- To get a hands on training in basic plant tissue culture techniques, callusing, micropropagation and analysis.

V. Theory

Unit I (12 Lectures)

History of plant tissue culture, principle of Totipotency; Tissue culture media; Plant hormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of planttissueculture; National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods – PCR, ELISA

Unit II (12 Lectures)

Micropropagation of field and ornamental crops; Virus elimination by meristem culture, meristemtip culture and micrografting; Androgenesis and gynogenesis - production of androgenic and gynogenic haploids - diploidization; Protoplast culture - isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybridization - Production of Somatic hybrids and Cybrids;, Wide hybridization - embryo culture and embryo rescuetechniques; Ovule, ovary culture and endosperm culture.

Unit III (12 Lectures)

Large-scalecell suspension culture - Production of alkaloids and other secondary metabolites- techniques to enhance secondary metabolite production, Somaclonal and gametoclonal variations – causes and applications; Callus culture and *in vitro* screening for stress tolerance; Artificial seeds, *In vitro* germplasm storage and cryo-preservation. Commercial Tissue Culture: Case studies and success stories, Market assessment; project planning and preparation, economics, government policies

VI. Practical (12)

- Preparation of stocks - macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium.
- Micro-propagation of plants by nodal and shoot tip culture.
- Embryo culture to overcome incompatibility, Anther culture for haploid production.
- Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis.
- Acclimatization of tissue culture plants and establishment in greenhouse.
- Virus indexing in tissue culture plants. (Using PCR and ELISA).
- Plan of a commercial tissue culture unit.

VII. Suggested Reading

- Razdan, M.K. 2003. *Introduction to plant tissue culture*, 2nd edition, Oxford publications group
- Butenko, R.G. 2000. *Plant Cell Culture* University Press of Pacific
- Herman, E.B. 2008. *Media and Techniques for Growth, Regeneration and Storage*, Agritech Publications, New York, USA.
- Bhojwani, S.S and Dantu P. 2013. *Plant Tissue Culture – An Introductory Text*. Springer Publications.
- Gamborg, O.L and G.C. Philips (eds.). 2013. *Plant Cell, Tissue and Organ culture-Lab Manual*. Springer Science & Business media.

I. Course Title : Microbial/ Industrial Biotechnology

II. Course Code : MBB 510

III. Credit Hours : 2-+1

IV. Aim of the course

To familiarize about the various microbialprocesses/systems/activities, which have been used for the development of industrially important products/processes.

V. Theory

Unit (8 Lectures)

Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms.

Unit II (8 Lectures)

Primary metabolites, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non-ribosomal peptide antibiotics as case study; Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry.

Unit III (8 Lectures)

Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio-transformations, Bio- augmentation with production of vitamin C as a case study; Bioreactors, their design and types; Immobilized enzymes-based bioreactors; Microencapsulation technologies for immobilization of microbial enzymes.

Unit IV (8 Lectures)

Environmental Biotechnology, biotreatment for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bio-remediation of soil; Production of eco-friendly agricultural chemicals, bio- pesticides, bio-herbicides, bio-fertilizers, bio-fuels, etc.

VI. Practical

- Isolation of industrially important microorganisms, their maintenance and improvement.
- Lab scale production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery.
- Study of bio-reactors and their operations.
- Production of bio-fertilizers.
- Experiments on microbial fermentation processofantibiotics, bio-pigments, dairy products,

harvesting purification and recovery of end products.
- Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomassestimation.
- Determination of mass transfer coefficient.

VII. Suggested Reading

- Waites, M.J., Morgan, N.L., Rockey, J.S., Higton, G. 2001. *Industrial Microbiology: An Introduction*, Wiley-Blackwell.
- Slater, A., Scott, N.W., & Fowler, M.R. 2003. *The Genetic Manipulation of Plants. Plant Biotechnology Oxford, England: Oxford University Press.*
- Kun, L.Y. (Ed.). 2003. *Microbial biotechnology: principles and applications*. World Scientific Publishing Company.

I. Course Title : Molecular Plant Breeding

II. Course Code : MBB 511

III. Credit Hours : 2-+1

IV. Aim of the course

- To familiarize the students about the use of molecular biology tools in plant breeding.
- To provide a hands on training in data analysis, diversity analysis and mapping of genes and QTLs.

V. Theory

Unit I (8 Lectures)

Inheritance of qualitative and quantitative traits. Heritability – its estimation, Population structure of self- and cross-pollinated species, Factors affecting selection efficiency. Development of different kinds of segregating populations – F_2, F_3, BC_1F_1, BC_1F_2, BC_4F_2, RIL (Recombinant Inbred Lines), AIL (Advanced Intercrossed Lines), DH (Di-haploid population), NIL (Near Isogenic lines), NAM (Nested Association Mapping), MAGIC (Multi-parent Advanced Generation Intercross population).

Unit II (8 Lectures)

Causes of sequence variation and its types, Types of molecular markers and development of sequence based molecular markers – RFLP, AFLP, SCARs, CAPS, SSRs, STMS, SNPsInDel and DARTseq; Inheritance of markers, Linkage analysis using test cross, F_2, F_3, BC_1F_1, RIL. Construction of genetic map, Mapping genes for qualitative traits; Genotyping by sequencing and high-density chip arrays.

Unit III (8 Lectures)

QTL mapping using structured populations; Association mapping using unstructured populations; Genome Wide Association Studies (GWAS),Principle of Association mapping– GWAS-SNP genotyping methods, DART array sequencing, Illumina's Golden Gate Technology, Genotyping by sequencing methods- Fluidigm; GBS, Illumina Hi seq- Nano pore sequencing, Principles and methods of Genomic Selection, Fine mapping of genes/QTL; Development of gene based markers; Allele mining by TILLING and Eco-TILLING.

Unit IV (8 Lectures)

Tagging and mapping of genes. Bulk segregant and co-segregation analysis, Marker

assisted selection (MAS); Linked, unlinked, recombinant, flanking, peak markers. Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples. Haplotype concept and Haplotype-based breeding; Genetic variability and DNA fingerprinting. Molecular markers in Plant variety protection, IPR issues, hybrid purity testing, clonal fidelity testing and transgenic testing.

VI. Practical

- Construction of linkage map.
- QTL analysis using the QTL cartographer and other software.
- SNP data analysis using TASEEL.
- Detection of haplotype block using SNP data - pLinksoftware.
- Genotyping by sequencing methods –Illumina genotyping platform.
- Marker assisted breeding – MABB case studies quality traits in rice/maize.
- Genome Assisted Breeding in model crops, Genomic Selection models usingthe morphological and SNP data

VII. Suggested Reading

- Acquaah, G. 2007. *Principles of Plant Genetics and Breeding*, Blackwell Publishing Ltd. USA.
- Weising, K., Nybom, H., Wolff, K., and Kahl, G. 2005. *DNA Fingerprinting in Plants: Principles, Methods and Applications*, 2nd ed. Taylor and Francis Group, Boca Raton, FL.
- Halford, N. 2006. *Plant Biotechnology-Current and future applications of genetically modified crops*, John Wiley and Sons, England.
- Singh, B. D. and Singh, A. K. 2015. *Marker-Assisted Plant Breeding: Principles and Practices* Springer (India) Pvt. Ltd.

5. Boopathi, NM. 2013. *Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits*. Springer India. p293.

I. Course Title : IPR, Bio-safety & Bioethics

II. Course Code : MBB 512

III. Credit Hours : 2+0

IV. Aim of the course

- To familiarize the students about ethical and biosafety issues in plant biotechnology.
- To provide a hands-on training in data analysis, diversity analysis and mapping of genes and QTLs.

V. Theory

Unit I (10 Lectures)

IPR: historical background in India; trade secret; patent, trademark, design& licensing; procedure for patent application in India; Patent Cooperation Treaty (PCT); Examples of patents in biotechnology-Case studies in India and abroad; copyright and PVP; Implications of IPR on the commercialization of biotechnology products, ecological implications; Trade agreements- The WTO and other international agreements, and Cross border movement of germplasms.

Unit II (8 Lectures)

Biosafety and bio-hazards; General principles for the laboratory and environmental bio-safety; Biosafety and risk assessment issues; handling and disposal of bio-hazards; Approved regulatory laboratory practice and principles,The Cartagena

Protocol on biosafety; Biosafety regulations in India; national Biosafety Policy and Law; Regulations and Guidelines related to Biosafety in other countries

Unit III (8 Lectures)

Potential concerns of transgenic plants – Environmental safety and food and feed safety. Principles of safety assessment of Transgenic plants – sequential steps in risk assessment. Concepts of familiarity and substantial equivalence. Risk - Environmental risk assessment – invasiveness, weediness, gene flow, horizontal gene transfer, impact on non-target organisms; food and feed safety assessment – toxicity and allergenicity.Monitoring strategies and methods for detecting transgenics.

Unit IV (6 Lectures)

Field trails – Biosafety research trials – standard operating procedures, labeling of GM food and crop,Bio-ethics- Mankind and religion, social, spiritual & environmental ethics; Ethics in Biotechnology, labeling of GM food and crop; Biopiracy

VI. Suggested Reading

- Goel, D. and Parashar, S. 2013. *IPR, biosafety, and bioethics*.
- Joshi, R. 2006. *Biosafety and Bioethics*.
- Nambisan, P. 2017. *An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology*.

I. Course Title : Immunology and Molecular Diagnostics

II. Course Code : MBB 513

III. Credit Hours : 3+0

IV. Theory

Unit I (6 Lectures)

Immunity and its classification; Components of innate and acquired immunity; Lymphatic system; Hematopoiesis; Organs and cells of the immune system- primary, secondary and tertiary lymphoid organs Descriptions of Antigens - immunogens, hapten and adjuvants.

Unit II (12 Lectures)

Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Basis of self and non-selfdiscrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cluster of Differentiations (CDs), Cytokines-properties, receptors and therapeutic uses.

Unit III (8 Lectures)

Phagocytosis; Complement and Inflammatory responses; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing; Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten-carrier system

Unit IV (10 Lectures)

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques – RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosenor assays for assessing ligand –receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, Transgenic mice, Gene knock outs

Unit V (12 Lectures)

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies, Immunity to Infection,Bacteria, viral, fungal and parasitic infections, Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases, MHC and TCR in autoimmunity; Transplantation, Immunological basis of graft rejection, immunosuppressive therapy; Tumor immunology – Tumor antigens.

V. Suggested Reading

- Owen J.A., Punt, J., & Stranford, S. A. 2013. *Kuby immunology* (p. 692). New York: WH Freeman.
- Kenneth, M., and Weaver, C. 2017. *Janeways Immunobiology*, 9th Edition, New York, USA: Garland Science, Taylor & Francis publisher.
- William, P. 2013. *Fundamental of Immunology*, 7th edition, Lippencott, William and Wilkins publisher.

I. Course Title : Nano Biotechnology

II. Course Code : MBB 514

III. Credit Hours : 2+1

IV. Aim of the course

Understanding the molecular techniques involved in structure and functions of nano-biomolecules in cells such as DNA, RNA and proteins.

V. Theory

Unit I (8 Lectures)

Introduction to Nanotechnology - Nanomaterials - Self-assembly to artificial assembly for creation of useful nanostructures – Bottoms up and Top down approach (Nano rods, nano cages, nanotubes, quantum dots, nanowires, metal/ polymer-based nanostructures) – Preparation and Characterization of nanoparticles (particle size analyzer, microscopy, viz. electron microscopy, atomic force microscopy, etc).

Unit (8 Lectures)

Cell structure – Bio macromolecules: Types, Structure, Dynamics and interaction with water – Cellular nano machines – cellular transducers, membrane channels, membrane transporters, Membrane motors – Creation of bio-nanostructures (Nano liposomes, Nano micelles, Nanomotors, etc).

Unit III (8 Lectures)

Chemical, physical and biological properties of biomaterials and bio response: biomineralization, biosynthesis, and properties of natural materials (proteins, DNA,

and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems,

Unit (8 Lectures)

Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

VI. Practical

- Isolation of enzymes and nucleic acids involved in biosynthesis of nanomaterials
- Synthesis of Gold/silver Nanoparticles by biogenic methods, Synthesis of micelles and inverse micelles
- Synthesis of Carbon Nano-materials by Chemical Vapor Deposition and Sputtering technique
- Preparation ofthiolate silver nanoparticles, Purification and measurement of carbon nano materials
- Zinc selenide quantum dot preparation, Synthesis of Iron Oxide Nanoparticle
- Thin film preparation by spin coating technique, Synthesis of Nickel metal nanoparticle by urea decomposition method
- Synthesis of Zinc Oxide nanoparticle

VII. Suggested Reading

- Nalwa, H.S. 2005. *Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology*. American Scientific Publications.
- Niemeyer C.M. and Mirkin C.A. (Eds) 2005. *Nanobiotechnology: Concepts Applications and Perspectives,* Wiley Inter-science publications.
- Cao, G., and Wang, Y. 2004. *Nanostructures and Nanomaterials: Synthesis, Properties and Applications,* Imperial College Press.

I. Course Title : Environmental Biotechnology

II. Course Code : MBB 515

III. Credit Hours : 3+0

IV. Aim of the course

To apprise the students about the role of biotechnology in environment management for sustainable eco-system and human welfare.

V. Theory

Unit I (8 Lectures)

Basic concepts and environmental issues; types of environmental pollution; problems arising from high-input agriculture; methodology of environmental management; air and water pollution and its control; waste water treatment - physical, chemical and biological processes; need for water and natural resource management.

Unit II (8 Lectures)

Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides and toxic chemicals,detergentsetc; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc); anaerobic processes: digestion, filtration, etc.

Unit III (8 Lectures)

Renewable and non-Renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas; microbial hydrogen production; conversion of sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture etc.

Unit IV (8 Lectures)

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

VI. Suggested Reading

- Evans, G. M. and Furlong, J. C. 2010. *Environmental Biotechnology: Theory and Application.* 2nd edition, Wiley-Blackwell.
- Jordening HJ and Winter J. 2006. *Environmental Biotechnology: Concepts and Applications.* Wiley-VCH Verlag.

I. Course Title : Bio-entrepreneurship

II. Course Code : MBB 516

III. Credit Hours : 1+0

IV. Aim of the course

The objective of this course is to teach students about fundamentals of entrepreneurship, launching a venture or a start up in biotechnology-based theme.

V. Theory

Unit I (4 Lectures)

Scope in biotechnology; types of bio-industries – bio-pharma, bio-agri, bio-services and bio-industrial; Importance of entrepreneurship; introduction to bioentrepreneurship – biotechnology in a global scale; –skills for successful entrepreneur–creativity, leadership, managerial, team building, decision making; opportunities for bio-entrepreneurship- entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India)

Unit II (4 Lectures)

Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/ support from various agencies; statutory and legal requirements for starting a company/ venture.

Unit III (4 Lectures)

Entry and exit strategy; identifying needs of customers; Market linkages, branding issues; developing distribution channels - franchising; policies, promotion, advertising; branding and market linkages for 'virtual startup company'. Pricing strategy.

Unit IV (4 Lectures)

Knowledge centers e.g., in universities, innovation centres, research institutions (public & private) and business incubators; R&D for technology development and upgradation; assessment of technology development; managing technology transfer;

VI. Suggested Reading

- Adams, D.J. and Sparrow, J.C. 2008. *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences*. Bloxham: Scion.
- Shimasaki, C.D. 2014. *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies*. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
- Onetti, A., and Zucchella, A. 2014. *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge*. Routledge.
- Jordan, J. F. 2014. *Innovation, Commercialization, and Start-Ups in Life Sciences*. London: CRC Press.
- Desai, V. 2009. *The Dynamics of Entrepreneurial Development and Management*. New Delhi: Himalaya Pub. House.

I. Course Title : Stress Biology and Genomics

II. Course Code : MBB 517

III. Credit Hours : 2+0

IV. Aim of the course

To provide advanced knowledge on genomics with reference to abiotic stress tolerance and biotic stress resistance in plants tolerance.

V. Theory

Unit I (10 Lectures)

Different kinds of stresses (biotic and abiotic) and adaptation strategies: Plant cell as a sensor of environmental changes; role of cell membranes in signal perception; Ways of signal transduction in cells and whole plants as a response to external factors.Abiotic stresses affecting plant productivity – Drought, salinity, water logging, temperature stresses, light stress and nutrient stress; Drought stress – Effects on plant growth and development; Components of drought resistance; Physiological, biochemical and molecular basis of tolerance mechanisms; Biotic stress (insect and pathogen) resistance mechanism.

Unit II (12 Lectures)

Strategies to manipulate drought tolerance – Osmotic adjustment and Osmoprotectants - synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants; hormonal metabolism - ABA signaling; signaling components – transcription factors. Water logging stress – effects on plant growth and metabolism; adaptation to water logging,tolerance mechanisms -hormones and flooding tolerance. Strategies for improving submergence tolerance. Salinity stress – effects on physiology and metabolism of plants, SOS pathways and ion homeostasis,Strategies to improve salinity tolerance in plants. Water logging stress – effects on plant growth and metabolism; tolerance mechanisms. Physiological and biochemical changes – High & Low temperature tolerance mechanisms - molecular basis of thermo tolerance. Morphological and physiological changes in plants due to high and low light stresses - photo oxidation -plastid development. Characters of heliophytes and sciophytes – solar tracking – sieve effect and light channeling. Heavy metal stress – Al and Cd stress - effects on plant growth and development, biotech Strategies to overcome heavy metal stress Nutrient stress-effects on plant growth and development. Genetic manipulation strategies to overcome the stress effects.

Unit III (10 Lectures)

Genomics; transcriptomes, small RNAs and epigenomes; functional genomics; transfer of tolerance/resistant genes to model plants and validation of gene function. Different techniques for the functional validation of genes.

Signaling pathway related to defense gene expression, R proteins, RNAi approach and genes from pathogens and other sources, coat protein genes, detoxification genes, transgenic and disease management. Bt proteins, resistance management strategies in transgenic crops, ecological impact of field release of transgenic crops. Bioinformatics approaches to determine gene function and network in model plants under stress.

VI. Suggested Reading

- Buchanan, B.B., Gruissem, W. and Jones R. 2015. *Biochemistry and Molecular Biology of Plants*, 2nd edition, Wiley and Blackwell Publications.
- Sarwat, M., Ahmad, A., Abdin, M.Z. 2013. *Stress Signaling in Plants: Genomics and Proteomics Perspective*, Volume 1, Springer.
- Heribert Hirt. 2010. *Plant Stress Biology: From Genomics to Systems Biology*, John Wiley.
- Pandey, G.K. 2015. *Elucidation of Abiotic Stress Signaling in Plants*, Stringer.

I. Course Title : Gene Regulation

II. Course Code : MBB 518

III. Credit Hours : 2+0

IV. Aim of the course

To understand the basics of gene regulation including a wide range of mechanisms that are used by organisms to increase or decrease the production of specific gene products in terms of time, space, conditions or their combinations.

V. Theory

Unit I (8 Lectures)

Transcriptional regulation – Regulatory proteins, Activators and Repressors, Binding of RNA polymerase, Allosteric regulation, DNA looping, Cooperative binding, Anti-termination, Combinatorial control – Regulation of *lac, trp* and *ara* Operons. Gene regulation in Lambda phage – lytic or lysogenic establishment.

Unit II (10 Lectures)

Regulatory sequences – Promoters, Enhancers, Silencers, Insulators, Locus Control Region. Activator proteins and their binding sites, DNA binding domain – Homeodomain, Zinc containing proteins, Leucine Zipper Motif, Helix-Loop-Helix, HMG proteins. Recruitment of RNA polymerase to promoter region, Nucleosomes and their modifiers. Signal integration. Signal transduction and transcriptional regulation. Gene Silencing. Epigenetic gene regulation.

Unit III (10 Lectures)

Regulation by RNA in prokaryotes and eukaryotes, RNA as defense agents. Ribo-switches. Gene Silencing by RNA - siRNA & miRNA – synthesis and function. Non-coding RNAs their impact, categories and role in gene regulation, chromatin assembly etc.

Unit IV (4 Lectures)

Negative auto-regulation, Positive auto-regulation, Bistable and Bimodal switch, Oscillating pattern of gene eXpression.

VI. Suggested Reading

- Nelson, D. L. and Cox, M. M. 2017. *Lehinger's Principles of Biochemistry*, 7th edition, W H Freeman Publication New York
- Krebs, J. E., Goldstein, E. S., Kilpatrick, S. T. 2017. *Lewin's Genes* XII 12th edition, Jones & Bartlett Learning publisher, Inc
- Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine,M., & Lonick, R. 2014. *Molecular Biology of the Gene*, 7th Edition, Cold Spring Harbor Laboratory Press, New York.
- Gardner, E. J., Simmons MJ and Snustad, D.P. 2006. *Principles of Genetics* (2006) eighth Edition. Wiley

Course Title with Credit Load
Ph.D in Molecular Biology and Biotechnology

Course Code	Course Title	Credit Hours
	Major: 12 credits (6 credits of core + 6 credits of optional)	
MBB 601	Plant Molecular Biology*	3+0
MBB 602	Plant GenomeEngineering*	3+0
MBB 603	Plant Omics and Molecular Breeding	3+0
MBB 604	Commercial Plant Tissue Culture	2+0
MBB 605	Plant Microbe interaction#	2+0
MBB 606	RNA Biology#	1+0
MBB 607	Plant Hormones and Signaling#	2+0
MBB 608	Computational and Statistical tools in Biotechnology#	2+1
	Any other appropriate 500 series courses	
	Minor (6 credits) from anyof the following disciplines	
	Biochemistry	
	Genetics and Plant Breeding	
	Microbiology	
	Plant Physiology	
	Plant Pathology	
	Entomology	
	Bioinformatics	
	Plant Genetic Resources	
	Any other related discipline	

	Supporting (5 credits) from the following disciplines	
	Biochemistry	
	Genetics and Plant Breeding	
	Microbiology	
	Bioinformatics	
	Computer Applications	
	Statistics	
	Common Courses	-
MBB	Seminar I	0+1
MBB	Seminar II	0+1
MBB 600	Research	0+75
	Total	**100**

*Core Courses; # New Courses

Course Contents
Ph.D. in Molecular Biology and Biotechnology

I. Course Title : Plant Molecular Biology
II. Course Code : MBB 601
III. Credit Hours : 3+0

IV. Theory

Unit I (10 Lectures)

Model Systems in Plant Biology (Arabidopsis, Rice, etc.) Forward and Reverse Genetic Approaches. Organization expression and interaction of nuclear, Mitochondrial and Chloroplast Genomes. Cytoplasmic male sterility.

Unit II (12 Lectures)

Transcriptional and Post-transcriptional Regulation of Gene Expression, Isolation of promoters and other regulatory elements, RNA interference, Transcriptional Gene Silencing, Transcript and Protein Analysis.

Unit III (12 Lectures)

Plant Developmental Processes, ABC Model of Floral Development, Role of hormones (Ethylene, Cytokinin, Auxin and ABA, SA and JA) in plant development. Regulation of Flowering, Plant photoreceptors and light signal transduction, vernalization, Circadian Rhythms.

Unit IV (14 Lectures)

Abiotic Stress Responses: Salt, Cold, Heat and Drought.Biotic Stress Responses. Molecular Biology of Plant-pathogen Interactions, Molecular Biology of *Rhizobium* and *Agrobacterium*- Plant interaction. Role of programmed Cell Death in Development and Defense.

V. Suggested Reading

- Buchanan, B.B., Gruissem, W. and Jones R. 2015. *Biochemistry and Molecular Biology of Plants*, 2nd edition, Wiley and Blackwell Publications.
- Slater, A., Scott, N.W., and Fowler, M.R. 2003. *The Genetic Manipulation of Plants. Plant Biotechnology Oxford, England: Oxford University Press.*
- Walker, J.M., Rapley, R. 2008. *Plant Biotechnology and Genetics: Principles, Techniques and Applications.*

I. Course Title : Plant Genome Engineering

II. Course Code : MBB 602

III. Credit Hours : 3+0

IV. Theory

Unit I (14 Lectures)

Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available molecular marker, transformation and genomic tools for crop improvement.Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc) and biotic (insect pests, fungal, viral and bacterial diseases, weeds, etc) stresses; Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fiXation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, mineral nutrients, etc.); edible vaccines, etc.

Unit II (12 Lectures)

Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement; Regulated and tissue-specific eXpression of transgenes for crop improvement;

Unit III (12 Lectures)

Gene stacking; Pathway engineering; Marker-free transgenic development strategies; Genome editing: principles and methods, Development of genome edited plants; High throughput phenotyping of transgenic plants.

Unit IV (10 Lectures)

Field studies with transgenic crops; Environmental issues associated with transgenic crops; Food and feed safety issues associated with transgenic crops; Risk assessment of transgenic food crops.

V. Suggested Reading

- Christou P and Klee H. 2004. *Handbook of Plant Biotechnology*. John Wiley & Sons.
- Stewart Jr, C.N. 2016. *Plant Biotechnology and Genetics: Principles, Techniques, and Applications*. John Wiley & Sons.
- Kirakosyan A and Kaufman PB. 2009. *Recent Advances in Plant Biotechnology* p. 409. Dordrecht: Springer.

I. Course Code : MBB603

II. Course Title : Plant Omics and Molecular Breeding

III. Credit Hours : 3+0

IV. Theory

Unit I (12 Lectures)

Complex traits and genetic architecture, Mapping genes and QTLs, statistical concepts in QTL mapping, high-throughput genotyping using automated platforms, genetic and physical mapping of genomes, study of population structure and kinship, association genetic analysis of QTL, case studies on QTL mapping using different approaches, map-based of cloning genes and QTLs – case studies.

Unit II (12 Lectures)

Marker Assisted Breeding (MAB): Principles and methods, marker assisted foreground and background selection, marker assisted recurrent selection, whole genome selection, case studies in MAS, requirement for successful marker assisted breeding, cost of MAB.

Unit III (12 Lectures)

Concepts and methods of next generation sequencing (NGS), assembly and annotation of NGS data, genome resequencing, DNA sequence comparison, annotation and gene prediction. Genome-wide insertion mutagenesis and its use in functional genomics, transcriptome profiling using microarrays and deep sequencing, study of methylome and its significance, proteome analysis using mass spectrometry, crystallography and NMR, analysis of proteome data, study of protein- protein interactions.

Unit IV (12 Lectures)

Study of themetabolome, use of 1D/2D NMR and MS in metabolome analysis, multivariate analysis and identification of metabolite as biomarkers, study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), correlating the data from genome, transcriptome, proteome, metabolome and ionome with phenome.

V. Suggested Reading

- Speicher, D.W. (Ed.). 2004. *Proteome analysis: interpreting the genome.* Elsevier.
- Tomita, M. and Nishioka, T. (Eds.). 2006. *Metabolomics: the frontier of systems biology*. Springer Science and Business Media
- Horst, L. and Wenzel, G. (Eds.). 2007. *Molecular marker systems in plant breeding and crop improvement* (Vol. 55). Springer Science and Business Media.
- Stewart C.N. 2008. *Plant Biotechnology and Genetics: Principles, Techniques and Applications*.
- Singh, B.D. and Singh, A.K. 2015. *Marker-Assisted Plant Breeding: Principles and Practices* Springer (India) Pvt. Ltd.

I. Course Title : Commercial Plant Tissue Culture
II. Course Code : MBB 604
III. Credit Hours : 2+0

Theory

Unit I (8 Lectures)

Micro-propagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing.

Unit II (8 Lectures)

Production of useful compounds via, biotransformation and secondary metabolite production: suspension cultures, immobilization, examples of chemicals being produced for use in pharmacy, medicine and industry.

Unit III (9 Lectures)

Value-addition by transformation; development, production and release of transgenic plants; patent, bio-safety, regulatory, environmental and ethical issues; management and commercialization.

Unit IV (7 Lectures)

Project planning and preparation, economics (entrepreneurship, cost profit ratio), government policies (incubators, different facilitation projects, loan opportunities). Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/industries.

IV. Suggested Reading

- Honda, H., Liu, C., Kobayashi, T. 2001. *Large-Scale Plant Micropropagation*. In: Zhong J.J. *et al*. (eds) *Plant Cells. Advances in Biochemical Engineering/ Biotechnology*, vol 72. Springer, Berlin, Heidelberg.
- Bhojwani SS and Razdan MK. 1986. *Plant tissue culture: theory and practice* (Vol. 5). Elsevier.

I. Course Title : Plant Microbe Interaction

II. Course Code : MBB 605

III. Credit Hours : 2+0

IV. Theory

Unit I (8 Lectures)

Microbial communities in the soil and atmosphere, Community dynamics and population interactions with particular reference to plant–microbe and microbe-microbe interactions leading to symbiotic, associative, endophytic and pathogenic interactions, effects of microorganisms on plants, effects of plants on microorganisms. Recognition processes and signal exchange, Molecular aspects of Plant Growth Promoting Rhizobacteria (PGPR), Symbiotic diazotrophs: Rhizobia and association with legumes. Mycorrhizal associations: Ectomycorrhizae, Endomycorrhizae with particular emphasis to AM fungi, Ectendomycorrhizae. Biocontrol agents and their action, endophytes associations

Unit II (8 Lectures)

Enzymes, toxins, pili, siderophores, secretion systems of microbes and plants determining soil health, nutrient availability and uptake defense responses in

plants: pamp-triggered immunity,effector-triggered susceptibility,qualitative resistance, r genes, structure and function, effector-triggered immunity, regulation of plant cell death, plant hormones in immunity, Plant parasite interactions and its molecular basis and impact on plant functions including photosynthesis, respiration, nitrogen metabolism and translocation

Unit III (8 Lectures)

Quorum sensing in bacteria, understanding microbiome,phytobiomes,dynamics, Applied and ecological aspects of symbioses and pathogen defense, techniques to study plant microbe interaction including microbe tagging, metagenomics and use of organismal databases to identify genes involved in interactions. Industrial application of agriculturally important microbes.

Unit III (8 Lectures)

Resistance mechanisms against attack by plant pathogens, gene-for-gene interactions; induced resistance; non-host resistance. Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR), Plant and microbial gene expression and signal exchange, specific regulators for different interactions including transgenic plants. Recognition mechanism and signal transduction during plant - pathogen interaction

V. Suggested Reading

- Rangaswamy, G. Bhagyaraj. 1993. *Agricultural Microbiology*, Prentice Hall India.
- Stacey, G., and Keen, N.T. (Eds.). 1996. *Plant-microbe interactions*. Springer Science & Business Media.
- Dickinson M. 2005. *Molecular Plant Pathology*. Bios Scientific Press, Taylor and Francis group.
- Kosuge T and Nester EW. 1989. *Plant-Microbe Interactions: Molecular and Genetic Perspectives.*Vols I-IV. McGraw Hill.
- González MBR and Gonzalez-López J. (Eds.). 2013. *Beneficial plant-microbial interactions: ecology and applications*. CRC press.

I. Course Title : RNA Biology

II. Course Code : MBB 606

III. Credit Hours : 1+0

IV. Theory

Unit I (4 Lectures)

RNA structure, functional evolution: RNA structure, types of RNA and function; Genome evolution- RNA as genetic material to regulatory molecule, Non-Coding RNAs, structure, function and regulation

Unit II (4 Lectures)

RNA synthesis, processing and regulation: transcription and its regulation in prokaryotes and eukaryotes; RNA splicing and editing; Translation and its regulationin prokaryotes and eukaryotes

Unit III (4 Lectures)

Genome regulation: Prokaryotic- attenuation, ribozymes, aptamers, riboswitches, CRISPER-Cas; eukaryotic-Exon skipping, nonsense-mediated decay, RNAi, Long non-coding RNA.

Unit IV (4 Lectures)

Epigenetic regulation. RNA-based gene silencing technologies and their applications for crop improvement

V. Suggested Reading

- Elliott, D., and Ladomery, M. 2017. *Molecular biology of RNA*. Oxford University Press.
- Rao, M.R.S. (Ed.) 2017. *Long Non-Coding RNA Biology*, Springer,
- Donald, C.R., Hannon, G., Ares, M. and Nilsen, T.W. 2011. *RNA: A Laboratory Manual*, CSHL Press.
- Maas, S. (Ed.). 2013. *RNA Editing: Current Research and Future Trends*. Horizon Scientific Press.

I. Course Title : Plant Hormones and Signaling

II. Course Code : MBB 607

III. Credit Hours : 2+0

IV. Aim of the course

To provide in-depth knowledge of plant hormone and their role in plant growth and development.

V. Theory

Unit I (12 Lectures)

Hormone Biosynthesis, Metabolism and its Regulation: Auxin biosynthesis and metabolism, Gibberellin biosynthesis and Inactivation, Cytokinin biosynthesis and metabolism, Ethylene biosynthesis, Abscisic acid biosynthesis and metabolism, Brassinosteroid biosynthesis and metabolism. Salicylic acid and jasmonate biosynthesis and metabolism.

Unit II (12 Lectures)

Functioning of hormones in plant growth and development: Transport of Auxins, Induction of vascular tissues by Auxin, Hormones and the regulation of water balance, seed development and germination, Hormonal control of day length and senescence.

Unit III (12 Lectures)

Action of Hormones: Hormones in defense against insects and disease; Role of jasmonates, salicylic acids and peptide hormones for defense, growth, development and reproduction; Methods of plant hormone analysis. NPR 1 dependent Salicylic acid signaling, PAMP and effector triggered immunity, systemic acquired resistance and SA signaling.

Unit IV (12 Lectures)

Hormone Signal Transduction: Auxin metabolism, transport and signal transduction, Cytokinin types, synthesis, metabolism, transport and signal transduction, Gibberellin biosynthesis, transport, signal transduction in stem elongation & Leaf Growth, Ethylene metabolism, perception and signaling in seedling growth and development, Ethylene signal transduction in fruits and flowers, Abscisic acid metabolism, transport and signal transduction in nuclear gene expression and stomatal responses. Brassinosteroid biosynthesis, catabolism and signal transduction. Strigalactone biosynthesis, transport and signaling in plant parasitism and symbiosis. Methods of Plant Hormone Analysis**:** Quantitative analysis of plant hormones based on LC/MS.

VI. Suggested Reading

- Davies Jr. F. *et al.* 2017. Hart Mann and KRster's. *Plant Propagation: Principles and Practices.* Pearson.

I. Course Title : Computational and Statistical tools in Biotechnology

II. Course Code : MBB 608

III. Credit Hours : 2+1

IV. Theory

Unit I (8 Lectures)

Basic molecular biology; introduction to the basic principles of structure/function analysis of biological molecules; genome analysis; different types and classification of genome databases (e.g. HTGS, DNA, Protein, EST, STS, SNPs, Unigenes, etc.)

Unit II (8 Lectures)

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack- knifing; Markov Models. Hidden Markov Models, Bayesian estimation and Gibbs sampling

Unit III (8 Lectures)

DNA sequence retrieval system, various DNA and protein sequence file formats, Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments, DNA sequence analysis, different gene prediction models and gene annotation tools,

Unit IV (8 Lectures)

Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools, programming languages and their applications in bioinformatics

V. Practical (16)

- Different Types of Databases and Database Search and Retrieval,
- DNA and Protein Sequence Analysis,
- Similarity Searching and Multiple Alignments,
- Gene Annotation,
- Phylogenetic Analysis,
- Sequence Analysis,
- Protein Structure Prediction,
- Analysis of Microarray Data,
- Programming Languages in Bioinformatics.

VI. Suggested Reading

- Xiong J. 2012. *Essential Bioinformatics*, Cambridge University Press.
- Andreas, D.B., and Ouellette B.F.F., (Eds) 2004. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* 3rd Edition, Wiley Interscience.
- Mount D. 2004. *Bioinformatics: Sequence and Genome Analysis*, 2nd Edition. By, CSHL Press.
- Augen J. 2004. *Bioinformatics in the Post-Genomic Era: Genome, Transcriptome, Proteome, and Information-Based Medicine.*
- Galperin M.Y. and Koonin E.V. (Eds) 2003. *Frontiers in Computational Genomics.*

Restructured and Revised
Syllabi of Post-graduate Programmes
Vol. 2

Statistical Sciences

– Agricultural Statistics
– Computer Application

Contents

Acknowledgements

On behalf of the Broad Subject Matter Area (BSMA) Committee on Statistical Sciences and on our own personal behalf we wish to place on record our deepest sense of gratitude to Dr Arvind Kumar, Chairman, National Core Group and Vice Chancellor, RLBCAU, Jhansi for entrusting us with the responsibility to undertake this challenging but noble cause of revising the course curricula of all the disciplines in Statistical Sciences. This was a herculean task but the leadership of Dr Arvind Kumar, his fresh and fragrant ideas, and his knowledge and wisdom made the job easy for the committee. We would also like to articulate our feelings of indebtedness towards Dr G. Venkateshwarlu, ADG (EQR), Education Division, ICAR in particular, and for the Education Division, ICAR, in general, for providing necessary guidance from time to time and for also extending fullest support in successfully completing this exercise.

We gratefully acknowledge the full support received from Dr SD Sharma, Former Chairman, BSMA Committee (Statistical Sciences) New Delhi, during course of preparation of this report. The logistic support provided by Director and his dedicated team at ICAR-IASRI for holding the meetings of the BSMA committee and the workshop is duly acknowledged.

We have no word to express our most sincere and heartfelt gratefulness to Dr B.V.S. Sisodia, Dr S.P. Singh, Dr S.D. Samantray, and Dr A. Dhandapani members of the BSMA Committee (Statistical Sciences), whose unflinching efforts have culminated in the preparation of this report. The help received from Dr Sukanta Dash, Co-opted members of the BSMA Committee is praise worthy and we would like to express our highest appreciation of his efforts in this formidable work. The help received from Dr H.K. Jain, Head, Department of Agricultural Statistics and Computer application, Rajasthan Agriculture College, and his team members in organizing the meeting at Rajasthan Agriculture University, is held in high esteem. We would also like to express our sincere thanks to all the faculty of the meeting whose valuable suggestions have helped in shaping the course curricula.

The whole exercise started with a rough draft of course curricula prepared by the previous BSMA Committee during 2008 for which the BSMA Committee would like to convey its thankfulness to the entire members of the committee. Their help is also duly acknowledged. Another very important base material for revising the course curricula was the syllabi of the PG Courses of IARI, provided by ICAR-IASRI. The draft on the syllabi was also prepared by various members of the Committee. We very sincerely appreciate the help received from one and all which helped lay the foundation of the success of this phenomenal task.

Lastly, but most importantly, we would articulate our feelings for one and alland would like to reiterate the fact that it has been indeed a great pleasure working with everyone in the committee as well as outside the committee.

L.M. Bhar
Anil Kumar

Preamble

The origin of the discipline of Agricultural Statistics can be traced back to 1930 when the then Imperial Council of Agricultural Research decided setting up a Statistical Section to assist the State Departments of Agriculture and Animal Husbandry in planning their experiments and analysis of data. The activities of this section increased rapidly and acquired International recognition as a centre for research and training in the field of Agricultural Statistics. Training programmes were started in this discipline in 1945. This activity resulted in the conversion of this section to a full-fledged Institute named as Institute of Agricultural Research Statistics (IARS) where subsequently the M.Sc. and Ph.D. degree courses in Agricultural Statistics were started in 1964 in collaboration with Indian Agricultural Research Institute (IARI). With the strengthening of NARS through more SAUs and ICAR Institutes, the demand for trained and qualified manpower in Agricultural Statistics increased rapidly which resulted in starting of M.Sc. and Ph. D. degree courses in Agricultural Statistics in many other State Agricultural Universities (SAUs) and Deemed-to-be Universities (DUs). Throughout the growth of this discipline, the main emphasis was to develop trained manpower in the country in the field of Agricultural Statistics and later on in the field of Computer Application so as to meet the challenges of agricultural research in the newer emerging areas. These disciplines have now become an integrated component of agricultural research and help in making agricultural research globally acceptable.

Use of computers in agricultural research began more than three decades ago. Initially the electronic data processing requirements of agricultural research workers and students in the NARS were catered by ICAR-Indian Agricultural Statistics Research Institute (ICAR-IASRI). Late sixties and seventies saw statisticians - programmers at IASRI shouldering the onerous responsibility of training agricultural research workers in the use of computers. Around the same time a course on Computer Programming was introduced and offered in the curriculum of M.Sc. and Ph.D. students of PG School of IARI and subsequently at many other SAUs. Seventies witnessed an increase in the computing facilities in NARS; there was a great demand for qualified and trained manpower to manage these facilities. During mid-eighties, M.Sc. Course in Computer Application in Agriculture was introduced in the PG programme of IARI. During this time the computing environment started witnessing changes and Mainframe computers were getting replaced by PCs. Concepts like LAN, WAN, Information Technology (IT), Databases, Information Systems, etc., all became bywords among agricultural research workers. PG Programme in Computer Science/Application was also introduced in other SAUs. Computer Application became an important discipline in agricultural research and as such this discipline was introduced in the Agricultural Research Service of the ICAR in 1985. In the present day world, the role of Information Technology has become very important. Together with the discipline of Statistics, it does wonders in agricultural research. The newer areas of research like genomics, geo-informatics, market intelligence, quality management depend very heavily on Statistics and Information Technology. For outreaching the research in the labs to the farmers, information technology plays a vital role. Advisory and consultancy, distance learning, etc. have become possible through IT only. Data warehouses and data mining are the orders of the day.

In view of the importance of Statistical Sciences, it is important that the course curricula framed to initiate the students to conduct research in these areas and to expose them to their applications to agricultural sciences.Courses Syllabi content should have modified as practical oriented and job oriented. All modifications in syllabus are must be focused to Govt. sector and Corporate sector/ Industrial Benefits. Accordingly, a national level core group was constituted to revise the syllabi of agricultural sciences so as to cater to the requirements of the present day world. A Broad Subject Matter Area (BSMA) Committee for statistical sciences was constituted to look into the revision of the course curricula of the disciplines of Agricultural Statistics and ComputerApplication.

A meeting of the BSMA committee was held on 10th August, 2018 at IASRI, New Delhi to initiate the process of course curricula revision. The need for revision of the curricula was discussed and highlighted the importance and scope of statistical sciences due to its high practical applications in basic and applied research in agriculture. It wasalso emphasized about the need to broaden the scope, explore possibilities of collaboration and cooperation in all courses and to introduce technology oriented courses in statistical sciences. It was felt that the revised curricula should include all the necessary courses required to be studied by M.Sc. and Ph.D. students so as to prepare them to initiate the students to conduct research in these areas and to expose them to their applications to agricultural sciences. It was decided to ensure that the curricula mustbe modified as practical oriented and job oriented to handle competitive exam at both National and International level. Further, the course curricula should be such that it is focused to Govt. sector and Corporate sector/ Industrial Benefits. It was also felt that the curricula should be so framed that it includes the courses on newer areas of research. The committee members were then assigned the responsibility of restructuring the course curricula.

Thereafter another meeting of the BSMA committee was held during 24-25 November, 2018 at Rajasthan Agriculture College, MPUAT, Udaipur in which the revised course curricula was discussed. The committee was enlarged by inviting some experienced faculty members so as to take advantage of their experience. Several new courses were introduced. Since there are no Master's degrees of Computer applications in any SAUs except IARI, hence, it was decided to prepare the syllabus of computer applications in a view of IARI course content. Two courses for Ph.D. prgoramme in agricultural statistics have been restructuredand renamed as per modifications such as 'Advanced Statistical Computing' modified as 'Advanced Data Analytics' and 'Statistical Modeling' modified as 'Modeling Techniques for Forecasting'. Also the course 'Advanced Statistical Methods' was partitioned to two different courses as (i) 'Advanced Statistical Methods' and (ii) Linear Models.

A major recommendation from the meeting was to introduce many new course on computer application based on emerging issues in education like (i) IT Informatics-IT in Agriculture, (ii) Internet Technologies, (iii) Introduction to Big Data, (iv) Introduction to IoT, (v) Management Information. Also several courses have been restructuredand renamed as per modifications in computer application for both M.Sc. and Ph.D. programme.

Organization of Course Contents and Credit Requirements

- The current nomenclature of M.Sc. and Ph.D. programme has been finalized as M.Sc. (Ag.) Statistics/ Computer application and Ph.D. (Agricultural Statistics/ Computer Application).
- All courses are divided into two series: 500-series courses pertain to Master's level, and 600-series to Doctoral level. A Ph.D. student must take 500-series courses if not studied during Master's programme.
- Master's programme have a minimum 70 Credit Hours (consisting of 20 from core course, 8 from minorcourse, 6 from supporting course, 5 from common course, 1 credit seminar and 30 research credit hours).
- Similarly, for Ph.D. programme,the members suggested a total of 100 credit hours (including 12 from core course, 6 from minorcourse, 5 from supporting course, 2 credit seminars and 75 credit for research work).
- Maximum of credit load of 20 credit hours and 18 credit hours per semester for M.Sc. and Ph.D. programmes respectively.
- Credit seminar for Master's level is designated by Code no. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively.
- Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively.

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the Students.

Minimum Credit Requirements

		Masters' Programme	Doctoral Programme
i.	Course work		
	Major courses	20	12
	Minor courses	08	06
	Supporting courses	06	05
	Common courses	05	–
	Seminar	01	02
ii.	**Thesis Research**	30	75
	Total	70	100

Major courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken given *mark.

Minor courses: From the subjects closely related to a student's major subject.

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/her overall competence.

Common Courses: The following courses(one credit each) will be offered to all students undergoing Master's degree programme.

1. Library and Information Services
2. Technical Writing and Communications Skills
3. Intellectual Property and its management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approvalof the HoD/ BoS.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 2

Statistical Sciences

– Agricultural Statistics

Course Title with Credit Load
M.Sc. in Agricultural Statistics

Course Code	Course Title	Credit Hours	Semester
*STAT 552	Probability Theory	2+0	I
*STAT 553	Statistical Methods	2+1	I
*STAT 562	Statistical Inference	2+1	II
*STAT 563	Design of Experiments	2+1	II
*STAT 564	Sampling Techniques	2+1	II
*STAT 565	Statistical Genetics	2+1	II
*STAT 571	Multivariate Analysis	2+1	III
*STAT 572	Regression Analysis	1+1	III
*STAT 573	Statistical Computing	1+1	III
STAT 591	Seminar	0+1	III
STAT 599	Research	0+30	II-IV
STAT 551	Mathematics-I	3+0	I
STAT 554	Actuarial Statistics	2+0	I
STAT 555	Bioinformatics	2+0	I
STAT 556	Econometrics	2+0	I
STAT 561	Mathematics-II	2+0	II
STAT 566	Statistical Quality Control	2+0	II
STAT 567	Optimization Techniques	1+1	II
STAT 574	Time Series Analysis	1+1	III
STAT 575	Demography	2+0	III
STAT 576	Statistical Methods for Life Sciences	2+0	III
STAT 577	Statistical Ecology	2+0	III
	Supporting Courses		
STAT 501	Mathematics for Applied Sciences	2+0	I
STAT 502	Statistical Methods for Applied Sciences	3+1	I
STAT 511	Experimental Designs	2+1	II
STAT 512	Basic Sampling Techniques	2+1	II
STAT 521	Applied Regression Analysis	2+1	III
STAT 522	Data Analysis Using Statistical Packages	2+1	III

*Core Courses

Course Contents
M.Sc. in Agricultural Statistics

I. Course Title : Mathematics for Applied Sciences

II. Course Code : STAT 501

III. Credit Hours : 2+0

IV. Aim of the course

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. The students would get an exposure to Linear Algebra, differentiation, integration and differential equations etc.

V. Theory

Unit I

Set theory-set operations, finite and infinite sets, operations of set, function.

Unit II

Vectors and vector spaces, Matrices notations and operations, laws of matrix algebra; transpose and inverse of matrix, Eigen values and Eigen vectors. Determinants - evaluation and properties of determinants, Solutions of Linear Equations.

Unit III

Variables and functions, limits and continuity of specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, Differentiation of function of a function, derivatives of higher order, partial derivatives. Application of derivatives, determination of points of inflexion, maxima and minima.

Unit IV

Integration, methods of integration, reduction formulae, definite and indefinite integral, Applications of integration in Agriculture, Differential Equations.

VI. Suggested Reading

- Hohn FE. 2013. *Elementary Matrix Algebra*, 3rd Ed., Kindle Edition
- Harville D.A. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.
- Hohn F.E. 1973. *Elementary Matrix Algebra*. Macmillan.
- Searle S.R. 1982. *Matrix Algebra Useful for Statistics*. John Wiley. Stewart J. 2007. *Calculus*. Thompson.
- Thomas G.B. Jr. and Finney R.L. 1996. *Calculus*. 9th Ed. Pearson Edu.

I. Course Title : Statistical Methods for Applied Sciences

II. Course Code : STAT 502

III. Credit Hours : 3+1

IV. Aim of the course

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

V. Theory

Unit I

Box-plot, Descriptive statistics, Exploratory data analysis, Theory of probability, Random variable and mathematical expectation.

Unit II

Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, *t* and *F* distributions. Tests of significance based on Normal, chi-square, *t* and *F* distributions.

Unit III

Introduction to theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression coefficients, Coefficient of determination, Fitting of quadratic models.

Unit IV

Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomness of a sequence. Median test.

Unit V

Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

VI. Practical

- Exploratory data analysis, fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal.
- Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F.
- Confidence interval estimation and Correlation and regression analysis, fitting of Linear and Quadratic Model.
- Non-parametric tests. ANOVA: One way, Two Way, SRS.

VII. Suggested Reading

- Goon A.M, Gupta M.K and Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.
- Goon A.M, Gupta M.K. and Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.
- Hoel P.G. 1971. *Introduction to Mathematical Statistics*. John Wiley.
- Hogg R.V and Craig T.T. 1978. *Introduction to Mathematical Statistics*. Macmillan.
- Morrison D.F. 1976. *Multivariate Statistical Methods*. McGraw Hill.
- Hogg RV, McKean JW, Craig AT. 2012. *Introduction to Mathematical Statistics* 7th Edition.

- Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.
- Anderson TW. 2009. *An Introduction to Multivariate Statistical Analysis*, 3rd Ed . John Wiley
- http://freestatistics.altervista.org/en/learning.php.
- http://www.statsoft.com/textbook/stathome.html.

I. Course Title : Experimental Designs

II. Course Code : STAT 511

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

V. Theory

Unit I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

Unit II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

VI. Practical

- Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,
- Analysis with missing data,
- Split plot and strip plot designs.

VII. Suggested Reading

- Cochran WG and Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.
- Dean AM and Voss D. 1999. *Design and Analysis of Experiments*. Springer.
- Montgomery DC. 2012. *Design and Analysis of Experiments*, 8th Ed. John Wiley.
- Federer WT. 1985. *Experimental Designs*. MacMillan.
- Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.
- Nigam AK and Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.
- Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.
- www.drs.icar.gov.in.

I. Course Title : Basic Sampling Techniques

II. Course Code : STAT 512

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

V. Theory

Unit I

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

Unit II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Unit III

Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

Unit IV

Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

VI. Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling.

VII. Suggested Reading

- Cochran WG. 1977. *Sampling Techniques*. John Wiley.
- Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D, Singh P and Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.
- Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Cochran WG. 2007. *Sampling Techniques*, 3rd Edition. John Wiley & Sons Publication

I. Course Title : Applied Regression Analysis

II. Course Code : STAT 521

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multi collinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

V. Theory

Unit I

Introduction to correlation analysis and its measures, Correlation from grouped data, correlation, Rank correlation, Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

Unit II

Problem of correlated errors; Auto correlation; Heteroscedastic models, Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multi collinearity, Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

Unit III

Diagnostic of multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation.

Unit IV

Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

VI. Practical

- Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses;
- Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection;
- Handling of correlated errors, multi collinearity;
- Fitting of quadratic, exponential and power curves, fitting oforthogonal polynomials.

VII. Suggested Reading

- Kleinbaum DG, Kupper LL, Nizam A. 2007. *Applied Regression Analysis and Other Multivariable Methods* (Duxbury Applied) 4th Ed.
- Draper NR and Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- Ezekiel M. 1963. *Methods of Correlation and Regression Analysis*. John Wiley.
- Koutsoyiannis A. 1978. *Theory of Econometrics*. MacMillan.
- Kutner MH, Nachtsheim CJ and Neter J. 2004. *Applied Linear Regression Models*. 4th Ed. With Student CD. McGraw Hill.

I. Course Title : Data Analysis Using Statistical Packages

II. Course Code : STAT 522

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students a hands on experience in the analysis of their research data. This course is useful to all disciplines.

V. Theory

Unit I

Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

Unit II

Test for normality; Testing of hypothesis using chi-square, *t* and *F* statistics and Z-test.

Unit III

Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

Unit IV

Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

Unit V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

VI. Practical

- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data;
- Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test for large samples - Chi-squares test, F test, one-way analysis of variance;
- Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components;
- Linear regression, Multiple regression, Regression plots;
- Discriminant analysis - fitting of discriminant functions, identification of important variables;
- Factor analysis. Principal component analysis - obtaining principal component.

VII. Suggested Reading

- Anderson C.W. and Loynes R.M. 1987. *The Teaching of Practical Statistics*. John Wiley.
- Atkinson A.C. 1985. *Plots Transformations and Regression*. Oxford University Press.
- Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmount, California.
- Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall. Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.
- Cleveland W.S. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.
- Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley.
- Erickson B.H. and Nosanchuk T.A. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.
- Snell E.J. and Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman and Hall.
- Sprent P. 1993. *Applied Non-parametric Statistical Methods*. 2nd Ed. Chapman & Hall.

- Tufte ER. 1983. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Conn.
- Velleman PF and Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. DuXbury Press.
- Weisberg S. 1985. *Applied Linear Regression*. John Wiley.
- Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall.
- Wetherill GB.1986. *Regression Analysis with Applications*. Chapman & Hall.
- Cleveland WS. 1994. *The Elements of Graphing Data*, 2nd Ed., Chapman & Hall
- http://freestatistics.altervista.org/en/learning.php.
  http://freestatistics.altervista.org/en/stat.php.
  http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
  http://www.stat.sc.edu/~grego/courses/stat706/.
- www.drs.icar.gov.in.

I. Course Title : Mathematics-I

II. Course Code : STAT 551

III. Credit Hours : 3+0

IV. Aim of the course

This course lays the foundation of all other courses of Agricultural Statistics discipline by preparing them to understand the importance of mathematical methods in research. The students would be exposed to the basic mathematical tools of real analysis, calculus, differential equations and numerical analysis. This would prepare them to study their main courses that involve knowledge of Mathematics.

V. Theory

Unit I

Calculus: Limit and continuity, differentiation of functions, successive differentiation, partial differentiation, mean value theorems, Taylor and Maclaurin's series. Application of derivatives, L'hospital's rule.

Unit II

Real Analysis: Convergence and divergence of infinite series, use of comparison tests -D'Alembert's Ratio - test, Cauchy's nth root test, Raabe's test, Kummer's test, Gauss test. Absolute and conditional convergence. Riemann integration, concept of Lebesgue integration, power series, Fourier, Laplace and Laplace -Steiltjes' transformation, multiple integrals.Integration of rational, irrational and trigonometric functions. Application of integration.

Unit III

Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient.

Unit IV

Numerical Analysis: Simple interpolation, Divided differences, Numerical differentiation and integration.

VI. Suggested Reading

- Bartle RG. 1976. *Elements of Real Analysis*. John Wiley. Chatterjee SK. 1970. *Mathematical Analysis*. Oxford & IBH.
- Gibson GA. 1954. *Advanced Calculus*. Macmillan.
- Henrice P. 1964. *Elements of Numerical Analysis*. John Wiley.
- Hildebrand FB. 1956. *Introduction to Numerical Analysis*. Tata McGraw Hill.
- Priestley HA. 1985. *Complex Analysis*. Clarenton Press.
- Rudin W. 1985. *Principles of Mathematical Analysis*. McGraw Hill. Sauer T. 2006. *Numerical Analysis With CD-Rom*. Addison Wesley. Scarborough JB. 1976. *Numerical Mathematical Analysis*. Oxford & IBH. Stewart J. 2007. *Calculus*.Thompson.
- Thomas GB Jr. and Finney RL. 1996. *Calculus*. 9th Ed. Pearson Edu.

I. Course Title : Probability Theory

II. Course Code : STAT 552

III. Credit Hours : 2+0

IV. Aim of the course

This is a fundamental course in Statistics. This course lays the foundation of probability theory, random variable, probability distribution, mathematical expectation, etc. which forms the basis of basic statistics. The students are also exposed to law of large numbers and central limit theorem. The students also get introduced to stochastic processes.

V. Theory

Unit I

Basic concepts of probability. Elements of measure theory: class of sets, field, sigma field, minimal sigma field, Borel sigma field in R, measure- probability measure. Axiomatic approach to probability. Properties of probability based on axiomatic definition. Addition and multiplication theorems. Conditional probability and independence of events. Bayes theorem.

Unit II

Random variables: definition of random variable, discrete and continuous, functions of random variables. Probability mass function and Probability density function, Distribution function and its properties. Notion of bivariate random variables, bivariate distribution function and its properties. Joint, marginal and conditional distributions. Independence of random variables. Transformation of random variables (two dimensional caseonly). Mathematical expectation: Mathematical expectation of functions of a random variable. Raw and central moments and their relation, covariance, skewness and kurtosis. Addition and multiplication theorems of expectation. Definition of moment generating function, cumulating generating function, probability generating function and statements of their properties.

Unit III

Conditional expectation and conditional variance. Characteristic function and its properties. Inversion and uniqueness theorems. Chebyshev, Markov, Cauchy- Schwartz, Sequence of random variables and modes of convergence (convergence in distribution in probability, almost surely, and quadratic mean) and their interrelations.

Unit IV

Laws of large numbers: WLLN, Bernoulli and Kintchin's WLLN. Kolmogorov inequality, Kolmogorov's SLLNs.Central Limit theorems: Demoviere- Laplace CLT, Lindberg – Levy CLT and simple applications.

VI. Suggested Reading

- Ash RB. 2000. *Probability and Measure Theory*. 2nd Ed. Academic Press. Billingsley P. 1986. *Probability and Measure.* 2nd Ed. John Wiley.
- Capinski M and Zastawniah. 2001. *Probability Through Problems*. Springer. Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.
- Feller W. 1972. *An Introduction to Probability Theory and its Applications*. Vols. I., II. John Wiley.
- Loeve M. 1978. *Probability Theory*. 4th Ed. Springer.
- Marek C, Tomasz JZ. 2003. *Probability* Through Problems (Problem Books in Mathematics) Corrected Ed.
- Marek F. 1963. *Probability Theory and Mathematical Statistics*. John Wiley.
- Rohatgi VK & Saleh AK Md. E. 2005. *An Introduction to Probability and* Statistics. 2nd Ed. John Wiley.

I. Course Title : Statistical Methods

II. Course Code : STAT 553

III. Credit Hours : 2+1

IV. Aim of the course

This course lays the foundation of probability distributions and sampling distributions and their application which forms the basis of Statistical Inference. Together with probability theory, this course is fundamental to the discipline of Statistics. The students are also exposed to correlation and regression, and order statistics and their distributions. Categorical data analysis is also covered in this course.

V. Theory

Unit I

Descriptive statistics: probability distributions: Discrete probability distributions ~ Bernoulli, Binomial, Poisson, Negative-binomial, Geometric and Hyper Geometric, uniform, multinomial ~ Properties of these distributions and real life examples. Continuous probability distributions ~ rectangular, exponential, Cauchy, normal, gamma, beta of two kinds, Weibull, lognormal, logistic, Pareto. Properties of these distributions. Probability distributions of functions of random variables.

Unit II

Concepts of compound, truncated and mixture distributions (definitions and examples). Sampling distributions of sample mean and sample variance from Normal population, central and non–central chi-Square, *t* and *F* distributions, their properties and inter relationships.

Unit III

Concepts of random vectors, moments and their distributions. Bivariate Normal distribution - marginal and conditional distributions. Distribution of quadratic forms. Cochran theorem. Correlation, rank correlation, correlation ratio and intra-class correlation. Regression analysis, partial and multiple correlation andregression.

Unit IV

Sampling distribution of correlation coefficient, regression coefficient. Categorical data analysis, Association between attributes. Variance StabilizingTransformations.

Unit V

Order statistics, distribution of *r*-th order statistics, joint distribution of several order statistics and their functions, marginal distributions of order statistics.

VI. Practical

- Fitting of discrete distributions and test for goodness of fit;
- Fitting of continuous distributions and test for goodness of fit; Fitting of truncated distribution;
- Computation of simple, multiple and partial correlation coefficient, correlation ratio and intra-class correlation;
- Regression coefficients and regression equations;
- Fitting of Pearsonian curves;
- Analysis of association between attributes, categorical data and log-linear models.

VII. Suggested Reading

- Agresti, A. 2012. *Categorical Data Analysis* 3rd Ed. John Wiley.
- Arnold BC, Balakrishnan N and Nagaraja HN. 1992. *A First Course in Order Statistics*. JohnWiley.

- David HA and Nagaraja HN. 2003. *Order Statistics*. 3rd Ed. John Wiley.
- Dudewicz EJ and Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.
- Huber PJ. 1981. *Robust Statistics*. John Wiley.
- Johnson NL, Kotz S and Balakrishnan N. 2000. *Continuous Univariate Distributions*. JohnWiley.
- Johnson NL, Kotz S and Balakrishnan N. 2000. *Discrete Univariate Distributions*. JohnWiley.
- Marek F.1963. *Probability Theory and Mathematical Statistics*. John Wiley.
- Rao CR. 1965. *Linear Statistical Inference and its Applications*. John Wiley.
- Rohatgi VK and Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.
- Gupta. S.P 2008. *Statistical Methods*. Sultan Chand & sons Educational Publisher

I. Course Title : Actuarial Statistics

II. Course Code : STAT 554

III. Credit Hours : 2+0

IV. Aim of the course

This course is meant to expose to the students to the statistical techniques such as probability models, life tables, insurance and annuities. The students would also be exposed top practical applications of these techniques in computation of premiums that include expenses, general expenses, types of expenses and per policy expenses.

V. Theory

Unit I

Insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

Unit II

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

Unit III

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Unit IV

Distribution of aggregate claims, compound Poisson distribution and its applications.

Unit V

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

Unit VI

Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions.

Unit VII

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

Unit VIII

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

Unit IX

Some practical considerations: Premiums that include expenses-general expenses

types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

VI. Suggested Reading

- Atkinson ME and Dickson DCM. 2000. *An Introduction to Actuarial Studies*. Elgar Publ.
- Bedford T and Cooke R. 2001. *Probabilistic Risk Analysis*. Cambridge.
- Booth PM, Chadburn RG, Cooper DR, Haberman, S and James DE.1999. Modern *Actuarial Theory and Practice*. Chapman & Hall.
- Borowiak Dale S. 2003. *Financial and Actuarial Statistics: An Introduction*. Marcel Dekker.
- Bowers NL, Gerber HU, Hickman JC, Jones DA and Nesbitt CJ.1997. *Actuarial Mathematics*. 2nd Ed. Society of Actuaries, Ithaca, Illinois.
- Dale SB, Arnold FS. 2013. *Financial and Actuarial Statistics: An Introduction*, 2nd Ed. (Statistics: A Series of Textbooks and Monogrphs)
- Daykin CD, Pentikainen T and Pesonen M. 1994. *Practical Risk Theory for Actuaries*. Chapman & Hall.
- Klugman SA, Panjer HH, Willmotand GE and Venter GG. 1998. *Loss Models: From data to Decisions*. John Wiley.
- Medina PK and Merino S. 2003. *Mathematical Finance and Probability: A Discrete Introduction*. Basel, Birkhauser.
- Melnikov, A. 2011. *Risk Analysis in Finance and Insurance* (Chapman & Hall/Crc Financial Mathematics Series) 2nd Ed.
- Neill A. 1977. *Life Contingencies*. Butterworth-Heinemann.
- Rolski T, Schmidli H, Schmidt V and Teugels J. 1998. *Stochastic Processes for Insurance and Finance*. John Wiley.
- Rotar VI. 2006. *Actuarial Models. The Mathematics of Insurance. Chapman*& Hall/CRC.
- Spurgeon ET. 1972. *Life Contingencies*. Cambridge Univ. Press.

I. Course Title : Bioinformatics

II. Course Code : STAT 555

III. Credit Hours : 2+0

IV. Aim of the course

Bioinformatics is a new emerging area. It is an integration of Statistics, Computer applications and Biology. The trained manpower in the area of Bioinformatics is required for meeting the new challenges in teaching and research in the discipline of Agricultural Sciences. This course is meant to train the students on concepts of basic biology, statistical techniques and computational techniques for understanding bioinformatics principals.

V. Theory

Unit I

Basic Biology: Cell, genes, gene structures, gene expression and regulation, Molecular tools, nucleotides, nucleic acids, markers, proteins and enzymes, bioenergetics, single nucleotide polymorphism, expressed sequence tag. Structural and functional genomics: Organization and structure of genomes, genome mapping, assembling of physical maps, strategies and techniques for genome sequencing and analysis.

Unit II

Computing techniques: OS and Programming Languages – *Linux, perl, bioperl,python, biopython,cgi, MySQL, phpMyAdmin*; Coding for browsing biological databases on web, parsing & annotation of genomic sequences; Database designing; Computer networks – Internet, World wide web, Web browsers– EMBnet, NCBI; Databases on public domain pertaining to Nucleic acid sequences, protein sequences, SNPs, etc.; Searching sequence databases, Structural databases.

Unit III

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack-knifing; Hidden Markov Models; Bayesian estimation and Gibbs sampling;

Unit IV

Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis, Approaches to EST analysis; Pairwise alignment techniques: Comparing two sequences, PAM and BLOSUM, Global alignment (The Needleman and Wunsch algorithm), Local Alignment (The Smith-Waterman algorithm), Dynamic programming, Pairwise database searching; Sequence analysis– BLAST and other related tools, Multiple alignment and database search using motif models, ClustalW, Phylogeny; Databases on SNPs; EM algorithm and other methods to discover common motifs in biosequences; Gene prediction based on Neural Networks, Genetic algorithms, Computational analysis of protein sequence, structure and function; Design and Analysis of microarray/ RNAseqexperiments.

VI. Suggested Reading

- Baldi P. and Brunak S. 2001. *Bioinformatics: The Machine Learning Approach*. 2nd Ed. (Adaptive Computation and Machine Learning). MIT Press.
- Baxevanis A.D. and Francis B.F. (Eds.). 2004. *Bioinformatics: A Practical Guide to the enes and Proteins*. John Wiley.

- Bergeron B.P. 2002. *Bioinformatics Computing*. Prentice Hall.
- Duda R.O, Hart P.E and Stork D.G. 1999. *Pattern Classification*. John Wiley.
- Ewens W.J and Grant G.R. 2001. *Statistical Methods in Bioinformatics: An Introduction* (*Statistics for Biology and Health*). Springer.
- Graham B. Zweig, J. Buffett, WE. 2006.*The Intelligent Investor: The Definitive Book on Value Investing*. A Book of Practical Counsel, Revised Edition
- Hunt S and Livesy F. (Eds.). 2000. *Functional Genomics: A Practical Approach* (*The Practical Approach Series, 235*). Oxford Univ. Press.
- Jones N.C. and Pevzner P.A. 2004. *An Introduction to Bioinformatics Algorithims*. MIT Press.
- Koski T and Koskinen T. 2001. *Hidden Markov Models for Bioinformatics*. Kluwer.
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- Krawetz S.A and Womble D.D. 2003. *Introduction to Bioinformatics: A Theoretical and Practical Approach*. Humana Press.
- Lesk A.M. 2002. *Introduction to Bio-informatics*. Oxford Univ. Press.
- Percus J.K. 2001. *Mathematics of Genome Analysis*. Cambridge Univ. Press.
- Sorensen D and Gianola D. 2002. *Likelihood, Bayesian and MCMC Methods in Genetics*. Springer.
- Tisdall J.D. 2001. *Mastering Perl for Bioinformatics*. O'Reilly & Associates.
- Wang J.T.L., Zaki M.J., Toivonen H.T.T. and Shasha D. 2004. *Data Mining in Bioinformatics*. Springer.
- Wu C.H. and McLarty J.W. 2000. *Neural Networks and Genome Informatics*. Elsevier.
- Wunschiers R. 2004. *Computational Biology Unix/Linux, Data Processing and Programming*. Springer.

I. Course Title : Econometrics

II. Course Code : STAT 556

III. Credit Hours : 2+0

IV. Aim of the course

This course is meant for training the students in econometric methods and their applications in agriculture. This course would enable the students in understanding the economic phenomena through statistical tools and economics principles.

V. Theory

Unit I

Representation of Economic phenomenon, relationship among economic variables, linear and non-linear economic models, single equation general linear regression model, basic assumptions, Ordinary least squares method of estimation for simple and multiple regression models; summary statistics correlation matrix, co-efficient of multiple determination, standard errors of estimated parameters, tests of significance and confidence interval estimation. BLUE properties of Least Squares estimates. Chow test, test of improvement of fit through additional regressors. Maximum likelihood estimation.

Unit II

Heteroscedasticity, Auto-correlation, Durbin Watson test, Multi-collinearity. Stochastic regressors, Errors in variables, Use of instrumental variables in regression analysis. Dummy Variables. Distributed Lag models: Koyck's Geometric Lag scheme, Adaptive Expectation and Partial Adjustment Mode, Rational Expectation Models and test for rationality.

Unit III

Simultaneous equation model: Basic rationale, Consequences of simultaneous relations, Identification problem, Conditions of Identification, Indirect Least Squares, Two-stage least squares, K-class estimators, Limited Information and Full Information Maximum Likelihood Methods, three stage least squares, Generalized least squares, Recursive models, SURE Models. Mixed Estimation Methods, use of instrumental variables, pooling of cross-section and time series data, Principal Component Methods.

Unit IV

Problem and Construction of index numbers and their tests; fixed and chain based index numbers; Construction of cost of living index number.

Unit V

Demand analysis – Demand and Supply Curves; Determination of demand curves from market data. Engel's Law and the Engel's Curves, Income distribution and method of its estimation, Pareto's Curve, Income inequality measures.

VI. Suggested Reading

- Croxton F.E. and Cowden D.J. 1979. *Applied General Statistics*. Prentice Hall of India.
- James H.S. and Mark W.W. 2017. Introduction to Econometrics, 3rd Ed. John Wiley
- Johnston J. 1984. *Econometric Methods*. McGraw Hill.
- Judge G.C., Hill R.C., Griffiths W.E., Lutkepohl H and Lee T.C. 1988. *Introduction to the Theory and Practice of Econometrics*. 2nd Ed. John Wiley.
- Kmenta J. 1986. *Elements of Econometrics*. 2nd Ed. University of Michigan Press.
- Koop G. 2007. *Introduction to Econometrics*. John Wiley.
- Maddala G.S. 2001. *Introduction to Econometrics*. 3rd Ed. John Wiley.
- Pindyck R.S. and Rubinfeld D.L. 1998. *Econometric Models and Economic Forecasts*. 4th Ed. McGraw Hill.
- Verbeek M. 2008. *A Guide to Modern Econometrics*. 3rd Ed. John Wiley.

I. Course Title : Mathematics-II

II. Course Code : STAT 561

III. Credit Hours : 2+0

IV. Aim of the course

This is another course that supports all other courses in Agricultural Statistics. The students would be exposed to the advances in Linear Algebra and Matrix theory. This would prepare them to study their main courses that involve knowledge of Linear Algebra and Matrix Algebra.

V. Theory

Unit I

Linear Algebra: Group, ring, field and vector spaces, Sub-spaces, basis, Gram Schmidt's orthogonalization, Galois field - Fermat's theorem and primitive elements. Linear transformations. Graph theory: Concepts and applications.

Unit II

Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form. Determinants, Trace of matrices rank and inverse of matrices. Special matrices – idempotent, symmetric, orthogonal. Eigen values and eigen vectors, Spectral decomposition of matrices.

Unit III

Unitary, Similar, Hadamard, Circulant, Helmert's matrices. Kronecker and Hadamard product of matrices, Kronecker sum of matrices. Sub-matrices and partitioned matrices, Permutation matrices, full rank factorization, Grammian root of a symmetric s olutions.

Unit IV

Generalized inverses, Moore-Penrose inverse, Applications of g-inverse. Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of vectors and matrices, Quadratic forms.

VI. Suggested Reading

- Aschbacher M. 2000. *Finite Group Theory*. Cambridge University Press.
- Deo N. 1984. *Graph Theory with Application to Engineering and Computer Science*. Prentice Hall of India.
- Gentle JE. 2007. *Matrix Algebra: Theory, Computations and Applications in Statistics*. Springer.
- Graybill FE.1961. *Introduction to Matrices with Applications in Statistics*. Wadsworth Publ.
- Hadley G. 1969. *Linear Algebra*. Addison Wesley.
- Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.
- Rao CR. 1965. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.
- Robinson DJS. 1991. *A Course in Linear Algebra with Applications*. World Scientific.
- Searle SR. 2006. *Matrix Algebra Useful for Statistics* John Wiley, 2nd Ed.
- Seber GAF. 2008. *A Matrix Handbook for Statisticians*. John Wiley.

I. Course Title : Statistical Inference

II. Course Code : STAT 562

III. Credit Hours : 2+1

IV. Aim of the course

This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testing of hypothesis. They would also be given the concepts of nonparametric and sequential test procedures and elements of decision theory.

V. Theory

Unit I

Concepts of point estimation: unbiasedness, consistency, efficiency and sufficiency. Statement of Neyman's Factorization theorem with applications. MVUE, Rao-Blackwell theorem, completeness, Lehmann- Scheffe theorem. Fisher information, Cramer-Rao lower bound and its applications.

Unit II

Moments, minimum chi-square, least square and maximum likelihood methods of estimation and theirproperties.Interval estimation-Confidence level, shortest length CI. CI for the parameters of Normal,distributions.Exponential, Binomial and Poisson

Unit III

Fundamentals of hypothesis testing-statistical hypothesis, statistical test, critical region, types of errors, test function, randomized and non- randomized tests, level of significance, power function, most powerful tests: Neyman-Pearson fundamental lemma, MLR families and UMP tests for one parameter exponential families. Concepts of consistency, unbiasedness and invariance of tests. Likelihood Ratio tests, asymptotic properties of LR tests with applications (including homogeneity of means and variances).Relation between confidence interval estimation and testing of hypothesis.

Unit IV

Sequential Probability ratio test, Properties of SPRT.Termination property of SPRT, SPRT for Binomial, Poisson, Normal and Exponential distributions. Concepts of loss, risk and decision functions, admissible and optimal decision functions, estimation and testing viewed as decision problems, conjugate families, Bayes and Minimax decision functions with applications to estimation with quadratic loss.

Unit V

Non-parametric tests: Sign test, Wilcoxon signed rank test, Runs test for randomness, Kolmogorov – Smirnov test for goodness of fit, Median test and Wilcoxon-Mann-Whitney U-test. Chi-square test for goodness of fit and test for independence of attributes. Spearman's rank correlation and Kendall's Tau testsfor independence.

VI. Practical

- Methods of estimation - Maximum Likelihood, Minimum c^2 and Moments;
- Confidence Interval Estimation;
- MP and UMP tests;
- Large Sample tests;
- Non-parametric tests, Sequential Probability Ratio Test;
- Decision functions.

VII. Suggested Reading

- Box G.E.P. and Tiao G.C. 1992. *Bayesian Inference in Statistical Analysis*.John Wiley.

- Casela G and Berger R.L. 2001. *Statistical Inference*. DuXbury Thompson Learning.
- Christensen R. 1990. *Log Linear Models*. Springer.
- Conover W.J. 1980. *Practical Nonparametric Statistics*. John Wiley.
- Dudewicz EJ and Mishra SN. 1988. *Modern Mathematical Statistics*. JohnWiley.
- Gibbons J.D. 1985. *Non Parametric Statistical Inference*. 2nd Ed. Marcel Dekker.
- Kiefer J.C. 1987. *Introduction to Statistical Inference*. Springer.
- Lehmann EL. 1986. *Testing Statistical Hypotheses*. John Wiley.
- Lehmann EL. 1986. *Theory of Point Estimation*. John Wiley.
- Randles R.H and Wolfe D.S. 1979. *Introduction to the Theory of Nonparametric Statistics*. John Wiley.
- Rao C.R. 2009. *Linear Statistical Inference and Its Applications*, 3rdEd. John Wiley.
- Rohatgi V.K. and Saleh A.K. Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.
- Rohtagi V.K. 1984. *Statistical Inference*. John Wiley
- Sidney S and Castellan N.J. Jr. 1988. *Non Parametric Statistical Methods for Behavioral Sciences*. McGraw Hill.
- Wald A. 2004. *Sequential Analysis*. Dover Publ.
- Michael J.Panik. 2012. *Statistical Inference*. A John Wiley & Sons, INC, publication

I. Course Title : Design of Experiments

II. Course Code : STAT 563

III. Credit Hours : 2+1

IV. Aim of the course

Design of Experiments provides the statistical tools to get maximum information from least amount of resources. This course is meant to expose the students to the basic principles of design of experiments. The students would also be provided with mathematical background of various basic designs involving one-way and two-way elimination of heterogeneity and their characterization properties. This course would also prepare the students in deriving the expressions for analysis of experimental data.

V. Theory

Unit I

Elements of linear estimation, Gauss Markoff Theorem, relationship between BLUEs and linear zero-functions. Aitken's transformation, test of hypothesis, Analysis of Variance, Partitioning of degrees of freedom.

Unit II

Orthogonality, contrasts, mutually orthogonal contrasts, analysis of covariance; Basic principles of design of experiments, uniformity trials, size and shape of plots andblocks, Randomization procedure.

Unit III

Basic designs - completely randomized design, randomized complete block design and Latin square design; Construction of orthogonal Latin squares, mutually orthogonal Latin squares (MOLS), Youden square designs, Graeco Latin squares.

Unit IV

Balanced Incomplete Block (BIB) designs – general properties and analysis without and with recovery of intra block information, construction of BIB designs. Partially balanced incomplete block designs with two associate classes - properties, analysis and construction, Lattice designs, alpha designs, cyclic designs, augmented designs.

Unit V

Factorial experiments, confounding in symmetrical factorial experiments ($2^n$and 3^nseries), partial and total confounding, asymmetrical factorials.

Unit VI

Cross-over designs. Missing plot technique; Split plot and Strip plot design; Groups of experiments.Sampling in field experiments.

VI. Practical

- Determination of size and shape of plots and blocks from uniformity trials data;
- Analysis of data generated from completely randomized design, randomized complete block design;
- Latin square design, Youden square design; Analysis of data generated from a BIB design, lattice design, PBIB designs;
- 2^n, 3^n factorial experiments without and with confounding;
- Split and strip plot designs, repeated measurement design;
- Missing plot techniques,

- Analysis of covariance;
- Analysis of Groups of eXperiments,
- Analysis of clinical trial eXperiments.

VII. Suggested Reading

- Chakrabarti M.C. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publ.House.
- Cochran W.G. and CoX D.R. 1957. *Experimental Designs*. 2nd Ed. John Wiley.
- Dean A.M. and Voss D. 1999. *Design and Analysis of Experiments*. Springer.
- Dey A and Mukerjee R. 1999. *Fractional Factorial Plans*. John Wiley.
- Dey A 1986. *Theory of Block Designs*. Wiley Eastern. Hall M Jr. 1986. *Combinatorial Theory*. John Wiley.
- John J.A. and Quenouille M.H. 1977. *Experiments: Design and Analysis*. Charles & Griffin.
- Kempthorne, O. 1976. Design and Analysis of EXperiments. John Wiley. Khuri AI & Cornell JA. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.
- Kshirsagar A.M. 1983. *A Course in Linear Models*. Marcel Dekker.
- Montgomery D.C. 2013. *Design and Analysis of Experiments*. John Wiley & Sons
- Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*. John Wiley.
- Searle S.R. 2006. *Linear Models*. John Wiley.
- Street A.P. and Street D.J. 1987. *Combinatorics of Experimental Designs*. OXford Science Publ.
- Design Resources Server. *Indian Agricultural Statistics Research Institute (ICAR), New Delhi-110 012, India*. Hyperlink “http: //www.iasri.res.in/design” www.drs.icar.gov.in.

I. Course Title : Sampling Techniques

II. Course Code : STAT 564

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant to expose the students to the techniques of drawing representative samples from various populations and then preparing them on the mathematical formulations of estimating the population parameters based on the sample data. The students would also be exposed to the real life applications of sampling techniques and estimation of parameters.

V. Theory

Unit I

Sample survey vs complete enumeration, probability sampling, sample space, sampling design, sampling strategy; Determination of sample size; Confidence-interval; Simple random sampling, Estimation of population proportion, Stratified random sampling, Proportional allocation and optimal allocation, Inverse sampling.

Unit II

Ratio, Product and regression methods of estimation, Cluster sampling, Systematic sampling, Multistage sampling with equal probability, Separate and combined ratio estimator, Double sampling, Successive sampling –two occasions. Unbiased ratio type estimators

Unit III

Non-sampling errors – sources and classification, Non-response in surveys, Randomized response techniques, Response errors/ Measurement error – interpenetrating sub-sampling.

Unit IV

PPS Sampling with and without replacement, Cumulative method and Lahiri's method of selection, Horvitz-Thompson estimator, Ordered and unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran. Inclusion probability proportional to size sampling.

VI. Practical

- Determination of sample size and selection of sample;
- Simple random sampling, Inverse sampling, Stratified random sampling, Cluster sampling, systematic sampling;
- Ratio and regression methods of estimation;
- Double sampling, multi-stage sampling, Imputation methods;
- Randomized response techniques;
- Sampling with varying probabilities.

VII. Suggested Reading

- Cassel C.M., Sarndal C.E. and Wretman J.H. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.
- Chaudhari A and Stenger H. 2005. *Survey Sampling Theory and Methods*. 2nd Ed. Chapman & Hall.
- Chaudhari A and Voss J.W.E. 1988. *Unified Theory and Strategies of Survey Sampling*. North Holland.
- Cochran W.G. 1977. *Sampling Techniques*. John Wiley.
- Hedayat A.S. and Sinha B.K. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.
- Kish L. 1965. *Survey Sampling*. John Wiley.
- Mukhopadhyay, P. 2008.

- *Theory and Methods of Survey Sampling*, John Wiley & Sons
- Murthy M.N. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Society, Calcutta.
- Sukhatme P.V., Sukhatme B.V., Sukhatme S and Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Thompson SK. 2000. *Sampling*. John Wiley.
- Kochran WG. 2007. *Sampling Techniques*. A John Wiley & Sons *Publication*

I. Course Title : Statistical Genetics

II. Course Code : STAT 565

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant to prepare the students in applications of statistics in quantitative genetics and breeding. The students would be exposed to the physical basis of inheritance, detection and estimation of linkage, estimation of genetic parameters and development of selection indices.

V. Theory

Unit I

Physical basis of inheritance. Analysis of segregation, detection and estimation of linkage for qualitative characters. Amount of information about linkage, combined estimation, disturbed segregation.

Unit II

Gene and genotypic frequencies, Random mating and Hardy -Weinberg law, Application and extension of the equilibrium law, Fisher's fundamental theorem of natural selection. Disequilibrium due to linkage for two pairs of genes, sex-linked genes, Theory of path coefficients.

Unit III

Concepts of inbreeding, Regular system of inbreeding. Forces affecting gene frequency - selection, mutation and migration, equilibrium between forces in large populations, Random genetic drift, Effect of finite populationsize.

Unit IV

Polygenic system for quantitative characters, concepts of breeding value and dominance deviation. Genetic variance and its partitioning, Effect of inbreeding on quantitative characters, Multipleallelism in continuous variation, Sex-linked genes, Maternal effects - estimation of their contribution.

Unit V

Correlations between relatives, Heritability, Repeatability and Genetic correlation. Response due to selection, Selection index and its applications in plants and animals' improvement programmes, Correlated response to selection.

Unit VI

Restricted selection index. Variance component approach and linear regression approach for the analysis of GE interactions. Measurement of stability and adaptability for genotypes. Concepts of general and specific combining ability. Diallel and partial diallel crosses - construction and analysis.

VI. Practical

- Test for the single factor segregation ratios, homogeneity of the families with regard to single factor segregation;
- Detection and estimation of linkage parameter by different procedures;
- Estimation of genotypic and gene frequency from a given data.
- Hardy-Weinberg law;
- Estimation of changes in gene frequency due to systematic forces, inbreeding coefficient, genetic components of variation, heritability and repeatability coefficient, genetic correlation coefficient;
- Examination of effect of linkage, epistasis and inbreeding on mean and variance of metric traits;

- Mating designs;
- Construction of selection index including phenotypic index, restricted selection index. Correlated response to selection.

VII. Suggested Reading

- Agarwal BL and Agarwal SP. 2007. *Statistical Analysis of Quantitative Genetics*. New Age International Publisher.
- Bailey NTJ. 1961. *The Mathematical Theory of Genetic Linkage*.Clarendon Press.
- Balding DJ, Bishop M and Cannings C. 2001. *Hand Book of Statistical Genetics*. John Wiley.
- Crow JF and Kimura M. 1970. *An Introduction of Population Genetics Theory*. Harper and Row.
- Dahlberg G. 1948. *Mathematical Methods for Population Genetics*. Inter Science Publ.
- East EM and Jones DF. 1919. *Inbreeding and Outbreeding*.
- Lippincott JB & Co. Ewens WJ. 1979. *Mathematics of Population Genetics*. Springer.
  Falconer DS. 1985. *Introduction to Quantitative Genetics*. ELBL.

- Fisher RA. 1949. *The Theory of Inbreeding*. Oliver & Boyd.
- Fisher RA. 1950. *Statistical Methods for Research Workers*. *Oliver*& Boyd.
- Fisher RA. 1958. *The Genetical Theory of Natural Selection*. *Dover* Publ.
- Kempthorne O. 1957. *An Introduction to Genetic Statistics*. The Iowa State Univ. Press.
- Lerner IM. 1950. *Population Genetics and Animal Improvement*.Cambridge Univ. Press.
- Lerner IM. 1954. *Genetic Homeostasis*. Oliver & Boyd.
- Lerner IM. 1958. *The Genetic Theory of Selection*. John Wiley.
- Li CC. 1982. *Population Genetics*. The University of Chicago Press.
- K & Jinks JL. 1977. *Introduction to Biometrical Genetics*.Chapman & Hall.
- Mather K and Jinks JL. 1982. *Biometrical Genetics*. Chapman & Hall.
- Mather K. 1949. *Biometrical Genetics*. Methuen.
- Mather K. 1951. *The Measurement of Linkage in Heredity*.
- Methuen. N. P. 1990. *Statistical Genetics*. Wiley Eastern.

I. Course Title : Statistical Quality Control

II. Course Code : STAT 566

III. Credit Hours : 2+0

IV. Aim of the course

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agribusiness and agro- processing industries. This course would enable the students to have an idea about the statistical techniques used in quality control. Students who do not have sufficient background of Statistical Methods.

V. Theory

Unit I

Introduction to Statistical Quality Control; Control Charts for Variables – Mean, Standard deviation and Range charts; Statistical basis; Rational subgroups.

Unit II

Control charts for attributes- 'np', 'p' and 'c' charts.

Unit III

Fundamental concepts of acceptance, sampling plans, single, double and sequential sampling plans for attributes inspection.

Unit IV

Sampling inspection tables for selection of single and double sampling plans.

VI. Suggested Reading

- Cowden D.J. 1957. *Statistical Methods in Quality Control*. Prentice Hall of India.
- Dodge H.F. and Romig H.G. 1959. *Sampling Inspection Tables.* John Wiley.
- Duncan A.J. 1986. *Quality Control and Industrial Statistics*. 5th Ed. Irwin Book Co.
- Grant E.L. and Leavenworth R.S. 1996. *Statistical Quality Control*. 7th Ed. McGraw Hill.
- Montgomery D.C. 2008. *Introduction to Statistical Quality Control.* 6th Ed. John Wiley.
- Wetherhil G.B. 1977. *Sampling Inspection and Quality Control.* Halsted Press.

I. Course Title : Optimization Techniques

II. Course Code : STAT 567

III. Credit Hours : 1+1

IV. Aim of the course

This course is meant for exposing the students to the mathematical details of the techniques optimization techniques. They will be taught numerical methods of optimization, linear programming techniques, nonlinear programming and multiple objective programming. Students will also be exposed to practical applications of these techniques.

V. Theory

Unit I

Classification of optimization problems, Classical optimization techniques: single variable optimization, multivariable optimization techniques with no constraints, multivariable optimization techniques with equality constraints, multivariable optimization techniques with inequality constraints.

Unit II

Linear programming: simplex method, duality, sensitivity analysis, Karmarkar's method, transportation problem.

Unit III

Nonlinear programming Unconstrained optimization techniques: direct search methods such as random search, grid search, Hooke and Jeeves' method, Powel's method. Descent methods such as gradient method, steepest descent method, conjugate gradient method, Newton's method, Marquardt method.

Unit IV

Quadratic programming, integer linear programming, integer nonlinear programming, geometric programming, dynamic programming, stochastic programming, multiobjective optimization, optimal control theory, genetic algorithms, simulated annealing, neural network based optimization,

VI. Practical

- Problems based on classical optimization techniques, optimization techniques with constraints, minimization problems using numerical methods.
- Linear programming (LP) problems through graphical method, simplex method, simplex two-phase method, primal and dual method.
- Sensitivity analysis for LP problem, LP problem using Karmarkar's method.
- Problems based on Quadratic programming, integer programming, dynamic programming, stochastic programming.
- Problems based on Pontryagin's maximum principle.
- Problems based on multiobjective optimization.

VII. Suggested Reading

- Antunes C.H., Alves, M.J., Climaco J. 2016. *Multi objective Linear and Integer Programming* (EURO Advanced Tutorials on Operational Research)
- Nocedal, J. and Wright, S.J. 1999. *Numerical Optimization*. Springer.
- Rao, S.S. 2007. *Engineering Optimization: Theory and Practice.* New Age International Publishers.
- Rustagi, J.S. 1994. *Optimization Techniques in Statistics*. Academic Press.
- Taha, H.A. 2007. *Operations Research: Introduction with CD.* Pearson Education.
- Xu, H, Teo, K.L. Zhang Y. 2016. *Optimization and Control Techniques and Applications* (Springer Proceedings in Mathematics & Statistics)
- Zeleny, M. 1974. *Linear Multi objective Programming*. Springer

I. Course Title : Multivariate Analysis

II. Course Code : STAT 571

III. Credit Hours : 2+1

IV. Aim of the course

This course lays the foundation of Multivariate data analysis. Most of the data sets in agricultural sciences are multivariate in nature. The exposure provided to multivariate data structure, multinomial and multivariate normal distribution, estimation and testing of parameters, various data reduction methods would help the students in having a better understanding of agricultural research data, itspresentation and analysis.

V. Theory

Unit I

Concept of random vector, its expectation and Variance-Covariance matrix. Marginal and joint distributions. Conditional distributions and Independence of random vectors. Multinomial distribution. Multivariate Normal distribution, marginal and conditional distributions. Sample mean vector and its distribution. Maximum likelihood estimates of mean vector and dispersionabout mean matrix. Tests of hypothesis vector.

Unit II

Wishart distribution and its simple properties. Hotelling's T^2 and Mahalanobis D^2 statistics. Null distribution of Hotelling's T^2. Rao's U statistics and its distribution. Wilks' □ criterion and its properties. Concepts of discriminant analysis, computation of linear discriminant function, classification between *k* (□2) multivariate normal populations based on LDF and Mahalanobis D^2.

Unit III

Principal Component Analysis, factor analysis. Canonical variables and canonical correlations. Cluster analysis: similarities and dissimilarities of qualitative and quantitative characteristics, Hierarchical clustering. Single, Complete and Average linkage methods. K-means cluster analysis.

Unit IV

Path analysis and computation of path coefficients, introduction to multidimensional scaling, some theoretical results, similarities, metric and non-metric scaling methods.

VI. Practical

- Maximum likelihood estimates of mean-vector and dispersion matrix;
- Testing of hypothesis on mean vectors of multivariate normal populations;
- Cluster analysis, Discriminant function, Canonical correlation, Principal componentanalysis, Factor analysis;
- Multivariate analysis of variance and covariance, multidimensional scaling.

Suggested Reading

- Abdelmonem A, Virginia AC and Susanne M. 2004. *Computer Aided Multivariate Analysis*. Chapman & Hall/CRC.
- Anderson TW. 1984. *An Introduction to Multivariate Statistical Analysis*. 2nd Ed. John Wiley.
- Arnold SF. 1981. *The Theory of Linear Models and Multivariate Analysis*. John Wiley.
- Giri NC. 1977. *Multivariate Statistical Inference*. Academic Press.
- Johnson RA and Wichern DW. 1988. *Applied Multivariate Statistical Analysis*. Prentice Hall.
- Kshirsagar AM. 1972. *Multivariate Analysis*. Marcel Dekker.
- Muirhead RJ. 1982. *Aspects of Multivariate Statistical Theory*. John Wiley. Muirhead, RJ. (2005) *Aspects of Multivariate Statistical Theory*. 2nd Ed. John Wiley.
- Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.
- Rencher AC. 2012. *Methods of Multivariate Analysis*. 3rd Ed. John Wiley.
- Srivastava MS and Khatri CG. 1979. *An Introduction to Multivariate Statistics*. North Holland.

VII.

I. Course Title : Regression Analysis

II. Course Code : STAT 572

III. Credit Hours : 1+1

IV. Aim of the course

This course is meant to prepare the students in linear and non-linear regression methods useful for statistical data analysis. They would also be provided a mathematical foundation behind these techniques and their applications in agricultural data.

V. Theory

Unit I

Simple and Multiple linear regressions: Least squares fit, Properties and examples. Polynomial regression: Use of orthogonal polynomials.

Unit II

Assumptions of regression; diagnostics and transformations; residual analysis ~ Studentized residuals, applications of residuals in detecting outliers, identification of influential observations. Lack of fit, Pure error. Test of normality, test of linearity,Testing homoscedasticity and normality of errors, Durbin-Watson test. Test of goodness of fit for the model evaluation and validation.Concept of multi-collinearity

Unit III

Weighted least squares method: Properties, and examples. Box-Cox family of transformations. Use of dummy variables, Over fitting and under fitting of model, Selection of variables: Forward selection, Backward elimination. Stepwise and Stagewise regressions.

Unit IV

Introduction to non-linear models, nonlinear estimation: Least squares for nonlinear models.

VI. Practical

- Multiple regression fitting with three and four independent variables;
- Estimation of residuals, their applications in outlier detection, distribution of residuals;
- Test of homoscedasticity, and normality, Box-Cox transformation;
- Restricted estimation of parameters in the model, hypothesis testing, Step wise regression analysis;
- Least median of squares norm, Orthogonal polynomialfitting.

VII. Suggested Reading

- Barnett V and Lewis T. 1984. *Outliers in Statistical Data*. John Wiley.
- Belsley DA, Kuh E and Welsch RE. 2004. *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity*. John Wiley.
- Chatterjee S and Hadi AS. 2013. *Regression Analysis* by *Example*. A John Wiley & sons Publication.
- Draper NR and Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- McCullagh P and Nelder JA. 1999. *Generalized Linear Models*. 2nd Ed.*Chapman* & Hall.
- Montgomery DC, Peck EA and Vining GG. 2003. *Introduction to Linear Regression Analysis*. 3rd Ed. John Wiley.
- Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd*Ed*. John Wiley.

I. Course Title : Statistical Computing

II. Course Code : STAT 573

III. Credit Hours : 1+1

IV. Aim of the course

This course is meant for exposing the students in the concepts of computational techniques. Various statistical packages would be used for teaching the concepts of computational techniques.

V. Theory

Unit I

Introduction to statistical packages and computing: data types and structures, Use of Software packages like, SAS, SPSS or "R: The R Project for Statistical Computing". Data analysis principles and practice, Summarization and tabulation of data, Exploratory data analysis; Graphical representation of data.Statistical Distributions: Fitting and testing the goodness of fit of discrete and continuous probability distributions;

Unit II

ANOVA, regression and categorical data methods; model formulation, fitting, diagnostics and validation; Matrix computations in linear models. Analysis of discrete data. Multiple comparisons, Contrast analysis.

Unit III

Numerical linear algebra, numerical optimization, graphical techniques, numerical approximations, Time Series Analysis.

Unit IV

Analysis of mixed models; Estimation of variance components, Analysis of Covariance, Fitting of non-linear model, Discriminant function; Principal component analysis. techniques in the analysis of survival data and longitudinal studies, Approaches to handling missing data, and meta-analysis

VI. Practical

- Data management, Graphical representation of data, Descriptive statistics;
- General linear models ~ fitting and analysis of residuals, outlier detection;
- Fitting and testing the goodness of fit of probability distributions;
- Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test for large samples - Chi-squares test, F test, One way analysis of variance, contrast and its testing, pairwise comparisons;
- Mixed effect models, estimation of variance components;
- Categorical data analysis, dissimilarity measures, similarity measures;
- Analysis of discrete data, analysis of binary data;
- Numerical algorithms;
- Spatial modeling, cohort studies;
- Clinical trials, analysis of survival data;
- Handling missing data.Analysis of time series data - fitting of ARIMA models.

VII. Suggested Reading

- Agresti A. 2013. *Categorical Data Analysis*. 3rd Ed. John Wiley.
- Everitt BS and Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.
- Geisser S. 1993. *Predictive Inference: An Introduction*. Chapman & Hall.
- Gelman A & Hill J. 2006. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge Univ. Press.

- Gentle JE, Härdle W and Mori Y. 2012. *Handbook of Computational Statistics - Concepts and Methods*. 2nd Ed. Springer.
- Han J and Kamber M. 2000. *Data Mining: Concepts and Techniques*. Morgan.
- Hastie T, Tibshirani R and Friedman R. 2001. *The Elements of Statistical Learning: Data Mining, Inference and Prediction*. Springer.
- Kennedy WJ & Gentle JE. 1980. *Statistical Computing*. Marcel Dekker.
- Miller RG Jr. 1986. *Beyond ANOVA, Basics of Applied Statistics*. John Wiley.
- Rajaraman V. 1993. *Computer Oriented Numerical Methods*. Prentice-Hall.
- Ross S. 2000. *Introduction to Probability Models*. Academic Press.
- Ryan BF and Joiner BL. 1994. *MINITAB Handbook*. 3rd Ed. Duxbury Press.
- Simonoff JS. 1996. *Smoothing Methods in Statistics*. Springer.
- Singh, AK. 2016. *Practical R-Book by Examples for Agricultural Statistics*. Deptt. Of Ag. Statistics, IGKV. Raipur
- Snell EJ. 1987. *Applied Statistics: A Handbook of BMDP Analyses*. Chapman & Hall.
- Thisted RA. 1988. *Elements of Statistical Computing*. Chapman & Hall.
- Venables WN and Ripley BD. 1999. *Modern Applied Statistics With S-Plus*. 3rd Ed. Springer.
- http: //www.r-project.org/
- http: //www.stat.sc.edu/~grego/courses/stat706/.
- Design Resources Server: www.drs.icar.gov.in.

I. Course Title : Time Series Analysis

II. Course Code : STAT 574

III. Credit Hours : 1+1

IV. Aim of the course

This course is meant to teach the students the concepts involved in time series data. They would also be exposed to components of time series, stationary models and forecasting/ projecting the future scenarios based on time series data. It would also help them in understanding the concepts involved in time series data presentation, analysis and interpretation.

V. Theory

Unit I

Components of a time-series. Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis.

Unit II

Linear stationary models: Autoregressive, moving average and Mixed processes. Linear non-stationary models: Autoregressive integrated moving average processes.

Unit III

Forecasting: Minimum mean square forecasts and their properties, Calculating and updating forecasts.

Unit IV

Model identification: Objectives, Techniques, and Initial estimates. Model estimation: Likelihood function, Sum of squares function, Least squares estimates. Seasonal models. Intervention analysis models and Outlier detection.

VI. Practical

Time series analysis, autocorrelations, correlogram and periodogram; Linear stationary model; Linear non-stationary model; Model identification and model estimation; Intervention analysis and outlier detection.

VII. Suggested Reading

- Box GEP, Jenkins GM and Reinsel GC. 2007. *Time Series Analysis: Forecasting and Control.* 3rd Ed. Pearson Edu.
- Brockwell PJ and Davis RA. 2002. *Introduction to Time Series and Forecasting*. 2nd Ed. Springer.
- Chatterjee S, Hadi A and Price B.1999. *Regression* Analysis by Examples.John Wiley.
- Draper NR and Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- Jenkins, GM, Reinsel, GC, Greta M. L,George E.P.B. 2015. *Time Series Analysis: Forecasting and Control*, Wiley Series in Probability and Statistics
- Johnston J. 1984. *Econometric Methods*. McGraw Hill.
- Judge GG, Hill RC, Griffiths WE, Lutkepohl H and Lee TC. 1988. *Introduction to the Theory and Practice of Econometrics*. 2nd Ed. John Wiley.
- Montgomery DC and Johnson LA. 1976. *Forecasting and Time Series Analysis*. McGraw Hill.
- Montgomery DC, Jennings CA and Kulahci M. 2015. *Introduction to Time Series Analysis and Forecasting*, Wiley Series in Probability and Statistics
- Shumway RH and Stoffer DS. 2006. *Time Series Analysis and its Applications: With R Examples*. 2nd Ed. Springer.

I. Course Title : Demography

II. Course Code : STAT 575

III. Credit Hours : 2+0

IV. Aim of the course

This course is meant for training the students in measures of demographic indices, estimation procedures of demographic parameters. Students would also be exposed to population projection techniques and principle involved inbioassays.

V. Theory

Unit I

Introduction to vital statistics, crude and standard mortality and morbidity rates, Estimation of mortality, Measures of fertility and mortality, period and cohort measures.

Unit II

Life tables and their applications, methods of construction of abridged life tables, Increment-Decrement Life Tables.

Unit III

Stationary and stable populations, Migration and immigration. Application of stable population theory to estimate vital rates, migration and its estimation. Demographic relations in Nonstable populations. Measurement of population growth, Lotka's model (deterministic) and intrinsic rate of growth, Measures of mortality and morbidityPeriod.

Unit IV

Principle of biological assays, parallel line and slope ratio assays, choice of doses and efficiency in assays quantal responses, probit and logit transformations, epidemiological models.

VI. Suggested Reading

- Cox DR. 1957. *Demography*. Cambridge Univ. Press.
- Charles Griffin. Fleiss JL. 1981. *Statistical Methods for Rates and Proportions*. John Wiley.
- Finney DJ. 1981. *Statistical Methods in Biological Assays*.
- Grow A, Bavel JV. 2016. *Agent-Based Modelling in Population Studies: Concepts, Methods, and Applications* (The Springer Series on Demographic Methods and Population Analysis)
- Lawless JF. 1982. *Statistical Models and Methods for Lifetime Data*. John Wiley.
- MacMahon B and Pugh TF. 1970. *Epidemiology- Principles and Methods*.Little Brown, Boston.
- Mann NR, Schafer RE and Singpurwalla ND. 1974. *Methods for Statistical Analysis of Reliability and Life Data*. John Wiley.
- Newell C. 1988. *Methods and Models in Demography*. Guilford Publ.
- Preston S, Heuveline P and Guillot M. 2001. *Demography: Measuring and Modeling Population Processes*. Blackwell Publ.
- Rowland DT. 2004. *Demographic Methods and Concepts*. Oxford Press.
- Siegel JS and Swanson DA. 2004. *The Methods and Material ofDemography*. 2nd Ed. Elsevier.
- Woolson FR. 1987. *Statistical Methods for the Analysis of Biomedical Data*. JohnWiley.
- Yakovlev AY, Klebanov L and Gaile D. 2013. *Statistical Methods for Microarray Data Analysis: Methods and Protocols* (Methods in Molecular Biology)

I. Course Title : Statistical Methods for Life Sciences

II. Course Code : STAT 576

III. Credit Hours : 2+0

IV. Aim of the course

This course focuses on statistical methods for discrete data collected in public health, clinical and biological studies including survival analysis. This would enable the students to understand the principles of different statistical techniques useful in public health and clinical studies conducted.

V. Theory

Unit I

Proportions and counts, contingency tables, logistic regression models, Poisson regression and log-linear models, models for polytomous data and generalized linear models.

Unit II

Computing techniques, numerical methods, simulation and general implementation of biostatistical analysis techniques with emphasis on data applications. Analysis of survival time data using parametric and non- parametric models, hypothesis testing, and methods for analyzing censored (partially observed) data with covariates. Topics include marginal estimation of a survival function, estimation of a generalized multivariate linear regression model (allowing missing covariates and/or outcomes).

Unit III

Proportional Hazard model: Methods of estimation, estimation of survival functions, time-dependent covariates, estimation of a multiplicative intensity model (such as Cox proportional hazards model) and estimation of causal parameters assuming marginal structural models.

Unit IV

General theory for developing locally efficient estimators of the parameters of interest in censored data models. Rank tests with censored data. Computing techniques, numerical methods, simulation and general implementation of bio-statistical analysis techniques with emphasis on data applications.

Unit V

Newton, scoring, and EM algorithms for maximization; smoothing methods; bootstrapping; trees and neural networks; clustering; isotonic regression; Markov chain Monte Carlomethods.

VI. Suggested Reading

- Biswas S. 2007. *Applied Stochastic Processes. A Biostatistical and Population Oriented Approach*. Wiley Eastern Ltd.
- Collett D. 2003. *Modeling Survival Data in Medical Research*. Chapman & Hall.
- Cox D.R. and Oakes D. 1984. *Analysis of Survival Data*. Chapman & Hall.
- Hosmer DW Jr. and Lemeshow S. 1999. *Applied Survival Analysis: Regression Modeling or Time to Event*. John Wiley.
- Klein J.P. and Moeschberger M.L. 2003. *Survival Analysis: Techniques for Censored and Truncated Data*. Springer.
- Kleinbaum D.G. and Klein M 2005. *Survival Analysis. A Self Learning Text*. Springer.
- Kleinbaum D.G. and Klein M. 2005. *Logistic Regression*. 2nd Ed. Springer.
- Lee ET. 1992. *Statistical Methods for Survival Data Analysis*.
- John Wiley and Miller RG. 1981. *Survival Analysis*. John Wiley.
- Therneau T.M. and Grambsch P.M. 2000. *Modeling Survival Data: Extending the Cox Model*.Springer.

I. Course Title : Statistical Ecology

II. Course Code : STAT 577

III. Credit Hours : 2+0

IV. Aim of the course

This course is meant for exposing the students to the importance and use of statistical methods in collections of ecological data, species-abundance relations, community classification and community interpretation.

V. Theory

Unit I

Ecological data, Ecological sampling; Spatial pattern analysis: Distribution methods, Quadrant-variance methods, Distancemethods.

Unit II

Species-abundance relations: Distribution models, Diversity indices; Species affinity: Niche-overlap indices, interspecific association, interspecificcovariation.

Unit III

Community classification: Resemblance functions, Association analysis, Cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondence analysis, Nonlinear ordination.

Unit IV

Community interpretation: Classification Interpretation and Ordination Interpretation.

VI. Suggested Reading

- Gotelli N.J. and Ellison A.M. 2004. *A Primer of Ecological Statistics*
- Pielou E.C. 1970. *An introduction to Mathematical Ecology*. John Wiley.
- Reynolds J.F. and Ludwig J.A. 1988. *Statistical Ecology: A Primer on Methods and Computing*. JohnWiley.
- Young L.J., Young J.H. and Young J. 1998. *Statistical Ecology: A Population Perspective.* Kluwer.

Course Title with Credit load
Ph.D. in Agricultural Statistics

Course Code	Course Title	Credit Hours	Semester
*STAT 601	Advanced Data Analytics	1+2	I
*STAT 602	Simulation Techniques	1+1	I
*STAT 603	Linear Models	2+0	I
*STAT 604	Advanced Statistical Methods	2+1	I
*STAT 611	Baysian Inference	2+0	II
STAT 691	Seminar I	0+1	I
STAT 692	Seminar II	0+1	II
STAT 699	Research	0+75	II-VI
STAT 605	Modeling Techniques for Forecasting	2+1	I
STAT 606	Stochastic Processes	2+0	I
STAT 607	Survival Analysis	2+0	I
STAT 608	Spatial Statistics	1+1	I
STAT 612	Advanced Design of Experiments	2+1	II
STAT 613	Advanced Sampling Techniques	2+1	II
STAT 614	Advanced Statistical Genetics	2+1	II
STAT 615	Advanced Time Series Analysis	2+0	II
STAT 616	Advanced Bioinformatics	2+0	II
STAT 617	Advanced Econometrics	2+0	II
STAT 618	Recent Advances in the Field of Specialization	1+0	II

*Core Courses

Course Contents
Ph.D. in Agricultural Statistics

I. Course Title : Advanced Data Analytics

II. Course Code : STAT 601

III. Credit Hours : 1+2

IV. Aim of the course

This is an advanced course in Statistical Computing that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences and use of statistical packages.

V. Theory

Unit I

Measures of association. Structural models for discrete data in two or more dimensions.

Estimation in complete tables. Goodness of fit, choice of a model. Generalized Linear Model for discrete data, Poisson and Logistic regression models. Log-linearmodels.

Unit II

Elements of inference for cross-classification tables. Models for nominal and ordinal response.

Unit III

Computational problems and techniques for robust linear regression, nonlinear and generalized linear regression problem, tree-structured regression and classification, cluster analysis, smoothing and function estimation, robust multivariate analysis.

Unit IV

Analysis of incomplete data: EM algorithm, single and multiple imputations. Markov Chain, Monte Carlo and annealing techniques, Neural Networks, Association Rules and learning algorithms.

Unit V

Linear mixed effects models, generalized linear models for correlated data (including generalized estimating equations), computational issues and methods for fitting models, and dropout or other missing data.

Unit VI

Multivariate tests of linear hypotheses, multiple comparisons, confidence regions, prediction intervals, statistical power, transformations and diagnostics, growth curve models, dose-response models.

Practical

- Analysis of qualitative data;
- Generalized linear for correlated data;
- Generalized linear models for discrete data;
- Robust methods of estimation and testing of non-normal data;
- Robust multivariate analysis;

- Cluster analysis;
- Analysis of Incomplete data;
- Classification and prediction using artificial neural networks;
- Markov Chain;
- Analysis of data having random effects using Linear mixed effects models;
- Analysis of data with missing observations;
- Applications of multiple comparison procedures;
- Building Simultaneous confidence intervals;
- Fitting of growth curve models to growth data;
- Fitting of dose-response curves and estimation of parameters.

Suggested Reading

- Everitt B.S. and Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.
- Geisser S. 1993. *Predictive Inference: An Introduction*. Chapman & Hall.
- Gentle J.E., Härdle W and Mori Y. 2004. *Handbook of Computational Statistics-Concepts and Methods*. Springer.
- Han J and Kamber M. 2000. *Data Mining: Concepts and Techniques*. Morgan.
- Hastie T, Tibshirani R and Friedman R. 2017. *The Elements of Statistical Learning: Data Mining, Inference and Prediction*. Springer. 2nd Ed.
- Kennedy W.J. and Gentle J.E. 1980. *Statistical Computing*. Marcel Dekker.
- Miller R.G. Jr. 1986. *Beyond ANOVA, Basics of Applied Statistics*. John Wiley.
- Rajaraman V. 1993. *Computer Oriented Numerical Methods*. Prentice-Hall.
- Robert C.P. and Casella G. 2004. *Monte Carlo* Statistical *Methods*. 2nd Ed. Springer.
- Ross S. 2000. *Introduction to Probability Models*. Academic Press.
- Simonoff J.S. 1996. *Smoothing Methods in Statistics*. Springer.
- Thisted R.A. 1988. *Elements of Statistical Computing*. Chapman & Hall.
- Venables W.N. and Ripley B.D. 1999. *Modern Applied Statistics With S-Plus*. 3rd Ed. Springer.
- Free Statistical Softwares: http: //freestatistics.altervista.org/en/stat.php.
- Design Resources Server: www.drs.icar.gov.in.

I. Course Title : Simulation Techniques

II. Course Code : STAT 602

III. Credit Hours : 1+1

IV. Aim of the course

This course is meant for students who have a good knowledge in Statistical Inference and Statistical Computing. This course would prepare students for undertaking research in the area of simulation techniques andtheir applications to agricultural sciences.

V. Theory

Unit I

Uses and purposes of simulation; Classification of models. Generation and testing of random numbers, Review of simulation methods; Implementation of simulationmethods - for Discrete and continuous probability distribution, sampling and
resampling methods: theory and application of the jackknife and thebootstrap.

Unit II

Randomization tests, analysis using computer software packages. Simulating multivariate distributions, MCMC methods and Gibbs sampler.

Unit III

Simulation of generalized linear models and time series models, Simulated data sets to be analyzed using popular computer software packages.

Unit IV

Stochastic simulation: Markov Chain, Monte Carlo, Hastings-Metropolis algorithms, critical slowing-down and remedies, auxiliary variables, simulated tempering, reversible- jump MCMC and multi-grid methods.

VI. Practical

- Simulation from various probability models;
- Resampling methods, jackknife and the bootstrap;
- Randomization tests;
- Simulating multivariate distributions, MCMC methods and Gibbs sampler;
- Simulated data sets to be analyzed using popular computer software packages;
- Markov Chain, Monte Carlo, Gibbs' sampling;
- Reversible- jump MCMC and multi-grid methods.

VII. Suggested Reading

- Averill M.L. 2017. *Simulation, Modeling and Analysis*. Tata McGraw Hill.
- Balakrishnan N, Melas V.B. and Ermakov S. (Ed.). 2000. *Advances in Stochastic Simulation Methods*. Basel-Birkhauser.
- Banks J. (Ed.). 1998. *Handbook of Simulation: Principles, Methodology, Advances, Applications and Practice*. John Wiley.
- Brately P, Fox B.L. and Scharge L.E. 1987. *A Guide to Simulation*. Springer. Davison A.C. and Hinkley D.V. 2003. *Bootstrap Methods and their Application*. Cambridge Univ. Press.
- Gamerman D, Lopes H.F. and Lopes H.F. 2006. *Markov Chain* Monte *Carlo: Stochastic Simulation for Bayesian Inference*. CRC Press.
- Gardner F.M. and Baker J.D. 1997. *Simulation Techniques Set*. John Wiley. Gentle J.E. 2005. *Random Number Generation and Monte Carlo Methods*. Springer.
- Janacek G and Louise S. 1993. *Time Series: Forecasting, Simulation, Applications*. Ellis Horwood Series in Mathematics and its Applications.
- Kleijnen J and Groenendaal W.V. 1992. *Simulation: A Statistical Perspective*. John Wiley.
- Kleijnen J. 1974 (Part I), 1975 (Part II). *Statistical Techniques in Simulation*. Marcel Dekker.
- Law A and Kelton D. 2000. *Simulation Modeling and Analysis*. McGraw Hill.
- Press W.H., Flannery B.P., Tenkolsky S.A. and Vetterling W.T. 1986. *Numerical Recipes*. Cambridge Univ.Press.
- Ripley B.D. 1987. *Stochastic Simulation*. John Wiley. Ross SM. 1997. *Simulation*. John Wiley.

I. Course Title : Linear Models

II. Course Code : STAT 603

III. Credit Hours : 2+0

IV. Aim of the course

The students would be exposed to the theory of linear models, estimation of variance components for unbalanced data and advanced techniques for analysis of data in agriculture.

V. Theory

Unit I

General Gauss Markoff set up, Gauss-Markoff's theorem, Aitken's transformation. Theory of linear estimation, test of hypothesis in linear models. Analysis of variance, partitioning of degrees of freedom. Restricted least squares. Special cases of one and two way classifications (including disproportionate cell frequencies and interaction, cross and nested classifications).

Unit II

Analysis of covariance. Variance components models, estimation of variance components from unbalanced data. Unified theory of least-squares, MINQUE, MIVQUE. Mixed models. LAR, LASSO.

VI. Suggested Reading

- Bapat, R.B. 2012. *Linear Algebra and Linear Models*. Springer-Verlag.
- Graybill, F. A. 1976. *Theory and Application of the Linear Model.* Duxbury, North Scituate.
- Joshi, D.D. 1987. *Linear Estimation and Design of Experiments*. Wiley Eastern.
- Rao, C. R. 2001. *Linear Inference and its Application*. Wiley Eastern.
- Searle, S. R. 1998. *Variance Components.* John Wiley.
- Searle, S.R. 1971. *Linear Models.* John Wiley.
- Seber, G.A. F. 1996. *The Linear Hypothesis: A General Theory*. Griffin, Charles and Co. Ltd.
- Sheffe, H. 1999. *Analysis of Variance.* John Wiley.

I. Course Title : Advanced Statistical Methods

II. Course Code : STAT 604

III. Credit Hours : 2+1

IV. Aim of the course

This is an advanced course in Statistical Methods that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agriculturalsciences.

V. Theory

Unit I

Truncated and compound distributions. Fitting of orthogonal polynomials. Pearsonian curves.Categorical data analysis - loglinear models, Association between attributes. Variance stabilizingtransformations.

Unit II

Sampling distribution of correlation coefficient, regression coefficient, correlation ratio, intra class correlation coefficient.

Unit III

Non-central t, χ^2 and F distributions. Distribution of quadratic forms. Cochran's theorem. Tests for normality. Large sample tests. Tests of significance based on t, χ^2 and F distributions. Order statistics, distribution of r^{th} order statistics, joint distribution of several order statistics andtheir functions, marginal distributions of order statistics, distribution of range, median, etc.

Unit IV

Fitting of a generalized linear model, mixed model and variance components estimation, MINQUE, MIVQUE, REML.

VI. Practical

- Fitting of truncated distribution,
- Fitting of Pearsonian curves,

- Analysis of association between attributes, categorical data.
- Fitting of non-central t, χ^2 and F distributions.
- Computation of Tests of significance based on t, χ^2 and F distributions.
- Order statistics.

VII. Suggested Reading

- Chatterjee S, Hadi A and Price B. 2013. *Regression Analysis by Examples*. 5th Ed. John Wiley.
- Draper N.R. and Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- Rao C.R. 2009. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.
- Searle S.R, Casella G and McCulloch C.E. 1992. *Variance Components*. John Wiley.
- Searle S.R. 1971. *Linear Models*. John Wiley.

I. Course Title : Modeling Techniques for Forecasting

II. Course Code : STAT 605

III. Credit Hours : 2+1

IV. Aim of the course

This is an advanced course in Statistical Methods that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in the area of empirical and mechanistic models and nonlinear estimation and the replications in different disciplines of agricultural sciences.

V. Theory

Unit I

Empirical and mechanistic models. Nonlinear growth models: monomolecular, logistic, Gompertz, Richards. Applications in agriculture and fisheries.

Unit II

Nonlinear estimation: Least squares for nonlinear models, Methods for estimation of parameters like Linearization, Steepest, and Levenberg- Marquardt's Parameterization.

Unit III

Two-species systems. Lotka-Volterra, Leslie-Gower and Holling-Tanner non-linear prey-predator models. Volterra's principle and its applications. Gauss competition model.

Unit IV

Compartmental modelling - First and second order input-output systems, Dynamics of a multivariable system.

Forecasting techniques with special reference to agriculture. Forecast based on time series data: exponential smoothing, Box – Jenkins approach and non-linear models. Forecast models using weather parameters, crop-weather relationships and their use in yield forecast. Forecast using plant characters.

Unit VI

Forecast surveys, between-year models (regression model, Markov chain probability model and group method of data handling) and within-year models. Agro-meteorological models: climatic water balance model and crop yield assessment. Forewarning of crop pests and diseases. Application of remote sensing techniques in forecasting. Use of ANN in forecasting.

VI. Practical

- Fitting of mechanistic non-linear models;
- Application of Schaefer and Fox non-linear models;
- Fitting of compartmental models.Fitting of forecast models using weather parameters.
- Time series analysis: plots, decomposition, stationarity tests, exponential smoothing. •Univariate Box – Jenkins ARIMA models and seasonal ARIMA models.
- Forecast models using plant characters,
- Agrometeorological models for crop forecasting, Markov chain models and ANN models.

VII. Suggested Reading

- Draper, N.R. and Smith, H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- Efromovich S. 1999. *Nonparametric Curve Estimation*. Springer.

- Fan, J. and Yao, Q. 2003. *Nonlinear Time Series-Nonparametric and Parametric Methods*. Springer.
- France, J. and Thornley, J.H.M. 1984. *Mathematical Models in Agriculture*. Butterworths.
- Harvey, A.C. 1996. *Forecasting, Structural Time Series Models and the Kalman Filter*. Cambridge Univ. Press.
- Makridakis, S., Wheelwright, S.C. and Hyndman, R.J. 1998. *Forecasting: Methods and Applications*. John Wiley.
- Pankratz, A. 1983. *Forecasting with Univariate Box Jenkins Models: Concepts and Cases*. John Wiley.
- Thornley, J. and France J. 2006. *Mathematical Models in Agriculture: Quantitative Methods for the Plant, Animal and Ecological Sciences* (Cabi) 2nd Ed.

I. Course Title : Stochastic Processes

II. Course Code : STAT 606

III. Credit Hours : 2+0

IV. Aim of the course

This is a course on Stochastic Processes that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

V. Theory

Unit I

Introduction to stochastic process - classification according to state space and time domain. Finite and countable state Markov chains; time- homogeneity; Chapman-Kolmogorov equations, marginal distribution and finite dimensional distributions. Classification of Markov chain. Canonical form of transition probability matrix of a Markov chain. Fundamental matrix; probabilities of absorption from transient states into recurrent classes in a finite Markov chain, mean time for absorption. Ergodic state and Ergodic chain. Stationary distribution of a Markov chain, existence and evaluation of stationary distribution. Random walk and gamblers ruin problem.

Unit II

Discrete state continuous time Markov process: Kolmogorov difference – differential equations. Birth and death process, pure birth process (Yule- Fury process). Immigration-Emigration process. Linear growth process, pure death process.

Unit III

Renewal process: renewal process when time is discrete and continuous. Renewal function and renewal density. Statements of Elementary renewal theorem and Key renewal theorem.

Unit IV

Stochastic process in biological sciences: Markov models in population genetics, compartmental analysis. Simple deterministic and stochastic epidemic model. General epidemic models-Karmack and McKendrick's threshold theorem. Recurrent epidemics.

Unit V

Elements of queueing process; the queuing model M/M/1: steady state behaviors. Birth and death process in queuing theory- Multi channel models. Network of Markovian queuing system.

Unit VI

Branching process: Galton-Watson branching process. Mean and variance of size of nth generation, probability of ultimate extinction of a branching process. Fundamental theorem of branching process and applications.

Unit VII

Wiener process- Wiener process as a limit of random walk. First passage time for Wiener process. Kolmogorov backward and forward diffusion equations and their applications.

VI. Suggested Reading

- Adke SR and Manjunath SM. 1984. *Finite Markov Processes*. John Wiley.
- Bailey NTJ. 1964. *Elements of Stochastic Processes with Applications to the Natural Sciences*. Wiley Eastern.
- Bartlett MS. 1955. *Introduction to Stochastic Processes*. Cambridge Univ. Press.
- Basawa IV and Prakasa Rao BLS. 1980. *Statistical Inference for Stochastic Processes*. Academic Press.
- Bharucha-Reid AT. 2012. *Elements of the Theory of Markov Processes and their Applications*. McGraw Hill.
- Bhat BR. 2000. *Stochastic Models; Analysis and Applications*. New Age.
- Draper NR and Smith H. 1981. *Applied Regression Analysis*. Wiley Eastern. France J &Thornley JHM. 1984. *Mathematical Models in Agriculture*. Butterworths.
- Lawler GF. 2006. *Introduction to Stochastic Processes*. Chapman & Hall. 2nd Ed.
- Medhi J. 2001. *Stochastic Processes*. 2nd Ed. Wiley Eastern.
- Prakasa Rao BLS and Bhat BR.1996. *Stochastic Processes and Statistical Inference*. New Age.
- Ratkowsky DA. 1983. *Nonlinear Regression Modelling: a Unified Practical Approach*. Marcel Dekker.
- Ratkowsky DA. 1990. *Handbook of Nonlinear Regression Models*. Marcel Dekker.
- Seber GAF and Wild CJ. 1989. *Non-linear Regression*. John Wiley.

I. Course Title : Survival Analysis

II. Course Code : STAT 607

III. Credit Hours : 2+0

IV. Aim of the course

The course deals with the study of demographic profiles and survival times. In-depth statistical properties and analysis is an important component of this course.

V. Theory

Unit I

Measures of Mortality and Morbidity: Ratios and proportions, rates of continuous process, rates of repetitive events crude birth rate, Mortality measures used in vital statistics relationships between crude and age specific rates, standardized mortality ratios evaluation of person-year of exposed to risk in long term studies, prevalence and incidence of a disease, relative risk and odds ratio. Survival Distribution: Survival functions, hazard rate, hazard function, review of survival distributions: exponential, Weibull, Gamma, Rayleigh, Pareto, Lognormal~ IFR and TFRA, Gompertz and Makeham. Gompertz and logistic distributions. Parametric (m.l.e) estimation. Types of Censoring: Type I, Type II, random and other types of censoring, right and left truncated distributions. Expectation and variance of future life time, series and parallel system of failures. Life Tables: Fundamental and construction.

Unit II

Complete Mortality data, Estimation of Survival Function: Empirical survival function, estimation of survival function from grouped mortality data, joint distribution of the number of deaths, distribution of the estimation P_i covariance of estimate, estimation of curves of deaths and central death rate and force of mortality rate. Incomplete Mortality data (non-parametric models): Actuarial method, m.1.e method, moment and reduced sample method of estimation and their comparison. Product limit (Kaplan-Meier) method and cumulative hazard function (CHF) of estimation of survival function.

Unit III

Fitting Parametric Survival Distribution: Special form of survival function cumulative hazard function (CHF) plots, Nelson's method of ungrouped data, construction of the likelihood function for survival data, least squares fitting, fitting a Gompertz distribution to grouped data. Some tests of Goodness of fit: Graphical, Kolmogorov-Smirnov statistics for complete, censored and truncated data, Chi-Square test and Anderson- Darling A^2-statistics. Comparison of Mortality Experiences: Comparison of two life tables, some distribution- free methods (two samples) for ungrouped data, Two samples Kolmogorov-Smirnov test, Wilcoxon test for complete data and modified Wilcoxon test for incomplete data .Gilbert and Gehan's test, mean and variance of Wilcoxon statistics, generalization of Gehan's test. Testing for Consistent Differences in Mortality: Mantel-Haenszel and log rank test. Generalized Mantel-Haenszel test (k-sample).

Unit IV

Concomitant Variables: General parametric model for hazard function with observed concomitant variables. Additive and multiplicative models of hazard rate functions. Estimating multiplicative models, selection of concomitant variables. Logistic linear model, Concomitant Variable regarded as random variable. Age of onset distributions: Models of onset distributions and their estimation. Gompertz distribution, parallel system and Weibull distribution, Fatal short models of failure.

Two component series system.

Unit V

Interval Censoring Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter-relations.Concept of COX regression Stochastic Epidemic Models: Simple epidemic models, general epidemic model definition and concept (without derivation). Duration of an epidemic.

VI. Suggested Reading

- Anderson B. 1990. *Methodological Errors in Medical Research*. Blackwell.
- Armitage P and Berry G. 1987. *Statistical* Methods *in Medical Research*. Blackwell.
- Biswas, S. 2007. *Applied Stochastic Processes*: *A Biostatistical and Population Oriented Approach*, 2nd Ed., New Central Book Agency.
- Collett D. 2014. *Modeling Survival Data in Medical Research*. Chapman & Hall. 3rd Ed.
- Cox D.R. and Oakes D. 1984. *Analysis of Survival Data*. Chapman & Hall.
- Elandt-Johnson R.C. and Johnson N.L. 1980. Survival *Models and Data Analysis*. John Wiley.
- Everitt B.S. and Dunn G. 1998. *Statistical Analysis of Medical Data*. Arnold. Hosmer D.W. Jr. and Lemeshow S. 1999. *Applied Survival Analysis: Regression Modeling or Time to Event*. John Wiley.
- Indrayan, A. 2008. *Medical Biostatistics*, 2nd Ed. Chapman and Hall/CRC.
- Lee E.T. 1980. *Statistical Methods for Survival Data Analysis*. Lifetime Learning Publ.
- Kalbfleisch J.D. and Prentice. R.L. 2002. *The Statistical Analysis of Failure Time Data*. John Wiley.
- Klein J.P. and Moeschberger M.L. 2003. *Survival Analysis: Techniques for Censored and Truncated Data*. Springer.
- Kleinbaum D.G. and Klein M. 2002. *Logistic Regression*.Springer.
- Kleinbaum D.G. and Klein M. 2005. *Survival Analysis*. Springer.

I. Course Title : Spatial Statistics

II. Course Code : STAT 608

III. Credit Hours : 1+1

IV. Aim of the course

This is a course on Spatial statistics aims at exposing the students to some advanced level spatial methods and their applications to agricultural situations.

V. Theory

Unit I

Spatial Analysis and types of spatial data; Visualizing Spatial Data – Exploratory data Analysis.

Unit II

Spatial Relationship- Random forest, spatially autocorrelated data, weight matrix, measures of spatial Auto-correlation – Moran's I & Geary's C; Measuring of autocorrelation of spatially continuous data.

Unit III

Spatial Sampling – Methods and procedures, Statistical Analysis of Spatial Point Process – homogenous Poisson Process, Spatial interpolation – non-statistical methods; Variogram modelling; Spatial Prediction – Simple Kriging, Co-kriging;

Unit IV

Modelling Areal data – Autoregressive and spatial regression models and model diagnostics. Examples of Spatial Data analysis in Agriculture– Disease Mapping; Incorporating spatial effects in Agricultural Field experiments

VI. Practical

- Spatial Data – Import, export;
- Spatial Classes in R;
- Visualizing Spatial Data;
- Spatial Auto-correlation;
- Spatial Sampling, Spatial Interpolation, Spatial Autoregressive Models, Spatial Regression Model

VII. Suggested Reading

- Cressie, N.A.C. 1993.*Statistics for Spatial Data*. Revised Edition. JohnWiley
- Richard E.P. 2018. *Spatial Data Analysis in Ecology and Agriculture Using R*, 2nd Ed.
- Roger S. Bivand, E Pebesma J. and Rubio B.G. 2008. *Applied Spatial Data Analysis using R*. Springer-Verlog.

I. Course Title : Baysian Inference

II. Course Code : STAT 611

III. Credit Hours : 2+0

IV. Aim of the course

This course aims at describing the advanced level topics in statistical methods and statistical inference. This course would prepare students to have a strong base in basic statistics that would help them in undertake basic and applied research in Statistics.

V. Theory

Unit I

Introduction and history and criticism of Bayesian Approach; Subjective interpretation of Probability, Review of Bayes Theorem, Sufficiency, Likelihood Principle.

Unit II

Subjective Prior distribution of a parameter; Posterior Distribution of parameters using Bayes Theorem

Unit III

Informative and non-informative priors for Location and scale; Conjugate families –Discrete and Continuous and interpretation of Hyper-parameters of conjugates.

Unit IV

Non-informative, improper and invariant priors for location and scale and in general settings.

Unit V

Bayesian Point Estimation – squared error loss, absolute error loss etc. Bayesian Interval Estimation – Credible Interval, interpretation and comparison with frequentist confidence Intervals

Unit VI

Bayesian Hypothesis Testing - Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Prior odds, Posterior odds, Bayes factor for various types of testing hypothesis problems

Unit VII

Bayesian Prediction; Numerical and Monte-Carlo Integrations

Unit VIII

Applications of Bayesian Inference - Bayesian Data Analysis

VI. Suggested Reading

- Berger, J.O. 1985. *Statistical Decision Theory and Bayesian Analysis*, Springer Verlag.
- Box, G.P. and Tiao, G.C. 1992. *Bayesian Inference in StatisticalAnalysis*,Addison – Wesley
- Pilon C.D. 2015. *Bayesian Methods for Hackers: Probabilistic Programming and Bayesian Inference* (Addison-Wesley Data and Analytics)

I. Course Title : Advanced Design of Experiments

II. Course Code : STAT 612

III. Credit Hours : 2+1

IV. Aim of the course

This is an advanced course in Design of Experiments that aims at describing some advanced level topics for students who wish to pursue research in Design of Experiments. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

V. Theory

Unit I

General properties and analysis of block designs. Balancing criteria. *m*- associate PBIB designs, and their association schemes including lattice designs - properties and construction, Designs for test treatment – control(s) comparisons; Nested block designs, Mating designs.Structurally Incomplete block designs

Unit II

General properties and analysis of two-way heterogeneity designs, Youden type designs, generalized Youden designs, Pseudo Youdendesigns., Designs for two sets of treatments.

Unit III

Balanced factorial experiments - characterization and analysis (symmetrical and asymmetrical factorials). Factorial experiments with extra treatment(s). Orthogonal arrays, Mixed orthogonal arrays, balanced arrays, Fractional replication, Resolution plans, Regular and irregular fractions.

Unit IV

Response surface designs - Symmetrical and asymmetrical factorials, Response optimization and slope estimation, Blocking, Canonical analysis and ridge analysis, CCD, Box-Jenkins, Experiments with mixtures: design and analysis. Experiments with qualitative cum quantitative factors.

Unit V

Optimality criteria and optimality of designs, robustness of designs against loss of data, outliers, etc. Diagnostics in design of experiments.

VI. Practical

Analysis of block designs, Analysis of Latin square type designs, group divisible designs, triangular designs, lattice designs. Analysis of fractional replications of factorial experiments, analysis of asymmetrical factorials and block designs with factorial structure. Analysis of second order response surface designs.

VII. Suggested Reading

- Chakraborti M.C. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publ.House.
- Dean A.M. and Voss D. 1999. *Design and Analysis of Experiments*.
- pringer. Dey A and Mukerjee R. 1999. *Fractional Factorial Plans*. John Wiley.
- Dey A 1986. *Theory of Block Designs*. Wiley Eastern.
- Hall M Jr. 1986. *Combinatorial Theory*. John Wiley.
- Hedayat A.S., Sloane N.J.A. and Stufken J. 1999. *Orthogonal Arrays: Theory and Applications*. Springer.
- John J.A. and Quenouille M.H. 1977. *Experiments: Design and Analysis*. Charles and Griffin.
- Khuri A.I. and Cornell J.A. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.

- Montgomery D.C. 2005. *Design and Analysis of Experiments*. John Wiley.
- Ogawa J. 1974. *Statistical Theory of the Analysis of Experimental Designs*. Marcel Dekker.
- Parsad R, Gupta V.K., Batra P.K., Satpati S.K. and Biswas P. 2007. *Monograph on a-designs*. IASRI, New Delhi.
- Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*. John Wiley.
- Shah K.R. and Sinha B.K. 1989. *Theory of Optimal Designs. Lecture notes in Statistics*. Vol. 54. Springer.
- Sharma M.K. 2012. *Design and Analysis of Experiments*. Kindle Ed. 1st Ed.
- Street A.P. and Street D.J. 1987. *Combinatorics of Experimental Designs*.Oxford Science Publ.
- Design Resources Server: www.drs.icar.gov.in.

I. Course Title : Advanced Sampling Techniques

II. Course Code : STAT 613

III. Credit Hours : 2+1

IV. Aim of the course

This is an advanced course in Sampling Techniques that aims at describing some advanced level topics for students who wish to pursue research in Sampling Techniques. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to Statistical System in thecountry.

V. Theory

Unit I

Optimum Stratification, two-way stratification, collapsed strata, Controlled selection, Use of combinatorics in controlled selection, Systematic sampling in two dimensions. Sampling with varying probabilities without replacement, Horvitz – Thompson estimator

Unit II

Variance estimation in complex surveys. Taylor's series linearization, balanced repeated replication, Jackknife and bootstrap methods.Ordered and unordered estimators, Sampling strategies, Midzuno-Sen, Rao-Hartley-Cochran,ðPS Sampling: procedures such as Brewer, Durbin and Sampford,

Unit III

Unified theory of sampling from finite populations. UMV - Non-existence theorem and existence theorem under restricted conditions. Concept of sufficiency and likelihood in survey sampling. Admissibility and hyper- admissibility.

Unit IV

Post-stratified estimator, imperfect frames, multiple frames, randomized response techniques. Inference under super population models - concept of designs and model unbiasedness, prediction approach. Regression analysis and categorical data analysis with data from complex surveys. Domain estimation. Small area estimation. Longitudinal survey.

VI. Practical

- Sampling with varying probability,
- Ordered and un-ordered estimators,
- Sampling strategies due to Horvitz-Thompson, Midzuno-Sen, Rao-Hartley-Cochran and PPS sampling: procedures such as Brewer, Durbin and Sampford, etc.
- Imperfect frames, Randomized response technique.
- Small area estimation.

V. Suggested Reading

- Berger J.O. 1993. *Statistical Decision Theory and Bayesian Analysis*. Sringer.
- Bolfarine H and Zacks S. 1992. *Prediction Theory for Finite Population Sampling*. Springer.
- Cassel C.M., Sarndal C.E and Wretman J.H. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.
- Des Raj and Chandhok P. 1998. *Sample Survey Theory*. Narosa Publ.
- House. Ghosh M and Meeden G. 1997. *Bayesian Method for Finite Population*
- *Sampling. Monograph on Statistics and Applied Probability*. Chapman and Hall.
- Mukhopadhyay P. 1998. *Theory and Methods of Survey Sampling*. Prentice Hall of India.
- Rao J.N.K. 2003. *Small Area Estimation*. John Wiley.
- Sarndal C.E., Swensson B and Wretman J.H. 1992. *Model Assisted Survey Sampling*. Springer.

I. Course Title : Advanced Statistical Genetics

II. Course Code : STAT 614

III. Credit Hours : 2+1

IV. Aim of the course

This is an advanced course in Statistical Genetics that aims at describing some advanced level topics for students who wish to pursue research in Statistical Genetics. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject in plant and animal breeding.

V. Theory

Unit I

Hardy-Weinberg law with multiple allelic systems, auto-tetraploids and self-sterility alleles. Complex cases of selection with two or more loci.

Unit II

Different approaches to study inbreeding process, methods of path co- efficient, probability and generation matrix. Fisher's approach to inbreeding. Stochastic process of gene frequency change, transition matrix approach using finite Markov chains, diffusion approximation, Steady decay and distribution of gene frequency, Probability of fixation of a gene, Conditional process - Markov chains and diffusion approaches, Distribution of time until fixation, random fluctuations in selection intensity, stationary distribution of gene frequency. Effective population size.

Unit III

Prediction and estimation of genetic merit. Best linear unbiased prediction, Use of mixed model methodology in analysis of animal and plant breeding experiments. Newer reproductive technology and its effect in genetic evaluation of individual merit. Estimation of genetic parameters - problems relating to computational aspects of genetic variance components, parameter estimation in variance component models for binary response data.

Unit IV

Identification of genes with large effects, Use of molecular markers (RFLP, PCR-AFLP, RAPD and SSR), Gene mapping and Quantitative trait loci. Molecular manipulation for genetic variability.

Unit V

Variance component approach and linear regression approach for the analysis of GE interactions.Measurement of stability and adaptability for genotypes. Concepts of general and specific combining ability, diallel and partial diallel crosses: construction and analysis.

Practical

- Hardy-Weinberg law,
- Estimation of genetic load and random genetic drift.
- Effect of finite population size.
- Estimation of path coefficients.
- Detection and estimation of multiple allelism in continuous variation, sexlinked genes, maternal effects.
- Analysis of G × E interaction, measurement of stability and adaptability.

- Analysis of data of diallel and partial diallel crosses.

VII. Suggested Reading

- Crow J.F. and Kimura M. 1970. *An Introduction of Population Genetics Theory*. Harper & Row.
- Ewens W.J. 1979. *Mathematical Population Genetics*. Springer.
- Falconer D.S. 1985. *Introduction to Quantitative Genetics*. ELBL.
- Fisher R.A. 1949. *The Theory of Inbreeding*. Oliver & Boyd.
- Fisher R.A. 1958. *The Genetical Theory of Natural Selection*. Dover Publ.
- Haldane J.B.S. 1932. *The Causes of Evolution*. Harper & Bros.
- Kempthorne O. 1957. *An Introduction to Genetic Statistics*. The Iowa State Univ. Press.
- Lerner I.M. 1950. *Population Genetics and Animal Improvement*. Cambridge Univ. Press.
- Lerner I.M. 1958. *The Genetic Theory of Selection*. John Wiley.
- Li C.C. 1982. *Population Genetics*. The University of Chicago Press.
- Mather K and Jinks J.L. 1982. *Biometrical Genetics*. Chapman & Hall.
- Mather K. 1951. *The Measurement of Linkage in Heredity*.
- Methuen. Nagilaki T. 1992. *Introduction to Theoretical PopulationGenetics*.Springer.
- Narain P. 1990. *Statistical Genetics*. Wiley Eastern.
- Nielsen R, Montgomery S. 2013. *An Introduction to Population Genetics: Theory and Applications* 1st Ed.

I. Course Title : Advanced Time Series Analysis

II. Course Code : STAT 615

III. Credit Hours : 2+0

IV. Aim of the course

This is an advanced course in Time Series Analysis that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agriculturalsciences.

V. Theory

Unit I

Multivariate time series: modelling the mean, stationary VAR models: properties, estimation, analysis and forecasting, VAR models with elements of nonlinearity, Non-stationary multivariate time series: spurious regression, co-integration, Vector Error Correction Model (VECM).

Unit II

Volatility: The class of ARCH and GARCH models; Extensions of GARCH models: TGARCH, IGARCH, PGARCH, EGARCH, GJR-GARCH, ARCH and GARCH model with-t distributed error; ARCD (Auto-Regressive Conditional Density), Multivariate GARCH model: estimation, analysis and forecasting, stochastic volatility.

Unit III

Structural time-series modelling: State space models, Kalman filter, Local level model, Local linear trend model, Seasonal models, Cyclical models. Threshold and Functional coefficient autoregressive models, Structural Break in time series.

Unit IV

Fuzzy time series models, Artificial Neural Network (ANN) methodology, Support vector machines, Wavelets for time series analysis, combinations of time series models.

VI. Suggested Reading

- Box G.E.P., Jenkins G.M. and Reinsel G.C. 2015. *Time Series Analysis: Forecasting and Control*. 5th Ed. John Wiley.
- Brockwell P.J. and Davis R.A. 1991. *Time Series: Theory and Methods*. 2nd Ed. Springer.
- Chatfield C. 2004. *The Analysis of Time Series: An Introduction*. 6th Ed. Chapman& Hall/ CRC.
- Johnston J. 1984. *Econometric Methods*. McGraw Hill.
- Singh, P. 2016. *Applications of Soft Computing in Time Series Forecasting: Simulation and Modeling Techniques*. Springer International Publishing AG
- Tong H. 1995. *Nonlinear Time Series: A Dynamical System Approach*.Oxford Univ. Press.
- Vapnik, V. N. (2000). *The Nature of Statistical Learning Theory*. Springer- Verlag, New York.
- Percival, D.B. and Walden, A.T. 2000. *Wavelet Methods for Time-Series Analysis*. Cambridge University Press, U.K.

I. Course Title : Advanced Bioinformatics

II. Course Code : STAT 616

III. Credit Hours : 2+1

IV. Aim of the course

This is a course on Bioinformatics that aims at exposing the students to some advanced statistical and computational techniques related to bioinformatics. This course would prepare the students in understanding bioinformatics principles and their applications.

V. Theory

Unit I

EM algorithm and other statistical methods to discover common motifs in biosequences. Concepts in phylogeny. Gene prediction based on codons, Decision trees, Clustering Techniques, Classificatory analysis, Neural Networks, Genetic algorithms, Pattern recognition, Hidden Markov models.

Unit II

Computational analysis of protein sequence, structure and function. Expression profiling by microarray/ gene chip/ RNAseq, proteomics etc., Multiple alignment of protein sequences, Modelling and prediction of structure of proteins, Designer proteins, Drug designing.

Unit III

Analysis of one DNA sequence (Modeling signals in DNA; Analysis of patterns; Overlaps and Generalizations), Analysis of multiple DNA or protein sequences (Alignment algorithms – Gapped global comparisons and Dynamic programming; use of linear gap models; protein sequences and substitution matrices – BLOSUM, PAM; Multiple sequences), BLAST (Comparison of two aligned sequences – Parameter calculation; Choice of a score; Bounds for P-value; Normalized and Bit scores, Karlin – Altschul sum statistic; comparison of two unaligned sequences; Minimum significance Lengths).

Unit IV

Markov Chains (MC with no absorbing states, higher order Markov dependence, patterns insequences, Markov Chain Monte Carlo – Hastings-Metropolis algorithm, simulated annealing,MC with absorbing States). Bayesian techniques and use of Gibbs Sampling. Advanced topicsin design and analysis of DNA microarray experiments.

Unit V

Modeling protein families; Multiple sequence alignments; Pfam; Gene finding), Computationally intensive methods (Classical estimation methods; Bootstrap estimation and Confidence Intervals; Hypothesis testing; Multiple Hypothesis testing), Evolutionary models (Models of Nucleotide substitution; Discrete time models – The Jukes-Cantor Model, The Kimura Model, The Felsenstein Model; Continuous-time models)

Unit VI

Phylogenetic tree estimation (Distances; Tree reconstruction – Ultrametric and Neighbor-Joining cases; Surrogate distances; Tree reconstruction; Parsimony and Maximum Likelihood; Modeling, Estimation and Hypothesis Testing;) Neural Networks (Universal Approximation Properties; Priors and Likelihoods, Learning Algorithms – Backpropagation; Sequence encoding and output interpretation; Prediction of Protein Secondary Structure; Prediction of Signal Peptides and their cleavage sites; Application for DNA and RNA Nucleotide Sequences), Analysis of SNPs and Haplotypes.

VI. Practical

- Genomic databases and analysis of high-throughput data sets, BLAST and related sequence comparison methods.
- Statistical methods to discover common motifs in biosequences.
- Multiple alignment and database search using motif models, clustalw, classificatory analysis, neural networks, genetic algorithms, pattern recognition,
- Hidden Markov models.
- Computational analysis of protein sequence.
- Expression profiling by microarray/ gene chip, proteomics.
- Modelling and prediction of structure of proteins.
- Bayesian techniques and use of Gibbs Sampling.
- Analysis of DNA microarray experiments.
- Analysis of one DNA sequence, multiple DNA or protein sequences.
- Computationally intensive methods, multiple hypothesis testing,
- Phylogenetic tree estimation,
- Analysis of SNPs and haplotypes.

VII. Suggested Reading

- Baldi P and Brunak S. 2001. *Bioinformatics: The Machine Learning Approach*. MIT Press. Baxevanis AD and Francis BF. (Eds.). 2004. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. John Wiley.

- Duda RO, Hart PE and Stork DG. 1999. *Pattern Classification*. John Wiley.
- Ewens WJ and Grant GR. 2001. *Statistical Methods in Bioinformatics*.Springer.
- Jones NC and Pevzner PA. 2004. *Introduction to Bioinformatics Algorithms*. The MIT Press.
- Koskinen T. 2001. *Hidden Markov Models for Bioinformatics*. Kluwer.
- Krane DE and Raymer ML. 2002. *Fundamental Concepts of Bio-informatics*.
- Benjamin/ Cummings.
- Krawetz SA &Womble DD. 2003. *Introduction to Bioinformatics: A Theoretical and Practical Approach*. Humana Press.
- Lesk AM. 2002. *Introduction to Bio-informatics*. Oxford Univ. Press.
- Linder E and Seefeld K. 2005. *R for Bioinformatics*. O'Reilly and Associates.
- Percus JK. 2001. *Mathematics of Genome Analysis*. Cambridge Univ. Press.
- Sorensen D and Gianola D. 2002. *Likelihood, Bayesian and MCMC Methods in Genetics*. Springer.
- Tisdall J.D. 2001. *Mastering Perl for Bioinformatics*. O'Reilly & Associates.
- Wang J.T.L., Zaki M.J., Toivonen H.T.T. and Shasha D. 2004. *Data Mining in Bioinformatics*. Springer.
- Wu C.H. and McLarty J.W. 2000. *Neural Networks and Genome Informatics*. Elsevier.
- Wunschiers R. 2004. *Computational Biology Unix/Linux, Data Processing and Programming*. Springer.
- Yang M.C.C. 2000. *Introduction to Statistical Methods in Modern Genetics*. Taylor & Francis.

I. Course Title : Advanced Econometrics
II. Course Code : STAT 617
III. Credit Hours : 1+1

IV. Aim of the course

This is a course on Econometrics aims at exposing the students to some advanced level econometric methods and their applications to agricultural situations.

V. Theory

Unit I

Quantile regression, binary quantile regression, extreme values, copula, loss functions, Point and interval forecasting, unconditional and conditional forecasting, forecasting with serially correlated errors, bootstrap: asymptotic expansion, bootstrap consistency, asymptotic refinement, recent developments for dependent timeseries. Co integration analysis.

Unit II

Multivariate time series: modelling the mean, stationary VAR models: properties, estimation, analysis and forecasting, VAR models with elements of nonlinearity, Non-stationary multivariate time series: spurious regression, co-integration, common trends; Volatility: Modelling the variance, The class of ARCH models: properties, estimation, analysis and forecasting, stochastic volatility, realized volatility.

Unit III

Basic Concepts of Bayesian Inference, Probability and Inference, Posterior Distributions and Inference, Prior Distributions. The Bayesian linear model and autoregressive (AR) processes; Model selection with marginal likelihoods and fractional priors, Comparison of Bayesian Methods with Classical approaches, Bayes risk and their applications, and Sample Selection Monte Carlo integration, importance sampling and Gibbs sampling, The Regression Model with General

Error Covariance Matrix, Qualitative Choice Models, Bayesian information criterion (BIC), Markov Chain Monte Carlo (MCMC) Model Composition and stochastic search variable selection, BUGS [Bayesian Inference Using Gibbs Sampling], BUCC [Bayesian Analysis, Computation and Communication].

VI. Practical

Fitting of equation with serially correlated errors, ordinary least-squares and generalized least squares methods of estimation. Non-stationary multivariate time series analysis. Fitting of The Regression Model with General Error Covariance Matrix, Qualitative Choice Models, Bayesian information criterion (BIC), Markov Chain Monte Carlo (MCMC) Model Composition and stochastic search variable selection, BUGS Fitting of ARCH model.

VII. Suggested Reading

- Banerjee A, Dolado J, Galbraith J and Hendry D.F. 1993. *Co-integration, Error Correction, and the Econometric Analysis of Nonstationary Data*. Oxford Univ. Press.
- Bauwens L, Lubrano M. and Richard J.F. 1999. *Bayesian Inference in Dynamics of Econometric Models*. Oxford Univ. Press.
- Carlin B.P. and Louis T.A. 2008. *Bayes and Empirical Bayes Methods for Data Analysis*. Chapman & Hall.
- Gilks W.R., Richardson S and Spiegelhalter D. 1996. *MCMC in Practice*.Chapman & Hall.
- Greenberg E. 2012. *Introduction to Bayesian Econometrics*. Cambridge Univ. Press.
- Hamilton J.D. 1994. *Time Series Analysis*. Princeton Univ. Press.
- Judge G.G., Griffith W.E., Hill R.C., Lee C.H. and Lutkepohl H. 1985. *The Theory and Practice of Econometrics*. 2nd Ed. JohnWiley.
- Koop G, Poirier D and Tobias J. 2007. *Bayesian Econometric Methods*.Cambridge Univ. Press.
- Koop G. 2003. *Bayesian Econometrics*. John Wiley.
- Lancaster A. 2004. *An Introduction to Modern Bayesian Econometrics*. Blackwell.
- Pindyck R.S. and Rubinfeld D.L. 1981. *Econometric Models and Economic Forecasts*. McGraw

Hill.

I. Course Title : Recent Advances in the Field of Specialization

II. Course Code : STAT 618

III. Credit Hours : 1+0

IV. Aim of the course

To familiarize the students with the recent advances in the areas of their specialization to prepare them for undertaking research.

V. Theory

Recent advances in the field of specialization - sample surveys / design of experiments /statistical genetics / statistical modeling / econometrics / statistical inference, etc. will be covered by various speakers from the University / Institute as well as from outside the University / Institute in the form of seminar talks.

VI. Suggested Reading

Recent journals related to the research works.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 2

Statistical Sciences

– Computer Application

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- Veterinary Para-Clinical Subjects
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Contents

Common Academic Regulations for PG and Ph.D. Programmes

1. Academic Year and Registration

- An academic year shall be normally from July to June of the following calendar year otherwise required under special situations. It shall be divided into two academic terms known as semesters. Dates of registration, commencement of instructions, semester end examination, end of semester and academic year, etc. The Academic Calendar shall be developed by the concerned University from time to time and notified accordingly by the Registrar in advance.
- An orientation programme shall be organized by the Director (Education)/ Dean PGS for the benefit of the newly admitted students immediately after commencement of the semester.
- On successful completion of a semester, the continuing students shall register for subsequent semester on the date specified in the Academic/ Semester Calendar or specifically notified separately. Every enrolled student shall be required to register at the beginning of each semester till the completion of his/ her degree programmes.

2. Credit requirements

Framework of the courses

The following nomenclature and Credit Hrs need to be followed while providing the syllabus for all the disciplines:

	Masters' Programme	Doctoral Programme
(i) Course work		
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	–
Seminar	01	02
(ii) Thesis Research	30	75
Total	70	100

Major courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken may be given *mark

Minor courses: From the subjects closely related to a student's major subject

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overallcompetence.

Common Courses: The following courses (one credit each) will be offered to all students undergoing Master's degree programme:

1. Library and Information Services
2. Technical Writing and Communications Skills
3. Intellectual Property and its management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approval of the Head of Department (HoD)/ Board of Studies (BoS).

Supporting Courses

The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. If required, the contents may be modified to suit the individual discipline with approval of the concerned BoS:

Code	Course Title	Credit Hours
STAT 501	Mathematics for Applied Sciences	2+0
STAT 502	Statistical Methods for Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 512	Basic Sampling Techniques	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
MCA 501	Computers Fundamentals and Programming	2+1

Course Code	Course Title	Credit Hours
MCA 502	Computer Organization and Architecture	2+0
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques in Biochemistry	2+2

Syllabus of Common Courses for PG programmes

LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

To equip the students/ scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
- Writing of abstracts, summaries, précis, citations, etc.;
- Commonly used abbreviations in the theses and research communications;
- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading;
- Writing of a review article;

- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- Accentual pattern: Weak forms in connected speech;
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

Suggested Readings

1. Barnes and Noble. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language.*
2. *Chicago Manual of Style*. 14th Ed. 1996. Prentice Hall of India.
3. *Collins' Cobuild English Dictionary*. 1995.
4. Harper Collins. Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed.
5. Holt, Rinehart and Winston. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.
6. James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
7. Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
8. Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
9. Richard WS. 1969. *Technical Writing*.
10. Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
11. Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

1. Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

2. Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
3. *Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC and Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
6. Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralisation of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taXonomy.

Suggested Readings

1. Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
2. Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural

development programmes and policies of Government.

Theory

UNIT I History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS and Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.
2. Punia MS. *Manual on International Research and Research Ethics*. CCS Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.
4. Singh K. 1998. *Rural Development - Principles, Policies and Management*. Sage Publ.

Mandatory requirement of seminars

- It has been agreed to have mandatory seminars one in Masters (One Credit) and two in Doctoral programmes (two Credits).
- The students should be encouraged to make presentations on the latestdevelopments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills.

3. Residential requirements

- The minimum and maximum duration of residential requirement for Masters' Degree and Ph.D. Programmes shall be as follows:

P.G. Degree Programmes	Duration of Residential Requirement	
	Minimum	Maximum
Masters' Degree	2 Academic Years (4 Semesters)	5 Academic Years (10 Semesters)
Ph.D.*	3 Academic Years (6 Semesters)	7 Academic Years (14 Semesters)

*Student may be allowed to discontinue temporarily only after completion of course

work

In case a student fails to complete the degree programme within the maximum duration of residential requirement, his/ her admission shall stand cancelled. The requirement shall be treated as satisfactory in the cases in which a student submits his/ her thesis any time during the 4th and 6th semester of his/ her residentship at the University for Masters' and Ph.D. programme, respectively.

4. Evaluation of course work and comprehensive examination

- For M.Sc., multiple levels of evaluation (First Test, Midterm and Final semester) is desirable. However, it has been felt that the comprehensive examination is redundant for M.Sc. students.
- For Ph.D., the approach should be research oriented rather than exam oriented. In order to provide the student adequate time to concentrate on the research work and complete the degree in stipulated time, the examination may have to be only semester final. However, the course teacher may be given freedom to evaluate in terms of assignment/ seminar/ first test.
- For Ph.D., the comprehensive examination (Pre-qualifying examination) is required. As the students are already tested in course examinations, the comprehensive examinationshould be based onoral examinationby an external expert and the evaluation should cover both the research problem and theoretical background to execute the project. This shall assess the aptitude of the student and suitability of the student for the given research topic. The successful completion of comprehensive examination is to obtain the "Satisfactory" remark by the external expert.

5. Advisory System

Advisory Committee

- There shall be an Advisory Committee for every student consisting of not fewer than three members in the case of a candidate for Masters' degree and four in the case of Ph.D. degree with the Advisor as Chairperson. The Advisory Committee should have representatives from the major and minor fields amongst the members of the Post-graduate faculty accredited for appropriate P.G. level research. However, in those departments where qualified staff exists but due to unavoidable reasons Post-graduate degree programmes are not existing, the staff having Post-graduate teaching experience of two years or more may be included in the Advisory Committee as member representing the minor.
- At any given time, a P.G. teacher shall not be a Chairperson, Advisory Committee (including Master's and Ph.D. programmes) for more than five students.
- The Advisor should convene a meeting of the Advisory Committee at least once in a Semester. The summary record should be communicated to the Head of Department, Dean of the College of concerned, Director (Education)/ Dean PGS and Registrar for information.

Advisor/ Co-guide/ Member, Advisory Committee from other collaborating University/ Institute/ Organization

- In order to promote quality Post-graduate research and training in cutting edge areas, the University may enter into Memorandum of Understanding (MOU) with other Universities/ Institutions for conducting research. While constituting an Advisory Committee of a student, if the Chairperson, Advisory Committee feels the requirement of involving of a faculty member/ scientist of such partnering university/ Institute/ Organization, he/ she may send a proposal to this effect to

Director (Education)/ Dean PGS along with the proposal for consideration of Student's Advisory Committee (SAC).

- The proposed faculty member from the partnering institution can be allowed to act as Chairperson/ Co-guide/ Member, SAC, by mutual consent, primarily on the basis of intellectual input and time devoted for carrying out the research work at the particular institution. The faculty member/ scientist of partnering institutions in the SAC shall become a temporary faculty member of the University by following the procedure approved by the Academic Council.

Allotment of students to the retiring persons

Normally, retiring person may not be allotted M. Sc. Student if he/ she is left with less than 2 years of service and Ph.D. student if left with less than 3 years of service. However, in special circumstances, permission may be obtained from the Director (Education)/ Dean PGS, after due recommendation by the concerned Head of the Department.

Changes in the Advisory Committee:

(i) Change of the Chairperson or any member of the Advisory Committee is not ordinarily permissible. However, in exceptional cases, the change may be effected with due approval of the Director of Education/ Dean PGS.

(ii) Normally, staff members of the university on extra ordinary leave or on study leave or who leave the University service will cease to continue to serve as advisors of the Post-graduate students of the University. However, the Director (Education)/ Dean PGS may permit them to continue to serve as advisor subject to the following conditions:
   (a) The concerned staff member must be resident in India and if he/ she agrees to guide research and must be available for occasional consultations;
   (b) An application is made by the student concerned duly supported by the Advisory Committee;
   (c) In case of a Ph.D. student, he/ she must have completed his/ her comprehensive examinations and the research work must be well in progress and it is expected that the student will submit the thesis within a year;
   (d) The Head of the Department and the Dean of the College concerned agree to the proposal;
   (e) The staff member, after leaving the University service is granted the status of honorary faculty's membership by the Vice-Chancellor on the recommendation of the Director (Education)/ Dean PGS for guiding as Chairperson or Member, Advisory Committee the thesis/ theses of the student(s) concerned only.

(iii) In case the Chairperson/ member of a Student's Advisory Committee retires, he/ she shall be allowed to continue provided that the student has completed his course work and minimum of 10 research credits and the retiring Chairperson/ member stays at the Headquarters of the College, till the thesis is submitted.

(iv) If the Chairperson/ member proceeds on deputation to another organization, he/ she may be permitted to guide the student provided his/ her new organization is at the Headquarters of the College and his/ her organization is willing for the same.

(v) The change shall be communicated to all concerned by the Head of Department.

6. Evaluation of research work

- It is highly desirablefor Ph.D. programme and this should be done annually as an

essential part of research evaluation. The Student Advisory Committee shallreview the progress of research and scrutinize annual progress reports submitted by the student.

- Midterm evaluation of Ph.D. (to move from JRF to SRF) is a mandatory requirement for all the funding agencies. Hence, the second review of annual progress report need to be done after completion of two years. The successful completion enables the students to become eligible for SRF.

Prevention of plagiarism

- An institutional mechanism should be in place to check the plagiarism. The students must be made aware that manipulation of the data/ plagiarism is punishable with serious consequences.

7. Learning through online courses

- In line with the suggestion in new education policy and the initiatives taken by ICAR and MHRD in the form of e-courses, MOOCs, SWAYAM, etc. and also changes taking place globally in respect of learning through online resources it has been agreed to permit the students to enrol for online courses. It is expected that the provision of integrating available online courses with the traditional system of education would provide the students opportunities to improve their employability by imbibing the additional skills and competitive edge.

The Committee recommends the following points while integrating the online courses:

1. Board of Studies (BoS) of each Faculty shall identify available online courses and a student may select from the listed courses. The interested students may provide the details of the on-line courses to the BoS for its consideration.
2. A Postgraduate student may take up to a maximum of 20% credits in a semester through online learning resources.
3. The host institute offering the course does the evaluation and provide marks/ grades. The BoS shall develop the conversion formula for calculation of GPA and it may do appropriate checks on delivery methods and do additional evaluations, if needed.

Internship for Development of Entrepreneurship in Agriculture (IDEA)

Currently, a provision of 30 credits for dissertation work in M.Sc./ M.Tech/ M.F.Sc./ M.V.Sc. programmes helps practically only those students who aspire to pursue their career in academic/ research. There is hardly any opportunity/ provision under this system to enhance the entrepreneurship skills of those students who could start their own enterprise or have adequate skills to join the industry. Therefore, in order to overcome this gap, an optional internship/ in-plant training (called as IDEA) in lieu of thesis/ research work is recommended which will give the students an opportunity to have a real-time hands-on experience in the industry.

It is envisaged that the internship/ in-plant training would enhance the interactions between academic organizations and the relevant industry. It would not only enable the development of highly learned and skilled manpower to start their-own enterprises but also the industry would also be benefitted through this process. This pragmatic approach would definitely result in enhancedpartnerships between academia and industry.

The main objectives of the programme:

1. To promote the linkages between academia and industry
2. To establish newer University – Cooperative R&D together with industry for

knowledge creation, research and commercialization
3. Collaboration between Universities and industries through pilot projects
4. To develop methods for knowledge transfer, innovation and networking potential
5. To enhance skill, career development and employability

Following criteria for IDEA will be taken into consideration:

- At any point of time there will not be more than 50% of students who can opt under IDEA
- Major Advisor will be from Academia and Co-advisor (or Advisory Committee member) from industry
- Total credits (30) will be divided into 20 for internship/ in-plant training and10 for writing the report followed by viva-voce similar to dissertation
- Work place will be industry; however, academic/ research support would be provided by the University or both. MoU may be developed accordingly
- The IPR, if any, would be as per the University policy

9. Teaching assistantship

- Teaching assistantship shall be encouraged. This will give the required experience to the students on how to conduct courses, practical classes, evaluation and other related academic matters. This is an important part of Ph.D. training all over the world and it is expected to address the shortage of faculty in many institutions/ universities.
- The fulltime doctoral students of the University with or without fellowship may be considered for award of Teaching Assistantships in their respective Departments. The Teaching Assistantship shall be offered only to those doctoral students who have successfully finished their course work. Any consideration for award of Teaching Assistantships must have the consent ofthe supervisor concerned.
- Teaching Assistantships shall be awarded on semester to semester basis on the recommendation of a screening/ selection committee to be constituted by the ViceChancellor. All classes and assignments given to the Teaching Assistants, including tutorials, practicals and evaluation work shall be under the supervision of a faculty member who would have otherwise handled the course/ assignment.
- Each Ph.D. student may be allowed to take a maximum of 16 classes in a month to UG/ Masters students.
- No additional remuneration shall be paid to the students who are awarded ICAR JRF/ SRF. The amount of fellowship to be paid as remuneration to other students (who are receiving any other fellowship or without any fellowships) may be decided by the concerned universities as per the rules in force.However, the total amount of remuneration/ and fellowship shall not exceed the amount being paid as JRF/ SRF of ICAR.
- At the end of each term, Teaching Assistants shall be given a certificate by the concerned Head of the Department, countersigned by the School Dean, specifying the nature and load of assignments completed.

10. Registration of project personnel (SRF/ RA) for Ph.D.

- A provision may be made to enable the project personnel (SRF/ RA) to register for Ph.D. However, this can be done only if they are selected based on some selection process such as walk-in-interview. The prior approval of PI of the project is mandatory to consider the application of project personnel (SRF/ RA) for Ph.D. admission
- The candidates need to submit the declaration stating that the project work

shall not be compromised because of Ph.D. programme. Further, in order to justify the project work and Ph.D. programme, the number of course credits should not be more than 8 in a semester for the project personnel (SRF/ RA) who intend to register for Ph.D.

11. Compliance with the National Education Policy-2020

- While implementing the course structure and contents recommended by the BSMA Committees, the Higher Education Institutions (HEIs) are required to comply with the provisions of National Education Policy-2020, especially the following aspects:
- Given the 21st century requirements, quality higher education must aim to develop good, thoughtful, well-rounded, and creative individuals. It must enable an individual to study one or more specialized areas of interest at a deep level, and also develop character, ethical and Constitutional values, intellectual curiosity, scientific temper, creativity, spirit of service, and 21st century capabilities across a range of disciplines including sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects. A quality higher education must enable personal accomplishment and enlightenment, constructive public engagement, and productive contribution to the society. It must prepare students for more meaningful and satisfying lives and work roles and enable economic independence (9.1.1. of NEP-2020).
- At the societal level, higher education must enable the development of an enlightened, socially conscious, knowledgeable, and skilled nation that can find and implement robust solutions to its own problems. Higher education must form the basis for knowledge creation and innovation thereby contributing to a growing national economy. The purpose of quality higher education is, therefore, more than the creation of greater opportunities for individual employment. It represents the key to more vibrant, socially engaged, cooperative communities and a happier, cohesive, cultured, productive, innovative, progressive, and prosperous nation (9.1.3. of NEP-2020).
- FleXibility in curriculum and novel and engaging course options will be on offer to students, in addition to rigorous specialization in a subject or subjects. This will be encouraged by increased faculty and institutional autonomy in setting curricula. Pedagogy will have an increased emphasis on communication, discussion, debate, research, and opportunities for cross-disciplinary and interdisciplinary thinking (11.6 of NEP-2020).
- As part of a holistic education, students at all HEIs will be provided with opportunities for internships with local industry, businesses, artists, crafts persons, etc., as well as research internships with faculty and researchers at their own or other HEIs/ research institutions, so that students may actively engage with the practical side of their learning and, as a by-product, further improve their employability (11.8 of NEP-2020).
- HEIs will focus on research and innovation by setting up start-up incubation centres; technology development centres; centres in frontier areas of research; greater industry-academic linkages; and interdisciplinary research including humanities and social sciences research (11.12. of NEP-2020).
- Effective learning requires a comprehensive approach that involves appropriate curriculum, engaging pedagogy, continuous formative assessment, and adequate student support. The curriculum must be interesting and relevant, and updated regularly to align with the latest knowledge requirements and to meet specified learning outcomes. High-quality pedagogy is then necessary to successfully impart the curricular material to students; pedagogical practices determine the learning

eXperiences that are provided to students, thus directly influencing learning outcomes. The assessment methods must be scientific, designed to continuously improve learning and test the application of knowledge. Last but not least, the development of capacities that promote student wellness such as fitness, good health, psycho-social well-being, and sound ethical grounding are also critical for high-quality learning (12.1. of NEP-2020).

Definitions of Academic Terms

Chairperson means a teacher of the major discipline proposed by the Head of Department through the Dean of the College and duly approved by the Director of Education/ Dean Post Graduate Studies (or as per the procedure laid down in the concerned University regulations) to act as the Chairperson of the Advisory Committee and also to guide the student on academic issues.

Course means a unit of instruction in a discipline carrying a specific number and credits to be covered in a semester as laid down in detail in the syllabus of a degree programme.

Credit means the unit of work load per week for a particular course in theory and/ or practical. One credit of theory means one class of one clock hour duration and one credit practical means one class of minimum two clock hoursof laboratory work per week.

Credit load of a student refers to the total number of credits of all the courses he/ she registers during a particular semester.

Grade Point (GP) of a course is a measure of performance. It is obtained by dividing the per cent mark secured by a student in a particular course by 10, eXpressed and rounded off to second decimal place.

Credit Point (CP) refers to the Grade point multiplied by the number of credits of the course, eXpressed and rounded off to second decimal place.

Grade Point Average (GPA) means the total credit point earned by a student divided by total number of credits of all the courses registered in a semester, eXpressed and rounded off to second decimal place.

Cumulative Grade Point Average (CGPA) means the total credit points earned by a student divided by the total number of credits registered by the student until the end of a semester (all completed semesters), eXpressed and rounded off to second decimal place.

Overall Grade Point Average (OGPA) means the total credit points earned by a student in the entire degree programme divided by the total number of credits required for the P.G. degree, eXpressed and rounded off to second decimal place.

Restructured and Revised
Syllabi of Post-graduate Programmes
Vol. 3

Basic Veterinary Sciences

– Veterinary Anatomy
– Veterinary Biochemistry
– Veterinary Biotechnology
– Veterinary Extension Education
– Veterinary Physiology

Contents

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Basic Veterinary Sciences

– Veterinary Anatomy

Course Title with Credit Load
M.V.Sc. in Veterinary Anatomy

Course Code	Course Title	Credit Hours
ANA 601	Comparative osteology and arthrology	1+2
ANA 602	Comparative splanchnology	2+2
ANA 603	Myology, angiology, neurology and aesthesiology of Ox	2+2
ANA 604	Gross, histological and histochemical techniques	1+3
ANA 605	Clinical anatomy	0+1
ANA 606	General histology and ultrastructure	1+1
ANA 607	Systemic histology and ultrastructure	3+1
ANA 608	Developmental anatomy	2+1
ANA 609	Wild life and forensic anatomy	1+0
ANA 610	Master's seminar	1+0
ANA 611	Master's research	0+30

Course Contents
M.V.Sc. in Veterinary Anatomy

I. Course Title : Comparative Osteology and Arthrology
II. Course Code : ANA 601
III. Credit Hours : 1+2

IV. Theory

Unit I

Technical terms, structure, chemical composition and classification of bones.

Unit II

Bones of appendicular skeleton of ox as a type and their comparison with those of horse, sheep, goat, dog, pig and poultry.

Unit III

Bones of axial skeleton of ox as a type and their comparison with those of horse, sheep, goat, dog, pig and poultry.

Unit IV

Classification and detailed study of different joints of the body.

Unit V

Study the various indices for estimating race, sex and age of different animals. Basics of biomechanics of the locomotor system. Radiography of normal and developing bones.

V. Practical

Demonstration of all bones and dissection of joints of buffalo/ Cattle. Radiographic study of bones and joints

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Course Title : Comparative Splanchnology
I. Course Code : ANA 602
II. Credit Hours : 2+2

III. Theory

Unit I

Overview of different systems constituting descriptive anatomy of various organs of digestive system and associated glands of ox and their comparison with those of horse, sheep, goat, dog, pig and poultry. Study of formation of thoracic, abdominal and pelvic cavities; reflection of these cavities.

Unit II

Study of various organs/ structures and associated glands constituting the respiratory system of ox and their comparison with those of horse, sheep, goat, dog, pig and poultry.

Unit III

Detailed study of organs and associated glands comprising the urinary system of ox as a type and their comparison with those of horse, sheep, goat, dog, pig and poultry.

Unit IV

Complete study of various organs and associated glands of male and female genital systems.

Unit V

Surgical sites for various operations and clinically significant areas for performing auscultation, percussion and for carrying out surgical procedures such as laryngotomy, oesophagotomy, gastrotomy, rumenotomy, cystotomy, urethrotomy, caesarian section, exploratory laparotomy, mammectomy, thoracotomy, thoracocentesis, etc.

Unit VI

Study of various endocrine organs of ox and their comparison with horse, sheep, goat, dog, pig and poultry

IV. Practical

Demonstration of structure and placement of organs in body cavities of all theanimals. Sonographic appearance of different organs

I. Course Title : Myology, Angiology, Neurology and Aesthesiology of Ox

II. Course Code : ANA 603

III. Credit Hours : 2 +2

IV. Theory

Unit I

Classification of muscle fibres. Origin, insertion and relations of muscles of different body parts.

Unit II

Topographic anatomy of the vascular system comprising of heart, arteries, veins and lymphatics.

Unit III

Study of various components of central nervous system, peripheral nervous system and autonomic nervous system.

Unit IV

Complete study of the gross anatomy of various sense organs.

Unit V

Study of different nerve blocks, intravenous sites and enucleation of eye ball.

V. Practical

Dissection of heart, different vessels, brain, cranial nerves, brachial plexuses and lumbo-sacral plexus. Dissection of eye, ear, hoof and horn of buffalo/ cattle.

I. Course Title : Gross, Histological and Histochemical Techniques

II. Course Code : ANA 604

III. Credit Hours : 1+3

IV. Theory

Unit I

Preparation of tissues for microtomy and lightmicroscopy using different fixatives.

Unit II

Different staining methods for routine light microscopy and special staining methods.

Unit III

Frozen sectioning techniques and staining methods for enzymes, carbohydrates, lipids, proteins, pigments, etc.

Unit IV

Silver staining techniques for nervous tissue.

Unit- V

Preparation of tissue for electron microscopic studies

V. Practical

Embalming fluids, embalming of animals, maceration and preparation of skeletons. Gross staining of brain sections. Demonstration of sites of ossifications. Preparation of transparent specimens, preparation of casts of various organs, blood vessels and ducts, etc. Study of different techniques for collection, fixation and processing of animal tissues; preparation of paraffin and frozen sections; handling and care of microtomes. Demonstration of staining of carbohydrates, lipids, proteins, nucleic acids and enzymes.

I. Course Title : Clinical Anatomy

II. Course Code : ANA 605

III. Credit Hours : 0+1

IV. Practicals

Clinical examination of animal in health and disease, auscultation of different organs, different types of nerve blocks, surgical conditions of different body systems, radiographical techniques and post-mortem examination.

I. Course Title : General Histology and Ultrastructure

II. Course Code : ANA 606

III. Credit Hours : 1+1

IV. Aim of the course

To understand basic principles of light microscopy and light and ultrastructure of four basic tissues.

V. Theory

Unit I

Light and ultrastructural details of animal cell.

Unit II

Light and ultrastructural details of epithelial tissue.

Unit III

Light and ultrastructural details of muscular tissue.

Unit IV

Light and ultrastructural details of connective tissue.

Unit V

Light and ultrastructural details of nervous tissue.

VI. Practical

Demonstration of different components of cells and intercellular substances of the above referred tissues by special staining through the use of light, phase contrast, dark field, fluorescent and electron microscopes.

I. Course Title : Systemic Histology and Ultrastructure

II. Course Code : ANA 607

III. Credit Hours : 3+1

IV. Theory

Unit I

Light and ultrastructure of different organs of digestive system of ruminants with differential features among domestic animals.

Unit II

Light and ultrastructure of different organs of respiratory, lymphoid and cardiovascular systems.

Unit III

Light and ultrastructure of different organs of urino-genital systems.

Unit IV

Light and ultrastructure of different sense organs and nervous system.

Unit V

Light and ultrastructure of different organs of endocrine system

V. Practical

Study of histological structure of organs of digestive, respiratory, urinary, genital and cardiovascular systems of buffalo, horse and dog/ cat.

I. Course Title : Developmental Anatomy

II. Course Code : ANA 608

III. Credit Hours : 2+1

IV. Theory

Unit I

Gametogenesis, Classification of eggs, fertilization, cleavage and gastrulation

Unit II

Development of foetal membranes and placenta in domestic animals.

Unit III

Histogenesis of nervous system, sense organs, lymphoid organs, endocrine organs and cardiovascular system

Unit IV

Embryonic development of digestive, respiratory, uro-genital and musculoskeletal system.

V. Practical

Study of serial sections of the chick and pig embryos at different stages of development.

I. Course Title : Wild Life and Forensic Anatomy

II. Course Code : ANA 609

III. Credit Hours : 1+0

IV. Theory

Unit I

Importance of anatomy of wild animals in veterinary anatomy.

Unit II

Anatomy of different body systems of wild animals.

Unit III

Anatomy of different body systems of wild birds.

Unit IV

Application of wild life anatomy in forensic veterinary medicine

Course Title with Credit Load
Ph.D. in Veterinary Anatomy

Course Code	Course Title	Credit Hours
RPE 700	Research and Publication Ethics*	1+1
ANA 701	Myology, angiology, neurology and aesthesiology of equine, canine and porcine	2+1
ANA 702	Principles and applications of biomechanics	1+0
ANA 703	Avian anatomy	1+1
ANA 704	Neuroanatomy	2+1
ANA 705	Comparative endocrine anatomy	1+1
ANA 706	Theory and applications of electronmicroscopy	1+1
ANA 707	Histoenzymology and immunocytochemistry	2+1
ANA 708	Applied embryology and teratology	1+1
ANA 709	Functional veterinary anatomy	1+0
ANA 710	Gross anatomy of laboratory animals	1+1
ANA 711	Cross sectional anatomy of ox	0+1
ANA 712	Animal alternatives in veterinary anatomy	1+1
ANA 713	Special problem	0+2
ANA 714	Doctoral seminar- I	1+0
ANA 715	Doctoral seminar- II	1+0
ANA 716	Doctoral research	0+75

*Compulsory Major course for Doctorate programme. The other 10 credits can be registered from remaining 700 Series courses listed above. Suggested list of specified Minor subjects (Departments).

Major Subject	Supporting subjects (Departments)*
Veterinary Anatomy	Biochemistry, Physiology, Veterinary Pathology, Veterinary Gynaecology and Obstetrics, Veterinary Surgery and Radiology, Biotechnology.

*The Minor courses may be taken from any number of disciplines/ departments listed against major discipline limiting to credits prescribed as decided by the Chairman of Advisory Committee of the student.

Minor courses may also be taken from the disciplines/ departments other than those listed above on the recommendations of advisory committee, if essentially required as per the research problem with the concurrence of Head of the Department and Concerned Authorities.

Course Contents
Ph.D. in Veterinary Anatomy

I. Course Title : Myology, Angiology, Neurology And Aesthesiology Of Equine, Canine And Porcine

II. Course Code : ANA 701

III. Credit Hours : 2+1

IV. Aim of the course

To teach students about anatomy of muscles, blood vessels, nervous tissue and sense organs in equine, canine and porcine.

V. Theory

Unit I

Comparative study of mycology of horse, dog and pig.

Unit II

Comparative study of angiology of horse, dog and pig.

Unit III

Comparative study of neurology of horse, dog and pig.

Unit IV

Comparative study of aesthesiology of horse, dog and pig.

VI. Practical

Dissection of different body regions with respect to muscles, blood vessels and nerves; and see the topographic positioning of different organs in different body cavities in equine, canine and porcine.

I. Course Title : Principles and Applications of Biomechanics

II. Course Code : ANA 702

III. Credit Hours : 1+0

IV. Aim of the course

To sensitize the student about the importance of biomechanics.

V. Theory

Unit I

Biomechanics, its definition and scope with reference to anatomy and physiology of domestic animals and musculo-skeletal dynamics.

Unit II

Locomotion and clinical applications. Biomechanics of cortical and trabecular bones.

Unit III

Biomechanics of fracture fixation. Instrumentation and techniques in locomotion and their applications in lameness.

S. No.	Topic	No. of Lectures
Theory		
1.	Definition of Biomechanics and its classification.	1
2.	Scope Biomechanics of with reference to anatomy and physiology of domestic animals	1
3.	Musculo-skeletal dynamics	2
4.	Locomotion and its type in domestic animals	2
5.	Instrumentation and techniques in locomotion and their applications in lameness.	2
6.	Biomechanics of microscopic structures	1
7.	Polariscope, its principle and application	2
8.	Biomechanics of cortical and trabecular bones.	1
9.	Biomechanics of articular cartilages	2
10.	Biomechanics of mammalian body; bow and string theory	2
11.	Biomechanics of fracture fiXation	1
12.	Biomechanics of heart	1
	Total	18

I. Course Title : Avian Anatomy

II. Course Code : ANA 703

III. Credit Hours : 1+1

IV. Theory

Unit I

The study of the gross features of different body systems of domestic fowl.

Unit II

The study of microscopic features of different body systems of domestic fowl.

V. Practical

Dissection and demonstration of various body systems of fowl and different domestic birds. Microscopic eXamination of slides of various organ systems of fowl.

I. Course Title : Neuroanatomy

II. Course Code : ANA 704

III. Credit Hours : 2+1

IV. Aim of the course

To provide in-depth knowledge of nervous system.

V. Theory

Unit I

The gross and microscopic anatomy of the brain and spinal cord.

Unit II

Study of various cranial and spinal nerves along with their associated nuclei and ganglia.

Unit III

Motor and sensory pathways, different ascending and ascending tracts of brain and spinal cord and autonomic nervous system.

VI. Practical

Gross dissection and microscopic eXamination of the brain and spinal cord; demonstration of the nerves, nerve pleXuses, ganglia of cranial importance, study of the serial sections of the brain and spinal cord in domestic animals.

I. Course Title : Comparative Endocrine Anatomy

II. Course Code : ANA 705

III. Credit Hours : 1+1

IV. Theory

Unit I

Advanced gross and microscopic anatomy of the pituitary gland.

Unit II

Advanced gross and microscopic anatomy of the thyroid, parathyroid and thymus.

Unit III

Advanced gross and microscopic anatomy of the adrenal gland, islets of Langerhans, corpus luteum, Leydig cells, pineal body and other tissues associated with endocrine secretions

V. Practical

Demonstration of the topographic anatomy in the embalmed specimens and microscopic examination of the endocrine glands of ruminants.

I. Course Title : Theory and Applications of Electron Microscope

II. Course Code : ANA 706

III. Credit Hours : 1+1

IV. Theory

Unit I

Introduction and principles of electron microscopy.

Unit II

Methods for transmission electron microscopy.

Unit III

Methods for scanning electron microscopy.

V. Practical

Preparation of blocks and demonstration of various techniques used for carrying out TEM and SEM.

I. Course Title : Histoenzymology and Immunocytochemistry

II. Course Code : ANA 707

III. Credit Hours : 2+1

IV. Theory

Unit I

Classification of enzymes – Principles of enzymes histochemistry methods.

Unit II

Substrates –combination–coupling azo-dye methods –capture reagents.

Unit III

Localization of enzymes and controls in enzyme histochemistry.

Unit IV

Fluorescence microscopy in enzyme histochemistry. Principles and techniques of immunohistochemistry.

V. Practical

Preparation of fixatives and buffers used in histochemistry. Methods of preparations and microscopical examination of routine and special preparations showing different cell organelles and inclusions. Methods for tryptophan-SS, SH groups; Glycogen-glycoproteins; Mucopolysaccharides and lipids. Methods and identification of alkaline and acid phosphatases-succinic dehydrogenase, cytochrome-oxidase, choline-esterase, catecholamines by fluorescence microscopy. Immunohistochemistry-principles and techniques.

I. Course Title : Applied Embryology and Teratology

II. Course Code : ANA 708

III. Credit Hours : 1+1

IV. Aim of the course

To apprise the students about the current trends in developmental processes.

V. Theory

Unit I

Principles of experimental embryology and teratology.

Unit II

Factors affecting the developmental mechanisms of embryo.

Unit III

Use of organizers implants, chemical and hormonal preparations in the developmental models and available literature on teratogenic experimentation.

VI. Practical

Collection and study of various teratological specimens from domestic animals. Class discussions on experimental models and available literature on teratogenic experimentation. To apprise the students about the current trends in developmental processes.

I. Course Title : Functional Veterinary Anatomy
II. Course Code : ANA 709
III. Credit Hours : 1+0
IV. Theory

Unit I

The relationship of structure to form and function.

Unit II

The relationship of structure for adaptation and behaviour.

Unit III

Relationship of structure in relation to clinical conditions/ applications.

I. Course Title : Gross Anatomy of Laboratory Animals
II. Course Code : ANA 710
III. Credit Hours : 1+1
IV. Theory

Unit I

Study of different organs of digestive system of different laboratory animals.

Unit II

Detailed study of urinary, male and female reproductive systems of different laboratory animals.

Unit III

Complete study of respiratory system of different laboratory animals.

Unit IV

Study of organs of circulation and nervous system of different laboratory animals.

Unit V

Descriptive anatomy of endocrine glands of different laboratory animals.

V. Practical

Demonstration of placement and relations of different organs in the body cavities of different laboratory animals.

I. Course Title : Cross Sectional Anatomy of Ox

II. Course Code : ANA 711

III. Credit Hours : 0+1

IV. Practical

Demonstration and topographic anatomy of various structures and organs at different levels of cross sections of the body. Correlation of different structures in different cross sections.

I. Course Title : Animal Alternatives in Veterinary Anatomy

II. Course Code : ANA 712

III. Credit Hours : 1+1

IV. Theory

Unit I

Introduction and ethical issues, scope, advantages and disadvantages of alternatives.

Unit II

Plastination, 2D and 3D Models.

Unit III

Taxidermy, computer simulations.

Unit IV

Maannequins, interactive mutimedia.

Unit V

Museum specimen preparation.

V. Practical

Techniques of Plastination, 2D and 3D Models, Taxidermy, computer simulations Maannequins, interactive mutimedia.

I. Course Title : Special Problem

II. Course Code : ANA 713

III. Credit Hours : 0+2

IV. Practical

S. No.	Topic	No. of Practicals
1.	Short research problem(s) involving contemporary issues and research techniques.	32

V. Recommended list of Books

Gross Anatomy

- Dyce KM, Sack WO and Wensing CJG. 1996. *Text Book of Veterinary Anatomy*. W.B. Saunders Co.
- Konig HE and Liebich HG. 2004. *Veterinary Anatomy of Domestic Animals: Textbook and Colour Atlas*.1st edn., Stuttgart, Schattauer Co., Germany.
- Nickel R, Schumer A, Seiferle E, Freewin J and Wills KH. 1986. *The Locomotor System of Domestic Mammals*. Verlag Paul Parey.
- Schummer A, Nickel R and Sack WO. 1979. *The Viscera of the Domestic Mammals*. Verlag

Paul Parey.
- Seiferle E. 1975. *Nervous System, Sensory Organs, Endocrine Glands of DomesticMammals.* Verlag Paul Parey.
- Sisson S and Grossman JD. 1975. *The Anatomy of the Domestic Animals*. Vols. I, II. W.B. Saunders Co.

Histology

- Banks WJ. 1993. *Applied Veterinary Histology*. Mosby Year Book, USA.
- Dellmann HD. 1993. *Textbook of Histology*. Lea and Febiger, USA.
- DiFiore MS, Mancini R and Derbertis EDP. 2006. *New Atlas of Histology*. Williams and Wilkins, Lippincott, USA.
- Eurell JA and Frappier BL. 2006. *Dellmann's Textbook of Veterinary Histology*. 6thedn., Blackwell Publishing, Ames, Iowa, USA.
- Greep RO. 1977. *Histology*. McGraw-Hill Book Co., New York, USA.
- Ham AW and Cormack DH. 1979. *Histology*. J.B. Lippincott, Philadelphia, USA.
- Stinson AW and Calhoun ML. 1993. *Text book of Veterinary Histology*. 4th edn., Lea and Febiger, Philadelphia, USA.

Embryology

- Arey LB 1965. *Developmental Anatomy*. W.B. Saunders.
- Freeman WH and Brace Girdle B. 1967. *Atlas of Embryology*. Heilemann Edu. Books Ltd.
- Langman J. 1976. *Medical Embryology*. William and Wilkin, Lippincott, USA.
- Latshaw WK. 1984. *Veterinary Developmental Anatomy; A Clinically Oriented Approach*. B.C. Decker Inc., Philadelphia, USA.
- Patten BM. 1985. *Foundation of Embryology*. Tata McGraw-Hill Book Co., USA.
- Patten BM. 2014. *Foundation of Embryology*. 6th edn., Tata McGraw-Hill Education, India.
- Tuchmann-Duplessis, MH David G, and Haegel P. 1972. *Illustrated Human Embryology*. Vol. I, II. Embryogenesis. Springer Verlag, USA.

Anatomical Techniques

- Durry RAB and Wallington EA. 1967. *Carleton's Histological Techniques*. OXford University Press, London.
- Luna LG 1968. *Manual of Histologic Staining Methods of the Armed Forces Institute of Pathology*. McGraw-Hill Book Co., USA.
- Pearse AGE. 1968. *Histochemistry-Theoretical and Applied*. 3rd edn., Vol. I, Churchill Livingstone, London.
- Tompsett DH and Wakeley SC. 1956. *Anatomical Techniques*. E. and W. Living Stone, London.
- Bancroft JD and Stevens A. 1977. *Theory and Practice of Histological Techniques*. Churchill Livingstone.
- Thomson SW and Hunt RD. 1968. *Selected Histochemical and Histopathological Methods*. Charles C. Thomas Publication, Springfield, Illinois, USA.

List of Journals

- *Acta Anatomica*
- *American Journal of Anatomy*
- *Anatomia Histologia and Embryologia*
- *Anatomical Record*
- *Anatomy and Embryology*
- *Indian Journal of Veterinary Anatomy*
- *Journal of Anatomy*

e-Resources

- http://www.interscience.wiley.com/journal/117927935/grouphome/home. (American Journalof Anatomy)
- http://www.ovid.com/site/catalog/Journal/1057.jsp (Journal of Anatomy)
- http:http:www.interscience.wilety.com/jpages/0003-276X/(Anatomical Record)
- http://www.blackwellpublishing.com/submit.asp (Anatomia Histologia and Embryologia)

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Basic Veterinary Sciences

– Veterinary Biochemistry

Course Title with Credit Load
M.V.Sc. in Veterinary Biochemistry

Course Code	Course Title	Credit Hours
BCT 601	Biophysical Chemistry	2 + 0
BCT 602	Biochemistry of Biomolecules	2 + 0
BCT 603	Enzymology	2 + 1
BCT 604	Analytical Techniques and Instrumentation in Biochemistry	1 + 1
BCT 605	Clinical Biochemistry of Animals	2 + 1
BCT 606	Intermediary Metabolism and Regulation	3 + 0
BCT 607	Molecular Biochemistry	2 + 1
BCT 608	Nutritional and Industrial Biochemistry	2 + 0
BCT 609	Endocrinology and Reproductive Biochemistry	2 + 0
BCT 610	Biochemistry of Ruminants and Wild Animals	1 + 1
BCT 611	Introduction to Bioinformatics and Computational Biology	1 + 1
BCT 612	Master's Seminar	1 + 0
BCT 613	Master's Research	0 + 30

Suggested list of specified Minor subjects (Departments)

Major Subject	Minor subjects (Departments)*
Veterinary Biochemistry	Physiology, Medicine, Animal Nutrition, Animal Genetics and Breeding, Biotechnology, Livestock Production Management, Pharmacology and Toxicology, Microbiology, Parasitology, Pathology, Gynaecology.

*The Minor courses may be taken from any number of disciplines/ departments listed against major discipline limiting to credits prescribed as decided by the Chairman of Advisory Committee of the student. Minor courses may also be taken from the disciplines/ departments other than those listed above on the recommendations of advisory committee, if essentially required as per the research problem with the concurrence of Head of the Department and Concerned Authorities.

Course Contents
M.V.Sc. in Veterinary Biochemistry

I. Course Title : Biophysical Chemistry

II. Course Code : BCT 601

III. Credit Hours : 2 + 0

IV. Theo

ryUnit

I

Physical properties of water-the medium of life, Acids and bases, ionic strength and activity, Henderson-Hasselbach equation, pH, indicators and buffers, Colloids and their properties, Mechanism of osmosis, osmotic pressure, Donnan membrane equilibrium, Viscosity, surface tension, surface forces, Adsorption and light scattering, Membrane filtration, dialysis, diffusion coefficient and partial specific volume.

Unit II

Laws of thermodynamics, Concepts of enthalpy, free energy and entropy in biochemical reactions. High energy compounds, Redox potential and free energy changes, Bioenergetics and biological oxidation, Components of mitochondrial electron transport chain. Formation of ATP and ATP cycle. Energy transformation in living cells.

Unit III

Basic Methods in Biophysical Chemistry: Basic Optical Principles, Optical Properties of Biomolecules, Optical spectroscopy, Basic Fluorescence Techniques, Chiroptical and Scattering Methods; Conventional and Confocal Fluorescence Microscopy, Basics of Super-Resolution Fluorescence Microscopy, Fluorescence spectroscopy, Patch Clamping.

V. Suggested Reading

- David L Nelson and Cox Michael M. 2008. *Lehninger's Principles of Biochemistry*. 5th Ed. Freeman.
- James P Allen. 2008. *Biophysical Chemistry*. 1st Ed. Wiley-Blackwell Publication.
- Peter Jomo Walla. 2014. *Modern Biophysical Chemistry: Detection and Analysis of Biomolecules*. 2nd Ed. Wiley-VCH Publication.

I. Course Title : Biochemistry of Biomolecules

II. Course Code : BCT 602

III. Credit Hours : 2 + 0

IV. Theory

Unit I

Carbohydrates: Structure and biological significance of important monosaccharides:Ribose, Glucose, Fructose, Galactose, Mannose and Amino Sugars; Chemical reactions of monosaccharides; Isomerism of carbohydrates; Structure and biological significance of Disaccharides (Maltose, Isomaltose, Lactose, Sucrose and Cellobiose); Structure and biological significance of polysaccharides (Starch, Dextrins, Dextrans, Glycogen, Cellulose, Inulin, Chitin), and Mucopolysaccharides including Blood group substances and Bacterial cell wall polysaccharides. Glycoconjugates in cell surface, extra cellular matrix, sugar code functions, peptidoglycan-specific

antibiotics; Basic principles of separation, purification and characterization of carbohydrates; Methods of structural analysis of carbohydrates.

Unit II

Lipids: Definition, Classification, Properties and Biological significance of simple, compound and derived lipids; Fat indices; Structure and functions of prostaglandins, steroids, steroid hormones and fat soluble vitamins. Basic principles of eXtraction and analysis of lipids; Lipid bilayers, lipid motility, integral membrane proteins, lipid linked proteins, peripheral membrane proteins, fluid mosaic model, membrane skeleton, lipid asymmetry, cardiac glycosides, abnormalities in cell membrane fluidity, signaling biomolecules.

Unit III

Proteins: Amino acids - Structure and classification. Physical and chemical properties of amino acids - amphoteric nature, acid-base property, optical activity and peptide bond formation; Structure and geometry of peptide bond. Chemical synthesis of polypeptide and Oligopeptides of biological significance; Classification of proteins; Structure – primary, secondary, tertiary and quaternary; Physico-chemical, acid-base and colloidal properties of proteins; Biological significance of proteins; Denaturation, eXtraction and purification criteria for proteins.

Unit IV

Nucleic acids: Chemistry of purines, pyrimidines, nucleosides and nucleotides. Biological significance of nucleosides and nucleotides. Structures and functions of Watson-crick model of deoXyribonucleic acid (DNA) and a typical ribonucleic acid (RNA). Different types of DNA, acid-base properties, sedimentation behaviour, hyperchromic effect, melting of DNA, Chemical and enzymatic hydrolysis of nucleic acids. Base sequence analysis of DNA, Nucleic acid- protein interaction - histone and non-histone proteins.

V. Suggested reading

- David L Nelson and CoX Michael M. 2017. *Lehninger's Principles of Biochemistry*. 7th Ed. Freeman.
- Voet D, Voet JG and Pratt CW. 2016. *Fundamentals of Biochemistry of Life at the Molecular Level*. 5th Ed. John Wiley and Sons.
- Berg JM, Tymoczko JL, Stryer L and Clarke ND 2015. *Biochemistry*. 8th Ed. WH Freeman and Co.
- Zubay GL. 1998. *Biochemistry*. 4th Ed. WCB London.

I. Course Title : Enzymology

II. Course Code : BCT 603

III. Credit Hours : 2 + 1

IV. Theory

Unit I

Introduction and historical perspective, Enzyme nomenclature and classification, enzyme compartmentalization in cell organelles, measurement of enzyme activity. ribozymes, isozymes, abzymes, restriction endonucleases.

Unit II

Enzyme structure, enzyme specificity, active site, active site mapping, mechanism of enzyme catalysis. cofactors, coenzymes- their structure and role.

Unit III

Enzyme kinetics, enzyme inhibition and activation, multienzyme complexes,

allosteric enzymes and their kinetics, regulation of enzyme activity. qualitative description of "concerted" and "sequential" models for allosteric enzymes. Half site reactivity, Flip-flop mechanism, positive and negative co-operativity. Monod Koshland Model.

Concept of ES complex, active site, specificity derivation of Michaelis-Menten equation for uni- substrate reactions. Different plots for the determination of Km and Vmax and their physiological significances. Importance of Kcat/ Km. Kinetics of zero and first order reactions. Significance and evaluation of energy of activation.

Unit IV

Isolation, purification and characterization of enzymes, Applications of enzymes in chemical and feed industry, enzyme immobilization, biosensors, clinical and diagnostic applications of enzymes.

V. Practical

- Enzyme assay by taking any model enzyme like alpha-amylase or alkaline phosphatase.
- Isolation, purification and characterization of any model enzyme like B-galoctosidase or acid phosphatase.
- Study of the effect of enzyme and substrate concentrations and determination of Km and Vmax.
- Determination of pH and temperature optima of alkaline phospatase.
- To study the effect of various inhibitors of enzymatic activity.
- Determination of the pH and temperature stability of alkaline phosphatase.
- Assay of Diagnostic enzymes from Clinical samples.
- Application of enzymes in ELISA and Western Blotting

VI. Suggested Reading

- Bergmeyer HU. 1983. *Methods of Enzymatic Analysis*. Vol. II. Verlag Chemie, Academic Press.
- Dixon M, Webb EC, Thorne CJR and Tipton KF. 1979. *Enzymes*. 3rd Ed. Longman.
- Maragoni AG. 2003. *Enzyme Kinetics - A Modern Approach*. John Wiley.
- Palmer T. 2001. *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. 5th Ed. Horwood Publ.
- Price NC and Stevens L. 2003. *Fundamentals of Enzymology*. Oxford Univ. Press.
- Wilson K and Walker J. (Eds.). 2000. *Principles and Techniques of Practical Biochemistry*. 5th Ed. Cambridge Univ. Press.
- David L Nelson and Cox Michael M. 2008. *Lehninger's Principles of Biochemistry*. 5th Ed. Freeman.
- Kaneko JJ, Harvey JH and Bruss ML. 2008. *Clinical Biochemistry of Domestic Animals*. 6th Ed. Academic Press.

I. Course Title : Analytical Techniques and Instrumentation in Biochemistry

II. Course Code : BCT 604

III. Credit Hours : 1 + 1

IV. Theory

Unit I

Solutions and Buffers: Units of expression of concentration of solutions - Preparation of solutions - Preparation of Buffers - Henderson-Hasselbalch equation in the preparation of buffers. Spectroscopy: Theory and applications of Colorimetry and Spectrophotometry; Major components of the following instruments and their functions: UV-Visible Spectrophotometer, Spectrofluorometer, Flame photometer, Atomic absorption spectrophotometer, Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES).

Unit II

Chromatographic Techniques: Basic principle and applications of Paper, Column and Thin layer chromatography including HPTLC; Factors affecting chromatographic resolution; Methods of preparation of biological samples for chromatographic analysis and common methods for qualitative and quantitative chromatography of amino acids, lipids and sugars including elution and densitometry. Molecular Sieving and its application in Biochemistry – General properties of dextran, acrylamide, agar and other media used for gel filtration. Principles and applications of chromatographic techniques, viz., ion-exchange, gel-filtration, affinity, hydrophobic interaction chromatography, metal chelate chromatography, planar chromatography, lateral flow immunochromatographic assays, Introduction to GLC and HPLC (Normal and Reverse Phase).

Unit III

Theory and applications of Electrophoresis: Factors affecting migration of charged particles – Moving boundary, paper and gel electrophoresis - Electrophoresis of amino acids, proteins and nucleic acids – Use of SDS PAGE in molecular weight determination. Isoelectric focusing and Isotachophoresis - Densitometry procedures and quantitative assays. Introduction to 2-D gel electrophoresis; Immuno-electrophoresis and other techniques like ELISA, RIA and Immuno-blotting.

Unit IV

Theory and applications of Centrifugation: Basic principle of sedimentation – Types, care and safety aspects of Centrifuges – Preparative centrifugation and Analytical centrifugation - Introduction to Ultracentrifugation - Fractionation of sub-cellular components - Density Gradient centrifugation – Determination of relative molecular mass.

N.B.: GLC and HPLC at length are to be discussed under BCT 705 (Ph.D. course); here only introduction.

V. Practical

- Preparation of solutions and buffers; Solving problems using Henderson–Hasselbalch equation, pH, pKa and buffer concentration, normality; Verification of Beer's – Lambert's law; Estimation of glucose and total cholesterol in serum; Determination of absorption maxima and molar extinction coefficient of p-Nitrophenol from its absorption spectrum; Estimation of proteins using biuret, foiln-ciocalteau methods and UV spectrophotometry; Estimation of enzyme activity by spectrophotometry (Kinetic mode).
- Separation of Lipids/ amino acids using paper chromatography and TLC; Fractionation of proteins by ammonium sulphate precipitation and desalting by dialysis; Separation of proteins using Ion-exchange chromatography, affinity chromatography and gel-filtration chromatography; Demonstration of separation of fatty acid methyl esters using GLC.
- Electrophoretic analysis of albumin using non-denaturing and denaturing conditions – Detection of molecular weight of protein by SDS-PAGE - Characterization of immunoglobulins by PAGE - Demonstration of sub-cellular fractionation by centrifugation.

VI. Suggested Reading

- David L Nelson and Cox Michael M. 2017. *Lehninger's Principles of Biochemistry*. 7th Ed. Freeman.
- Wilson K and Walker J. (Eds.). 2010. *Principles and Techniques of Biochemistry and Molecular Biology*. 7th Ed. Cambridge Univ. Press.
- Willard *et al.* 1988. *Instrumental Methods of Analysis*. 7th Ed. Wadsworth Pub Co.
- Garrity S. 1999. *Experimental Biochemistry*. 3rd Ed. Academic Press.

- Gowenlock AH. 2002. *Varley's Practical Clinical Biochemistry*. 6th Ed. CBS.
- Holme DJ and Hazel P. 1998. *Analytical Biochemistry*. 3rd Ed. Longman.
- George W. Latimer, Jr. 2016. *Official Methods of Analysis of AOAC International*, 20th Ed. AOAC International.
- Carl A. Burtis, Edward R. Ashwood and David E. Burns, 2014. *Tietz Textbook of clinical Biochemistry and Molecular Diagnostics*. 5th Edition. Elsevier

I. Course Title : Clinical Biochemistry of Animals

II. Course Code : BCT 605

III. Credit Hours : 2 + 1

IV. Theory

Unit I

Quality control and automation in clinical biochemistry. Disturbance in water, electrolytes and acid-base balance - electrolyte abnormalities - respiratory acidosis and alkalosis - metabolic acidosis and alkalosis – compensation – biochemical tests for diagnosis.

Unit II

Disorders of Carbohydrate metabolism: Diabetes mellitus, hyperinsulemia, glactosemia, hypoglycaemia, Glycogen storage disease and glycated proteins. Carbohydrate and protein balance for optimum rumen microflora. Ruminant ketosis – Ketosis associated with fasting, diabetes, pregnancy, lactation and post-exercise.

Unit III

Disorders of Lipid metabolism: Hypercholesterlemia, atherosclerosis, hyperlipidemia in canine, feline, equine – pathophysiology of ketonemia. Disorders of proteins, amino acids and nucleic acids metabolism: Normal and abnormal plasma proteins – Dysproteinemia – acute phase proteins – inborn errors of amino acid metabolism– Phenylketonuria, alkaptonuria, albinism, tyrosinosis, maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anemia, Histidinemia – defect in collagen biosynthesis. Abnormalities in Nitrogen Metabolism – Uremia, hyperuricemia, porphyria and factors affecting nitrogen balance. Composition and diagnostic significance of cerebrospinal fluid and amniotic fluid. Doping in horses.

Unit IV

Liver function tests - indications and limitations - classification of tests – Biochemical tests for liver function - serum enzyme activities to asses liver function - Hepatic encephalopathy – Hepatic photosensitivity – Ascites. Renal function: Direct and indirect test for glomerular filtration – tests for tubular function – test for kidney damage Gastrointestinal function: Disturbances in gastrointestinal function – disturbance in rumen function.

Unit V

Clinical enzymology - functional and non-functional plasma enzymes - plasma enzymes of diagnostic importance - ALP, CK, LDH, AST, ALT, OCT - Iso-enzymes and their diagnostic importance. Oxidative Stress: Biochemical basis of disease progression and diagnostic enzymes. Biochemical markers of cardiac diseases: Hypertension, myocardial infarction and heart failure. Respiratory distress syndrome, COPD, Ischemia, shock.

Unit VI

Disorders of mineral metabolism: Hypercalcaemia, hypocalcaemia, normocalcaemia, hypophosphataemia, hyperphosphataemia. Biochemistry of tumours and various types of tumour markers for the diagnosis of prostate cancer, ovarian cancer, mammary tumour, lymphoma, bladder cancer and pancreatic cancer.

Unit VII

Biochemical basis and diagnosis of prevalent diseases and metabolic disorders in wild animals, and poultry.

V. Practical

Urine analysis - Physical and chemical tests for normal and pathological constituents of urine. Quality Control-Precision, Accuracy, Sensitivity and Specificity; Estimation of Blood glucose - Serum biochemical parameters – Total protein, A/G ratio, Cholesterol, urea, uric acid, bilirubin, creatinine – Serum enymes – ALP, ACP, AST and ALT – Electrophoresis of plasma proteins - Separation of Iso-enzymes. Estimation of Ca, Mg, P, K, Na in serum samples. Estimation of Vit C, D and E.

VI. Suggested Reading

- David L Nelson and Cox Michael M. 2007. *Lehninger's Principles of Biochemistry*. 4th Ed. Freeman.
- Kaneko JJ, Harvey JH, Bruss ML. 2008. *Clinical Biochemistry of Domestic Animals*. 6th Ed. Academic Press.
- Racek J and Rajdl D. 2016. *Clinical Biochemistry*. 1st Ed. Karolinum Press.
- Voet D, Voet JG and Pratt CW. 2006. *Fundamentals of Biochemistry of Life at the Molecular Level*. 2nd Ed. John Wiley and Sons.

I. Course Title : Intermediary Metabolism and Regulation

II. Course Code : BCT 606

III. Credit Hours : 3 + 0

IV. Theory

Unit I

Carbohydrate metabolism and regulation - Major pathways - Glycolysis - Reactions, functions and its control - Metabolism of other sugars - Fructose, Galactose, Mannose and Lactose - Pyruvate dehydrogenase and reactions of Citric acid cycle - Anaplerotic reactions - Energetics of glucose oxidations. Alternate pathways of glucose metabolism - HMP pathway and its importance - Glucuronic acid cycle - Gluconeogenesis - Substrates - pathway and control of amino sugar - Glycogen metabolism - Glycogenolysis and Glycogenesis reactions - Metabolic disorders - Glycogen storage diseases (GSD).

Unit II

Lipid metabolism and regulation - Lipid transport and storage - Plasma lipoproteins - Role of liver and adipose tissue in fat metabolism - Role of brown adipose tissue in thermogenesis - Catabolism of triacylglycerols – Beta oxidation of fatty acids – Ketogenesis and utilization of ketone bodies - Biosynthesis of fatty acids, triacylglycerols, phopholipids and cholesterol – Production of Bile acids - Metabolism of Eicosanoids - Lipid storage diseases.

Unit III

Amino acids metabolism - Protein turnover and regulation - amino acid pools and absorption of amino acids - catabolism of amino acids - Deamination, transamination. Ammonia carriers; Excretion of nitrogen - urea cycle. Catabolism of carbon skeletons of amino acids. Conversion of amino acids to specialized products – Heme Biosynthesis - Physiologically active amines. Biosynthesis of non-essential amino acids. Metabolic disorders.

Unit IV

Catabolism and regulation of purine and pyrimidine nucleotides/ deoxynucleotides - Biosynthesis and regulation of purine and pyrimidine nucleotides - Biosynthesis of nucleotide coenzymes and regulation - Inhibitors of purine and pyrimidine metabolism and role in cancer therapy – Metabolic disorders.

Unit V

Structural and functional relationships of specialized tissues and organs; Organ specialization in fuel metabolism: Brain, muscle, adipose tissue, liver, kidney; Inter organ metabolic pathways, hormonal control of fuel metabolism. Tracing metabolic fates, perturbing the system. Metabolic interrelationships in obesity, diabetes, cancer, aerobic and anaerobic exercise in horses, pregnancy, lactation and stress injury.

V. Suggested Reading

- Berg JM, Tymoczko JL, Stryer L and Clarke ND 2015. *Biochemistry*. 8th Ed. WH Freeman and Co.
- David L Nelson and Cox Michael M. 2017. *Lehninger's Principles of Biochemistry*. 7th Ed. Freeman.
- Kaneko JJ, Harvey JH and Bruss ML. 2008. *Clinical Biochemistry of Domestic Animals*. 6th Ed. Academic Press.
- Metzler DE. *Biochemistry*. John Wiley.
- Swenson MJ and Reece WO.2015. *Dukes' Physiology of Domestic Animals*. 13th Ed. Panima.
- Voet D, Voet JG and Pratt CW. 2016. *Fundamentals of Biochemistry of Life at the Molecular Level*. 5th Ed. John Wiley and Sons.
- Zubay GL. 1998. *Biochemistry*. 4th Ed. WCB London.

I. Course Title : Molecular Biochemistry

II. Course Code : BCT 607

III. Credit Hours : 2 + 1

IV. Theory

Unit I

Historical development of molecular biology, nucleic acids as genetic material, chemistry and structure of DNA and RNA, Genome organization in prokaryotes and eukaryotes, repetitive and non-repetitive DNA, satellite DNA; chromatin structure and function.

Unit II

DNA replication mechanisms in prokaryotes and Eukaryotes, DNA polymerases, Topoisomerases, DNA ligase, Reverse transcriptase, Transcription mechanisms in Prokaryotes and Eukaryotes, RNA polymerases, RNA editing, post transcriptional RNA processing. Recombination mechanisms, DNA repair mechanisms, Telomeres, Telomerase, Role of Telomeres in Cancer.

Unit III

Ribosomes - structure and function, organization of ribosomal proteins, genetic code, aminoacyl tRNA synthases, Inhibitors of replication, transcription and translation; Translation mechanisms in Eukaryotes and Prokaryotes and Post - translational modification; Nucleases and restriction enzymes, regulation of gene expression in prokaryotes and eukaryotes.

Unit IV

DNA sequencing techniques, Recombinant DNA technology, Plasmid biology, Cloning Vectors, Expression vectors, selection of recombinants, Heterologous protein expression systems, Recombinant protein purification, Polymerase Chain Reaction and its variants; Site Directed Mutagenesis, *In-vitro* transcription, Gene Silencing. Transgenic Animals, Introduction to Systems Biology.

V. Practical

Isolation and purification of DNA - Plasmid isolation- Isolation and purification of RNA – Determination of concentration of DNA and RNA by spectrophotometry - Determination of Tm of DNA by Spectrophotometry - Restriction Digestion of DNA, Agarose gel electrophoresis - RAPD analysis of DNA - cDNA synthesis using PCR

- Jocelyn E Krebs *et al.* 2017. *Lewin's Genes XII*. Jones and Bartlett Publishers Inc.
- Watson JD *et al.* 2017. *Molecular Biology of the Gene*. 7th Ed. Pearson Education.
- Eberhard. O. Voit. 2017. *A First Course in Systems Biology*, 2nd Edition. Garland Science Publishers.
- *Genome Editing and Engineering*: From TALENs, ZFNs and CRISPRs to Molecular Surgery, Ed. Krishnarao Appasani, Cambridge University Press, 2018
- *Molecular Cell Biology*, 8th Ed, Lodish *et al.* WH Freeman and Co., 2016
- *Molecular Biology of the Cell*, 6th Ed. Bruce Alberts *et al*, WW Norton and Company, 2014
- *Transgenic Animal Technology: A laboratory handbook*, 3rd Edition, Ed. Carl. A. Pinkert, Academic Press, 2014.
- *Molecular Biology*, 4th Ed, Robert F. Weaver, McGraw Hill Higher Education, 2007.

I. Course Title : Nutritional and Industrial Biochemistry

II. Course Code : BCT 608

III. Credit Hours : 2 + 0

IV. Theory

Unit I

Introduction - Nutrients and their importance in ruminants, non-ruminants and poultry - Energy value of various nutrients their importance and calorimetry - Nutrient absorption and biochemical changes involved - Introduction to BMR, SDA, PER and Biological value for protein - Requirements of different nutrients in animals - Role of nutrients in growth and production of animals – Bio-availability of nutrients in different food sources.

Unit II

Metabolic role of Nutrients - Overview of metabolism of different nutrients and regulation of nutrient absorption and utilization - Alterations that occur in nutritional requirement s during diseases and biochemical reactions due to Toxic factors in feed - Biochemical role of Macro and micro minerals in animal production - Vitamins and their role as co enzymes in metabolism – Nutrient deficiencies and metabolic disorders in animals - Biochemical alterations occurring due to phyto-toxins in ruminants - Biochemical importance of different feed additives - Agonists and antagonists of minerals and vitamins - Nutrient control of gene expression - Clinical issues of micro mineral metabolism - Nutrients (minerals) that resist digestion process in animals - Energy releasing and hematopoietic water soluble vitamins.

Unit III

Industrial biochemistry - applications of biological molecules for medical, industrial, environmental, agricultural or analytical purposes - Generation of gene-mediated industrial/ medical products - Introduction and application of fermentation technology for ethanol and biogas production - conversion of sunlight into biomass (bioreactors and biophotolysis) - Significance of pharmaceuticals products of animal origin (sex hormones- oestrogens, progesterone; corticosteroids) - Significance of pharmaceuticals of plant origin (alkaloids, atropine, morphine, cocaine, ergot alkaloids, flavonoids, xanthenes and terpenoids) - Physical, chemical and biological treatment of waste water, bioremediation of contaminated soils.

V. Suggested Reading

- *Nutritional Biochemistry*, 2nd Edition, Tom Brody, Elsevier pub.2009
- *Text book of Biochemistry with clinical correlations.* 6th edition, Thomas M Devlin, Wileys-liss. Press.
- *A textbook of industrial microbiology* 2nd edition, Crueger W and Crueger A. 2000, Panima Publishing Corp.
- *Principle of fermentation technology*, 1997, Stanbury PF, Ethitaker H, Hall S, Aditya Books (P) Ltd.
- *Bioprocess Engineering: Basic Concepts*. Shuler M and Kargi F. Second Edition. Pearson Education. 2002
- *Nutritional Biochemistry of the vitamins*, by David a Bender, 2nd Edition, Cambridge University Press.

I. Course Title : Endocrinology and Reproductive Biochemistry

II. Course Code : BCT 609

III. Credit Hours : 2 + 0

IV. Theory

Unit I

Endocrinology - Classification, secretion, transport and regulation of hormones - Mechanism of hormone action and intracellular signalling after receptor activation - Releasing factors from hypothalamus and their effects on pituitary gland and metabolism - Synthesis, secretion, regulation, metabolic functions and physio-pathology of Hormones from Pituitary, Thyroid, Parathyroid, Pancreas, Adrenal and Pineal Glands.

Unit II

Endocrinology of Gonads and Reproductive Biochemistry - Female hormonal system - Synthesis, secretion, regulation, functions, and physio-pathology of ovarian hormones and male sex hormones - Prostaglandins: chemistry, functions and clinical importance - Endocrine aspects of reproduction status in domestic animals - Endocrine aspects of reproduction in poultry - Hormones involved in the development of ductal and lobule-alveolar system of mammary gland - Endocrine control of biosynthesis of milk.

V. Suggested Reading

- *Dukes' Physiology of Domestic Animals*, 13th edition/ editor, William O Reece, Wiley Blackwell.
- Guyton and Hall *Textbook of Medical Physiology*, 13th edition/ editor, John E Hall, Elsevier.
- *Applied Animal Endocrinology*, E. James Squires, CABI
- *Endocrinology: An Integrated Approach*, by SS Nussey, SA Whitehead, 1st edition, CRC Press.
- *Biochemistry of Lactation*, TB Mepham, Elsevier

I. Course Title : Biochemistry of Ruminants and Wild Animals

II. Course Code : BCT 610

III. Credit Hours : 1 + 1

IV. Aim of the course

To acquaint the students about comparative metabolism in ruminant species and the common metabolic disorders in ruminants; to impart a basic knowledge about biochemistry of wild animals.

V. Theory

Unit I

Biochemistry of Ruminants - An overview of metabolism of carbohydrates, proteins and lipids in ruminants - Metabolism of nutrients by rumen microflora - Blood biochemistry of ruminants - Disorders associated with carbohydrates, proteins and lipid metabolism in ruminants - Liver and Kidney function tests - Diseases associated with major and trace elements in ruminants.

Biochemistry of Wild Animals - Blood biochemistry and blood typing of wild animals - Fluid balance and electrolyte maintenance in wild animals - Biomarkers for assessment of diseases in wild animals - Diabetes mellitus in primates - Neurological diseases in cheetah

VI. Suggested reading

- Dvorak AM and Harris W. 1991. *Blood Cell Biochemistry*. 2nd Ed. Plenum.
- *Clinical Biochemistry of Domestic Animals*, 6th Edition/ Editors: Jiro Kaneko John Harvey Michael Bruss, Elsevier.
- *Lipid Metabolism in Ruminant Animals*, 1st Edition/ Editors: William W Christie, Elsevier.
- *Digestive Physiology and Metabolism in Ruminants*, Editors: Ruckebusch Y, Thivend.
- *Energy Nutrition in Ruminants*, Editors: Orskov ER.
- *Zoo and Wild Animal Medicine* (Current Therapy 3) by Murray E Fowler, 5th edition.
- *Textbook of Veterinary Biochemistry*, by RS Dhanotiya, JAYPEE.

I. Course Title : **Introduction to Bioinformatics and Computational Biology**

II. Course Code : **BCT 611**

III. Credit Hours : **1 + 1**

IV. Theory

Unit I

Introduction to bioinformatics, scope and applications of bioinformatics; biological databases: primary, secondary and structural; basic concept of Protein and Gene Information Resources-PIR, SWISS-PROT, PDB, GenBank, DDBJ; Basic concept of computational biology, applications in different subfield of biology, software tools.

Unit II

Basic concept of sequence search algorithm and alignment tools: BLAST and FASTA; DNA and protein sequence analysis, local and global alignment; Algorithms: Dot MatriX method, dynamic programming methods; Pairwise and multiple sequence alignment and its application; Tools of Multiple sequence alignment: ClustalW.

Unit III

Basic concept of Phylogeny study; cDNA libraries and EST, EST analysis; database search engines: introduction and application; Commercial databases and software packages, GPL software for Bioinformatics.

Unit IV

Computer aided drug design: basic principles, docking; QSAR, 2DQSAR, 3DQSAR, their basic concept and applications, machine learning tools for QSAR.

V. Practical

- Basic computing: Introduction to LINUX and Windows
- Nucleotide information resource: EMBL, GenBank, DDBJ
- Protein information resource: SwissProt, TrEMBL, Uniprot
- Structure databases: PDB, MMDB
- Search Engines: Entrez, ARSA, SRS
- Usage of NCBI resources
- Retrieval of sequence/ structure from databases
- Database searching
- Visualization of structures of DNA and Proteins using Rasmol
- Sequence similarity search using BLAST
- Multiple sequence alignment
- Primer designing

VI. Suggested Reading

- *Introduction to Bioinformatics* 2003. Attwood TK and Parry-Smith DJ, Pearson Education.
- *Essential bioinformatics* 2006. Xin Xiong. Cambridge University Press.
- *Bioinformatics: Concepts, Skills and Applications* 2004. Rastogi SC, Mendiratta N and Rastogi P. CBS.
- *Principles of Genome Analysis and Genomics* 2003. SB Primrose and RM Twyman, Blackwell Publishing.
- *Molecular Analysis and Genome Discovery* 2004. Ralph Rapley and Stuart Harbron (Eds.), John Wiley and Sons.
- *BioInformatics* 2001. Andreas D BaXevanis and BF Francis Ouellette (Eds.)
- *Wiley Interscience Proteins and Proteomics* 2003. Richard J. Simpson, Cold Spring Harbor Laboratory.

Course Title with Credit Load
Ph.D. in Veterinary Biochemistry

Course Code	Course Title	Credit Hours
RPE700*	Research and Publications Ethics	1 + 1
BCT 701	Applied Molecular Biochemistry and Systems Biology	2 + 1
BCT 702	Membrane Biochemistry	2 + 0
BCT 703	Recent trends in Enzymology	2 + 1
BCT 704	Diagnostic Techniques in Clinical Biochemistry	0 + 2
BCT 705	Recent Trends in Biochemical Techniques and Instrumentation	2 + 1
BCT 706	Developmental Biochemistry	2 + 0
BCT 707	Bioinformatics Tools in Biochemistry	1 + 1
BCT 708	Environmental and Toxicological Biochemistry	2 + 0
BCT 709	Biochemistry of Diseases and Disorders	2 + 0
BCT 710	Immuno-Biochemistry	2 + 0
BCT 711	Special Problem	0 + 2
BCT 712	Doctoral Seminar-I	1 + 0
BCT 713	Doctoral Seminar-II	1 + 0
BCT 714	Doctoral Research	0+75

*compulsory Major course for Doctorate programme. The other 10 credits can be registered from remaining 700 Series courses listed above

Course Contents
Ph.D. in Veterinary Biochemistry

I. Course Title : Applied Molecular Biochemistry and Systems Biology
II. Course Code : BCT 701
III. Credit Hours : 2 + 1
IV. Pre-requisite

Should have studied BCT-607: Molecular Biochemistry (2+1) or other equivalent courses with similar syllabi/ content at Master's level.

V. Theory

Unit I

Organization of prokaryotic genome, nuclear and organelle genes, concept of genome mapping and Organization, Molecular evolution, Prokaryotic and Eukaryotic gene regulation, RNA editing.

Unit II

Comparative genomics, functional genomics, transcriptomics and transcriptional network, Application of genomics, Livestock genomics, Buffalo Genome Inititative, Dog genome projects, Role of genomics in Wild life conservation and Reconstruction of species, Bioethics and biosafety guidelines and IPR in recombinant DNA research.

Unit III

Transgenics, Gene Knock – out technology, Site specific nucleases, Zinc – Fingers, TALENS and CRISPR – Cas 9, Applications of Gene knock out, Development of Knock - out Animal models, Gene silencing, Antisense oligos, Ribozymes, RNAi, 3'UTR and miRNA, Applications of gene silencing, Site directed mutagenesis, gene targeting and gene therapy.

Unit IV

Nucleic acid sequencing: Various methods of sequencing including automated sequencing and Microarrays, Whole Genome Sequencing, epigenetic regulation, Protein sequencing, Peptide synthesis, Peptide arrays, protein engineering, Directed evolution of proteins.

Unit V

Mathematical modelling, Static Network models, Mathematics of Biological systems, Parameter estimation, Gene systems, Gene regulation models, Protein systems, Metabolic systems, Signalling systems, Population systems, Physiological modelling, Systems biology in Medicine and Drug development, Basic design of biological systems, Introduction to nutrigenomics and pharmacogenomics, Applications in Veterinary Science.

VI. Practical

DNA methylation protocols, Genome Editing protocols, *in-vitro* Site Directed Mutagenesis, Gene silencing protocols, Next Generation sequencing platforms, Quantitative PCR, SAGE, Massively Parallel Signature Sequencing (MPSS), Oligonucleotide synthesis and quality control, Cap Analysis of Gene Expression (CAGE)/ deep CAGE, Chip-Chip assay Proteomics - 2D-PAGE, MSMS, MALDI-TOF, and Protein-protein interaction (Hybrid assay, DNA-Protein interaction and gene regulation (EMSA and Chip assay), DNA Microarrays, Protein sequencing protocols.

VIII. Suggested Reading

- *Molecular Biology of the Gene*, 7th Ed. JD Watson *et al*., Pearson Education, 2017
- *Lewin's Genes XII*, Jocelyn E Krebs *et al*., Jones and Bartlett Publishers Inc., 2017
- *A First Course in Systems Biology*, 2nd Edition, Eberhard. OVoit, Garland Science publishers 2017
- *Directed Enzyme Evolution: Advances and Applications*, Ed. Miguel Alcalde, Springer International Publishing, 2017
- *Genome Editing in Animals: Methods and Protocols*, Ed. Izuho Hatada, Springer Protocols, 2017
- *Genome Editing and Engineering*: From TALENs, ZFNs and CRISPRs to Molecular Surgery, Ed. Krishnarao Appasani, Cambridge University Press, 2018
- *Molecular Cell Biology*, 8th Ed, Lodish *et al*., WH Freeman and Co., 2016
- *Nutrigenomics*, Eds. Carsten Carlberg, Stine Marie Ulven and Ferdinand Molnar, Springer Intl. Pub, 2016
- *CRISPR: Methods and Protocols*, Eds. Magnus Lundgren, Emmanuelle Charpentier, Peter C Fineran, Humana Press, 2015
- *Genome Analysis: Current Procedures and Applications*, Ed Maria S Poptsava, Caister Academic Press, 2014
- *Transgenic Animal Technology: A laboratory handbook*, 3rd Edition, Ed. Carl A Pinkert, Academic Press, 2014
- *Molecular Biology of the Cell*, 6th Ed. Bruce Alberts *et al*, WW Norton and Company, 2014
- *Bovine Genomics*, Ed. James E Womack, Wiley Blackwell, 2012
- *The Genetics of the Dog*, Eds. Elaine A Ostrander and Anatoly Ruvinsky, CABI press, 2012
- *An Introduction to Systems Biology*. Ed. Sangdun Choi, Humana Press, 2010
- *Genome Mapping and Genomics in Domestic Animals*, Eds. Noelle E Cockett, Chittaranjan Kole, Springer Verlag, 2009.
- *Gene Knockout protocols*, Eds. Ralf Kuhn, Wolfgang Wurst, 2009, Springer
- *Molecular Biology*, 4th Ed, Robert F. Weaver, McGraw Hill Higher Education, 2007
- *Comparative Genomics*, Ed. Nicholas H Bergman, Humana press, 2007
- *Molecular Biology and Genomics*, Cornel Mulhardt, Academic Press, 2007
- *The Dog and Its Genome*, Eds. Elaine A. Ostrander, Urs Giger, Kerstin Lindblad-Toh, CSHL press, 2006
- *Life: An Introduction to Complex Systems Biology*, Springer, 2006
- *An Introduction to Systems Biology: Design principles of Biological circuits*, Uri Alon, 2006, Chapman and Hall/ CRC
- *Directed molecular Evolution of Proteins: or How to improve Enzymes for Biocatalysis*, Eds. Susanne Brakmann, Kai Johnsson, Wiley VCH Verlag GmbH, 2003
- *Directed Evolution Library Creation*, Eds. Frances H Arnold, George Georgiou, Humana Press, 2003.
- Selected articles from journals.

I. Course Title : Membrane Biochemistry

II. Course Code : BCT 702

III. Credit Hours : 2 + 0

IV. Pre-requisite

Should have studied BCT -602: Biochemistry of Biomolecules (3+0) or other equivalent courses with similar syllabi/ content at Master's level.

V. Theory

Unit I

Concept of biomembranes and their classification based on cellular organelles; physico-chemical properties of different biological and artificial membranes, Membrane biogenesis and differentiation, Trafficking of Membrane Components - lipids, carbohydrates and proteins, cell surface receptors and antigen.

Unit II

Distribution and organization of membrane components-lipids; proteins- intrinsic and extrinsic: their arrangement; carbohydrates in membranes and their function. Cell membrane structure and the Fluid-mosaic model. Restoration and maintenance of cell membrane integrity and permeability. Methods for analysis of plasma membrane integrity. Separation of different membrane components.

Unit III

Molecular basis of biochemical behaviours of membranes, Various membrane movements; transport across membrane-Active transport, passive transport, diffusion, osmosis, exocytosis and endocytosis, Fick's law of diffusion and its physiological importance, energy transduction.

Unit IV

Role of membrane in cellular metabolism, cell recognition and cell –to –cell interaction; signal transduction, Molecular mechanisms, ion translocating antibiotics, valinomycin, gramicidin, ouabain, group translocation, ionophores, electrical gradient, energy coupling mechanism, recent trends and tools in membrane research.

VI. Suggested Reading

- Alberts B, Johnson A, Lewis J, Raff M, Roberts HK and Walter P. *Molecular Biology of the Cell. Garland Science*, Taylor and Fransis Group.
- Cooper GM and Hausam RE. 2015. *The Cell: A Molecular Approach*. Oxford University Press. ISBN: 9781605352909
- Lodish H, Berk A, Zipursky SA, Matsudaira P, Baltimore D and Darnel J. 1999. *Molecular Cell Biology*. WH Freeman.
- Nelson DL and Cox MM. 2000. *Lehninger Principles of Biochemistry*. 3rd Ed. Replika Press Pvt. Ltd., New Delhi for Worth Publ., New York.
- Selected articles from journals.

I. Course Title : Recent Trends in Enzymology

II. Course Code : BCT 703

III. Credit Hours : 2 + 1

IV. Pre-requisite

Should have studied BCT-603: Enzymology (2+1) or other equivalent courses with similar syllabi/ content at Master's level.

V. Theory

Unit I

Enzyme: Structure, mechanism, and Regulation. Three dimensional structure of enzyme, flexibility and conformational mobility of enzymes, enzyme families, dehydrogenase and dinucleotide fold, Multienzyme complexes, features and mapping of active site of enzymes, methods of examining enzyme-substrate complexes, reaction mechanism of lysozyme, chymotrypsin, carboxypeptidase A and ribonuclease A. Regulation of enzyme activity by zymogen activation, covalent modification and feed back inhibition. Allosteric enzyme with special reference to aspartate trans carbomylase. Concerted and sequential models of allosteric enzymes.

Unit II

Enzyme catalysis: general acid-base, covalent electrostatic and metal ion catalysis, orbital steering, principles of kinetic equivalence and kinetic isotopic effects, transition state theory-application and significance of enzyme catalysis. Hammond postulate

Enzyme kinetics and inhibition: factors influencing enzyme reaction velocity, steady-state kinetic of enzyme catalyzed reaction, significance of Michacelis-Menten parameters, Extension and modification of the Michacelis-Menten mechanism. Kcat/ Km and kinetic perfection in enzyme catalysis, kinetics of multi-substrate system-random, sequential, ordered, Theorell-chance and the ping-pong mechanisms. Competitive, non-compititive enzyme inhibition, suicide substrates and anti-metabolites.

Unit III

Recent developments: Industrial application of Enzymes, Enzyme immobilization methods and application. Restriction endonucleases, enzyme engineering, use of site-directed mutagenesis for detection of enzyme mechanisms, Abzymes and ribozymes, Enzyme linkering. Biosensors.

Unit IV

Diagnostic enzymology: Assay of enzymes in clinical cases, Enzymes in Pathogenesis, Enzyme histochemistry and cytochemistry, Application of microscopy in enzymology, Enzyme immuno diagnostics, Cholinesterase, lipase, amylase, GGT, GPx, arginase, AST, ALT and SDH in diagnosis of diseases of animals. Therapeutic Enzymes.

VI. Practical

- Estimation of Antioxidant Enzymes (Superoxide dismutase, Glutathione Peroxidase, Catalase, Glutathione S-transferase) from tissue samples.
- Isolation, purification and characterization of enzymes from biological samples.
- Application of enzymes in competitive bioassays (ELISA, RIA)
- Determination of Enzyme activity in Native Gel Electrophoresis.
- Estimation of Diagnostic enzymes from Clinical samples.
- Application of Restriction enzymes in cloning experiments.
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VII. Suggested Reading

- David L Nelson and Cox Michael M. 2008. *Lehninger's Principles of Biochemistry*. 5th Ed. Freeman.
- Kaneko JJ, Harvey JH and Bruss ML. 2008. *Clinical Biochemistry of Domestic Animals*. 6th Ed. Academic Press.
- Maragoni AG. 2003. *Enzyme Kinetics - A Modern Approach*. John Wiley.

  Horwood Publ.
- Price NC and Stevens L. 2003. *Fundamentals of Enzymology*. Oxford Univ. Press.
- Voet D, Voet JG and Pratt CW. 2006. *Fundamentals of Biochemistry of Life at the Molecular Level*. 2nd Ed. John Wiley and Sons.
- Wilson K and Walker J. (Eds.). 2000. *Principles and Techniques of Practical Biochemistry*. 5th Ed. Cambridge Univ. Press.
- Selected articles from standard journals.

I. Course Title : Diagnostic Techniques in Clinical Biochemistry

II. Course Code : BCT 704

III. Credit Hours : 0 + 2

IV. Pre-requisite

Should have studied BCT-605: Clinical Biochemistry of Animals (2+1) or other equivalent courses with similar syllabi/ content at Master's level.

V. Theory

Unit I

Scope of diagnostic techniques in disease diagnosis. Fractionation of cell organelles. Molecular basis of cell injury and diseases; Molecular basis of autoimmunity, immunodeficiency, Immunochemical techniques: Immunochemical protein analysis: immunoelectrophoresis, immunofixation and immunoassays. Oncogenesis and tumour markers.

Unit II

Comparative ruminant metabolism, metabolism of various nutrients by micro flora. Postruminal digestion of dietary and microbial biomolecules. Metabolic disorders of rumen and recent development in disorders of ruminants associated with protein, carbohydrate, fat (LDL, HDL, VLDL, apoproteins, etc. and triglycerides), mineral and electrolyte metabolism.

Unit III

Photometric methods: spectrophotometry (UV, visible) atomic reflectometry, turbidimetry, nephelometry, spectrofluorometry, atomic emission, etc. Spectrometric methods: AAS, mass spectrometry, nuclear magnetic resonance (NMR), infra-red (IR) spectroscopy.

Unit IV

Functional tests: Nucleic acid extraction, DNA finger printing, micro and mini satellites, PCR, RT-PCR, RFLP, Fluorescent In-situ hybridization (FISH), genome mapping, DNA microarrays, biomolecular prospecting and molecular designing in clinical biochemistry.

Unit V

Tests for cardiovascular diseases: Involvement of enzymes in diagnostics of heart disease including aspartate transaminase, isoenzymes of creatine kinase and lactate dehydrogenase and troponin. Myocardial infarction and shock; enzyme patterns and marker proteins.

Unit VI

Diagnostic use of serum enzyme assays and radioactive isotopes. LFT, KFT and tests for drugs of abuse.

Unit VII

Case Based Learning and selected articles from journals pertaining to disease diagnosis.

VI. Suggested Reading

- Bishop ML, Fody EP and Schoeff LE. 2004. *Clinical Chemistry: Principles, Procedures, Correlations* 5th edition, Lippincott Williams and Wilkins Press
- Nelson DL and Cox MM. 2007. *Lehninger's Principles of Biochemistry*. 4th Ed. Freeman.
- Kaneko JJ, Harvey JH and Bruss ML. 2008. *Clinical Biochemistry of Domestic Animals*. 6th Ed. Academic Press.
- Voet D, Voet JG and Pratt CW. 2006. *Fundamentals of Biochemistry of Life at the Molecular Level*. 2nd Ed. John Wiley and Sons.
- Racek J and Rajdl D. 2016. *Clinical Biochemistry*. 1st Ed. Karolinum Press.

I. Course Title : **Recent Trends In Biochemical Techniques And Instrumentation**

II. Course Code : **BCT 705**

III. Credit Hours : **2 + 1**

IV. Pre-requisite

Should have studied VBC-604: Analytical Techniques and Instrumentation in Biochemistry (2+1) or other equivalent courses with similar syllabi/ content at Master's level.

V. Theory

Basic components of the Instrument, principle and applications of the following analytical techniques:

Unit I

Separation, purification and quantification of biomolecules:
Gas Chromatography (GC) and High performance liquid chromatography (HPLC) - Types of pumping systems and their essential features; Column packing; Normal and modified stationary phases; Detection systems;
Blotting techniques (Western), 2-D gel electrophoresis – IPG-DALT, IEF-SDS PAGE

Unit II

Structural elucidation of biomolecules and quantification:
NMR spectrometry, X-ray crystallography, ESR Spectroscopy, CD Spectroscopy and Mass Spectrometry (LC/ MS, GC/ MS, MALDI-TOF, SELDI-TOF).
Microscopy – Electron microscopy – SEM/ TEM/ STEM; Atomic force microscopy (AFM) or scanning force microscopy (SFM); Scanning Tunnelling Microscope (STM).
Other Analytical techniques: Radiotracer techniques: Radiotracers in study of biological processes.
Tissue Culture: Setting up a cell culture laboratory; Principles of aseptic handling;, Cell line derivation; Cell freezing and quantitation; Contamination control; Cell freezing and thawing; Cell culture media constituents and their functions; Designing serum-free medium. Techniques for short-term and long-term culture of organs.
Any other current technique with relevance to biochemistry.

VI. Practical

Demonstration of feasible techniques available at the department/ institute/ other institutes.

VII. Suggested Reading

- Burtis CA, Ashwood ER and Burns DE. 2014. *Tietz Textbook of clinical Biochemistry and Molecular Diagnostics*. 5th Edition. Elsevier
- Nelson DL and Cox MM. 2017. *Lehninger's Principles of Biochemistry*. 7th Ed. Freeman.
- Garrity S. 1999. *Experimental Biochemistry*. 3rd Ed. Academic Press.
- Gowenlock AH. 2002. *Varley's Practical Clinical Biochemistry*. 6th Ed. CBS.
- George W Latimer Jr. 2016. *Official Methods of Analysis of AOAC International*, 20th Ed. AOAC International.
- Holme DJ and Hazel P. 1998. *Analytical Biochemistry*. 3rd Ed. Longman.
- Wilson K and Walker J. (Eds.). 2010. *Principles and Techniques of Biochemistry and Molecular Biology*. 7th Ed. Cambridge Univ. Press.
- Willard *et al*. 1988. *Instrumental Methods of Analysis*. 7th Ed. Wadsworth Pub Co.
- Selected articles from standard journals.

I. Course Title : Developmental Biochemistry

II. Course Code : BCT 706

III. Credit Hours : 2 + 0

IV. Pre-requisite

Should have studied VBC-609: Endocrinology and Reproductive Biochemistry or other equivalent courses with similar syllabi/ content at Master's level.

V. Theory

Unit I

Biochemistry of fertilization - Sperm-egg structure - Acrosome reaction and capacitation, Sperm-egg interaction –receptors involved; sperm entry into egg; zygote formation. Formation of multicellular and multi-layered embryo: factors affecting cleavage of zygote; Types of cleavage; blastula formation; gastrulation; neurulation; somite formation and cell migration; factors affecting cell migration; cell-cell interactions and their expression; involvement of extracellular matrix during development(cell movement and regulation of shape); growth factors and their role; organogenesis-biochemistry and molecular biology. Application of "OMICS" techniques in developmental biology.

Unit II

Development and differentiation: Genes involved in the development of Drosophilla and C. elegans and their regulation. Expression of genes during differentiation of anterior and posterior and dorsal and ventral halves, head; thorax and abdomen. Pattern formation and positional information: Inductive interaction in the development of epithelia and body parts.

VI. Suggested Reading

- Scott F Gilbert. 2010. *Developmental Biology*, 9th edition. Sunderland (MA): Sinauer Associates.
- Scott Freeman 2014. *Biological Science*, 5th edition. Publisher: Benjamin-Cummings Publishing Co.
- Selected articles from standard journals.

I. Course Title : Bioinformatics Tools in Biochemistry

II. Course Code : BCT 707

III. Credit Hours : 1 + 1

IV. Pre-requisite

Should have studied VBC-611: Introduction to Bioinformatics and Computational Biology or other equivalent courses with similar syllabi/ content at Master's level.

V. Theory

Unit I

Biological databases, nucleic acid and protein sequence databases; Pair wise sequence alignment; global and local alignments, matrices, gap penalties; Multiple sequence alignment and phylogenetic analysis-methods and programs

Unit II

Genome sequencing using next generation sequencing (NGS) technologies, sequence assembly and comparison, human genome, livestock, bacterial and viral genomes, Computational gene discovery; Gene and promoter prediction; Microarray technology: basic concept and application

Unit III

Protein structure- secondary and tertiary structure prediction; Homology and ab-initio based tertiary structure prediction; Structure validation tools, Ramachandran Map; protein motifs and domain prediction; RNA folding and secondary structure predictions

Unit IV

Metabolomics: concepts and principles; Nutrigenomics: bioinformatics in nutrition and health; Pharmacogenomics: introduction, applications, current and future perspectives

VI. Practical

- Practical application of NCBI resources
- Web based tools: Expasy, SwissProt, EBI
- Perform local alignment using different BLAST variants
- Multiple sequence alignment using ClustalW, T Coffee
- Analysis packages-commercial databases and packages, GPL software for Bioinformatics
- Database searching
- Phylogenetic analysis by PHYLIP and MEGA tools
- Protein structure visualization tools: RASMOL, SWISSPDB viewer,
- Homology modelling and structure validation of protein structures
- Tools for protein secondary and tertiary structure prediction- SANJIVNI, BHAGIRATH, SWISS Model, MODELLER, ROSETTA, I-TASSER, etc.
- Biomolecule chemical structure creation and modification using ChemSketch

VII. Suggested Reading

- *Essential bioinformatics* 2006. Xin Xiong. Cambridge University Press
- *Discovering Genomics*, *Proteomics and Bioinformatics* 2007. A. Malcolm Campbell and Laurie J Heyer. Benjamin Cummings.
- *Proteins: Structures and Molecular Properties* 1993. Creighton TE. W.H. Freeman.
- *Bioinformatics: Sequence and Genome Analysis* 2001. Mount DW. Cold Spring Harbor.
- *Introduction to Computational Molecular Biology* 1997. Setubal Joao and Meidanis Joao. PWS Publishing Company.
- *Bioinformatics: Concepts*, *Skills and Applications* 2004. Rastogi SC, Mendiratta N and Rastogi

P. CBS.
- *Principles of Genome Analysis and Genomics* 2003. SB. Primrose and R.M. Twyman, Blackwell Publishing.
- *Molecular Analysis and Genome Discovery* 2004. Ralph Rapley and Stuart Harbron (Eds.), John Wiley and Sons.
- *BioInformatics* 2001. Andreas D. BaXevanis and B. F. Francis Ouellette (Eds.).
- Online Resources available on Internet and Selected articles from standard journals.

I. Course Title : Environmental and Toxicological Biochemistry

II. Course Code : BCT 708

III. Credit Hours : 2 + 0

IV. Theory

Unit I

Introduction to environmental pollutants and toxicants, their classification, sources and impact on animal health including poultry. Effect of various pollutants on animal and microbial metabolism; their detoxification mechanism in animals and birds, Biochemical basis of pollutant tolerance. Soil enzymes, their source and role in environment, methods for measurement of pollution, Pesticide residues and its effect on animal health. environmental chemo-dynamics. Heavy metals and metalloids, industrial chemicals and biotoxins on animal health and productivity.

Unit II

Water pollution, biochemical basis for measuring water pollution, chemical properties of water-physical, chemical and biological treatment process. Biochemical oxygen demand and water quality assessment. Biochemical aspects of water quality.

Unit III

Global environmental issues in the light of biochemistry, methanogenesis and role of ruminants, global warming, green house gases, acid rain and their effects on animal health and productivity.

Unit IV

Distribution and storage of toxicants in animal body, target organ toxicity, biotransformation and elimination of toxicants, methods for measurement of toxin level in animals.

Unit V

Clinical Biochemistry in Toxicology- Hepatotoxicity and biochemical changes due to hepatotoxicity, Nephrotoxicity and its effect, Effects of toxins on lungs, respiratory tract, endocrine system, nervous system, erythrocyte and haematopoietic system. Toxins affecting haemoglobin and oxidative metabolism.

V. Suggested Reading

- Casarett, Louis J.; Doull, John. *Casarett and Doull's Toxicology: The Basic Science of Poisons* 8th ed.: New York: McGraw-Hill, 2013. ISBN:9780071769235
- Hayes AW, Kruger CL. *Hayes' principles and methods of toxicology* 6th ed. ISBN:9781842145364
- Kaneko JJ, Harvey JW and Bruss ML. *Clinical Biochemistry of Domestic Animals*, *Academic* press, ISBN 13:978-0-12-370491-7.
- Selected articles from journals.

I. Course Title : Biochemistry of Diseases and Disorders

II. Course Code : BCT 709

III. Credit Hours : 2 + 0

IV. Pre-requisite

Should have studied BCT-605:Clinical Biochemistry of Animals (2+1) or other equivalent courses with similar syllabi/ content at Master's level.

V. Theory

Unit I

Scope of biochemistry and its applications in understanding the development of diseases and their control.

Biochemical basis of Immunological diseases: Equine immuno- deficiency, neutrophil function defects and its testing, Autoimmune Diseases, Primary Immune Deficiency Diseases, Secondary Immunodeficiency, Hypersensitivity Diseases.

Endocrine diseases arising from over or under production of hormones or from resistance to a particular hormone; Thyroid disorders; Pancreatic disorders; Cushings disease. Hemostatic diseases: Role of Vascular Endothelium, Platelets, Coagulation Proteins, Complexes, and Thrombin Activation; Fibrinolysis, Hereditary and Acquired disorders of hemostasis.

Unit-II

Nutritional diseases arising from over or under-nutrition of fat and water soluble vitamins and minerals: Night blindness, pernicious anaemia, iron overload, metabolic disorders of iron metabolism, rickets, osteomalacia, milk fever, swayback, anaemia of Inflammatory disease.

Toxic diseases: Hepatotoxicity, Nephrotoxicity; Toxins affecting: Skeletal and Cardiac muscle; Lung and Respiratory tract; Gastrointestinal tract; Erythrocytes, Haematopoietic system, Hemoglobin and oxidative metabolism; Endocrine system, Nervous system and neuromuscular disorders.

Unit III

Neoplastic diseases: Biochemical changes in development of various neoplasms, Deranged glucose metabolism in cancerous tissue, oncogenesis.

Degenerative diseases: *Neurodegenerative diseases* – including amyotrophic lateral sclerosis, Parkinson's *disease*, Alzheimer's *disease*, and Huntington's *disease*. Molecular basis of cell injury and diseases by Free Radicals.

Unit IV

Biochemical basis of cardiomyopathies in dogs and birds, Prions disease (Scrapie), Bovine spongiform encephalopathy, Reticuloendotheliosis in poultry, Avian Influenza; Retinitis pigmentosa, retinal degeneration and Lysosomal storage diseases in animals.

Comparative medical genetics: Genome sequences, Disease Gene Mapping, Genetic diseases, Gene therapy

VI. Suggested Reading

- Charles A Janeway Jr, Paul Travers, Mark Walport and Mark J Shlomchik. 2001. *Immunobiology*, *The Immune System in Health and Disease*, 5th edition, New York.
- David L Nelson and Cox Michael M. 2017. *Lehninger's Principles of Biochemistry*. 7th Ed. Freeman.
- Kaneko JJ, Harvey JW and Bruss ML. *Clinical Biochemistry of Domestic Animals*, Academic press, ISBN 13:978-0-12-370491-7.
- Kenneth M Murphy and Casey Weaver 2016. *Janeway's Immunobiology*, 9th Edition ISBN:

978-0-815-34505-3.
- Thomas M. Devlin (Ed) 2011. *Textbook of Biochemistry with Clinical Correlations,* John Wiley and Sons.
- Voet D, Voet JG and Pratt CW. 2016. *Fundamentals of Biochemistry of Life at the Molecular Level*. 5th Ed. John Wiley and Sons.
- Selected articles from standard journals.

I. Course Title : Immuno-biochemistry

II. Course Code : BCT 710

III. Credit Hours : 2 + 0

IV. Theory

Unit I

History and scope of immunology, Cellular basis of immunity-adaptive and non-adaptive immunity, Memory, Specificity and Diversity, Self and non self discrimination, Immune system, Organs, tissues and cells, Cell mediated vs Humoral immunity, Immunoglobulins, Concept of antigen, Immunogen, Adjuvant, Hapten

Unit II

Classes of antibodies, Antibody diversity, Theories of generation of antibody diversity, Monoclonal antibodies, Polyclonal antibodies, Hybridoma, Recombinant antibodies, Single chain and single domain antibodies in immunodiagnostics and immunotherapy, Phage display library, complement system- classical and alternate.

Unit III

Cellular interactions in the immune response, affinity, avidity, B-cell and T-cell response, major histocompatibility complex, cell mediated immune response, cytokines, Vaccine. Nanoparticles in vaccine development and delivery, Nanomedicine in immunodiagnostics and immunotherapy, Immunoregulation, immunological tolerance, hypersensitivity, innate resistance and specific immunity.

Unit IV

Current immunological techniques: Raising of antisera and antibody purification, Immunodiffusion, Immunoelectrophoresis, immunofluoresence, rocket electrophoresis, Immunological markers and fluorescence-activated cell sorting, Radioimmuno assay (RIA) and different types of ELISA, Immunohistochemistry, Immunoinformatics techniques.

V. Suggested Reading

- Abbas AK and Lichtman AH. 2003. *Cellular and Molecular Immunology*. 5th Ed. WB Saunders.
- David J Dabbs. 2018. *Diagnostic Immunohistochemistry*. 5th Ed. Elsevier.
- Goldsby RA, Kindt TJ and Osborne BA. 2003. *Immunology*. 4th Ed. WH Freeman.
- Harlow and Lane D. (Eds.). 1988. *Antibodies: A Laboratory Manual*. Cold Spring Harbor Laboratory.
- *Immunochemistry*: Edited by CJ van Oss and MHV van Reganmortel. pp 1069. Marcel Dekker, New York. 1994. ISBN 0 8247 9123 1; TR O'Brien.
- Ivan Roitt (Eds.). 1997. *Essential Immunology* Publisher -Blackwell Scientific Publication, Oxford.
- Kuby J. 1996. *Immunology*. 3rd edition WH Freeman.
- Male D, Brostoff J, Roth DB and Roitt I. 2006. *Immunology*. 7th Ed. Elsevier.
- Manson MM. (Eds.). 1992. *Immunochemical Protocols: Methods in Molecular Biology* Vol. 10- Humana Press Totowa NJ.
- Mariusz Skwarczynski, Istvan Toth. 2017. *Micro and Nanotechnology in Vaccine Development*. 1st ed. Elsevier.
- Mathew Sebastian, Neethu Ninan AK. Haghi. 2012. *Nanomedicine and Drug Delivery*. 1st Ed. Apple Academic Press.
- Selected articles from standard journals.

I. Course Title : Special Problem

II. Course Code : BCT 711

III. Credit Hours : 0+2

IV. Practical

Short research problem(s) involving contemporary issues and research techniques.

V. List of Journals

- *Indian Journal of Chemical Technology*
- *Indian Journal of Biochemistry and Biophysics*
- *Indian Journal of Chemistry - Section B*
- *Indian Veterinary Journal*
- *Journal of Chemical Sciences*
- *Journal of Indian Chemical Society*
- *Meat Science - An International Journal*
- *The EMBO Journal*
- *Theriogenology*
- *Trends in Biochemical Sciences*

e-Resources

- www.niscair.res.in/ScienceCommunication (Indian Journal of Biochemistry)
- www.medind.nic.in/iaf/iafm.shtml (Indian Journal of Clinical Biochemistry)
- www.ijcb.co.in (Indian Journal of Clinical Biochemistry)
- www.mcponline.org (Molecular and Cellular Proteomics)
- www.elsevier.com/vj/proteomics (Proteomics Virtual Journal)
- www.elsevier.com (Journal of Proteomics)
- www.elsevier.com (Clinical Biochemistry)
- www.sciencedirect.com/science/journal (Science Direct – Clinical Biochemistry)
- www.jbc.org (Journal of Biological Chemistry)

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Basic Veterinary Sciences

– Veterinary Extension Education

Course Title with Credit Load
M.V.Sc. in Veterinary Extension Education

Course Code	Course Title	Credit Hours
EXT 601	Development Perspectives of Extension Education	2+1
EXT 602	Communication for Livestock Development	1+1
EXT 603	Diffusion and Adoption of Innovations	2+1
EXT 604	Programme Planning and Evaluation	1+1
EXT 605	Research Methodology	2+1
EXT 606	Social Psychology and Group Dynamics	1+1
EXT 607	Livestock Entrepreneurship	1+2
EXT 608	Human Resource Management in Animal Husbandry Sector	1+1
EXT 609	Gender Empowerment and Livestock Development	1+0
EXT 610	Farm Journalism	1+1
SSS 600	Statistics for Social Sciences	2+1
EXT 611	Masters Seminar	1+0
EXT 612	Masters Research	0+30

Course Contents
M.V.Sc. in Veterinary Extension Education

I. Course Title : Development Perspectives of Extension Education

II. Course Code : EXT 601

III. Credit Hours : (2 +1)

IV. Theory

Unit I

Important concepts in extension science; various schools of thought; Critical review and reflections on the philosophy and principles of extension.

Unit II

Implications of earlier extension efforts. Emerging issues, problems and challenges of animal husbandry extension education.

Unit III

Changing approaches – ToT approach, Education Approach, Farmer Participatory Approaches (PRA, RRA, PLA, PTD, PCD, etc.), Demand Driven approach, Market led extension, FSA, Commodity Specific Approach, Market led Extension; Classification of PRA, Differences between PRA and RRA; Global concepts of extension (SAARC, BRICS, US, Japan, UK, Philippines and Israel) and its application to Indian context. Privatization of extension. Public Private Partnership.

Unit IV

Extension approaches of State and Central Governments, ICAR, SVUs/ SAUs, NGOs, corporate and other organizations. Extension Advisory Services - Meaning, Concept - Challenges in Animal Husbandry Extension Advisory Services. Extension approaches followed in current livestock development programmes, viz., Rashtriya Gokul Mission, National Livestock Mission, Rashtriya Krishi Vikas Yojana, Livestock Insurance Scheme, Livestock Health and Disease Control, Pashu Sanjivini, National Programme for Dairy Development, National Programme for Bovine Breeding, Aatmanirbhar Bharat Abhiyaan and digital initiatives such as E-Pashudhan Haat, National Animal Disease Reporting System for livestock development, etc. Linkages between researcher-extension agent - livestock farmer-industry in the generation, Dissemination and commercialization of animal husbandry practices/ technologies.

V. Practical

Study of the extension approaches, functions, roles, responsibilities, organizational

set-up of State Animal Husbandry Department/ Livestock Development Agency/ Dairy Federation/ Rural Development agencies, Study of selected FPOs, CIGs, NGOs, SHGs, etc. Critical analysis of cases on linkage between different actors of animal husbandry sector.

VI. Suggested Reading

- Anandajayasekeram P, Puskur R, Sindu Workneh and Hoekstra D. 2008. *Concepts and practices in agricultural extension in developing countries:* A source book. IFPRI (International Food Policy Research Institute), Washington, DC, USA, and ILRI (International Livestock Research Institute), Nairobi, Kenya. 275 pp. https://cgspace.cgiar.org/bitstream/handle/10568/99/Source_book.pdf
- Ashok G, Sharma P, Anisha S and Prerna T. 2018. *Agriculture Extension System in India Review of Current Status*, *Trends and the Way Forward*, Indian Council for Research on International Economic Relations (ICRIER). http://icrier.org/pdf/Agriculture-EXtension-System-in-India-2018.pdf
- Bitzer V, Wongtschowski M, Hani M and Blum M. 2016. *New directions for inclusive Pluralistic Service Systems. In New Directions for Inclusive Pluralistic Service Systems* Rome (Italy). FAO. http://www.fao.org/3/a-i6104e.pdf
- Burton ES and Kristin D. 2014. *Status of Agricultural Extension and Rural Advisory Services* Worldwide. GFRAS: Lindau, Switzerland. http://www.g-fras.org/en/knowledge/gfras-publications.html?download=391:status-of-agricultural-eXtension-and-rural-advisory-services-worldwide
- Burton ES, Robert PB and Andrew JS. 1997. *Improving agricultural extension A reference manual,* FAO Rome https://www.oerafrica.org/FTPFolder/Website%20Materials/Agriculture/haramaya/Perspective_Agricultural_EXtension/Attachment/Improving%20AgEX.-FAO.pdf
- Dahama OP and Bhatnagar OP. 1987. *Education and Communication for Development*. Cambridge Univ. Press.
- Davis K and Sulaiman RV. 2016. *Extension Methods and Tools*. Module 2 NELK. GFRAS. https://www.g-fras.org/en/component/phocadownload/category/70-new-eXtensionist-learning-kit-nelk.html?download=560:nelk-module-2-eXtension-methods-and-tools-teXtbook
- Dharma OP. 2017. *Development Perspectives in Extension Education* Agro Tech Publishing Academy, Udiapur
- FAO. 2016. *New directions for inclusive Pluralistic Service Systems*. Report of FAO EXpert Consultation. Food and Agriculture Organization of the United Nations and Royal Tropical Institute, Rome. http://www.fao.org/3/ai6103e.pdf
- GFRAS. 2016. *The New Extensionist Learning Kit*. http://g-fras.org/en/knowledge/new-eXtensionist-learningkit-nelk.html#module-1-introduction-to-the-new-eXtensionist
- Gwyn EJ and Garforth C. n.d. *The history*, *development*, *and future of agricultural extension*. FAO. Rome. http://www.fao.org/docrep/W5830E/w5830e03.htm
- Rivera WM and Schram SG. (Ed). 1987. *Agricultural Extension World wide – Issues*, *Practices and Emerging Priorities*. Croome Helm,
- Roling N. 1988. *Extension science*, *information systems in agricultural development*. Cambridge University Press
- S Adolph B. 2011. *Rural Advisory Services Worldwide: A Synthesis of Actors and Issues*. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/knowledge/gfras-publications.html?download =6:rural-advisory-services-worldwide and start=40
- Swanson BE. 2008. *Global Review of Good Agricultural Extension and Advisory Service Practices*. Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/docrep/pdf/011/i0261e/i0261e00.pdf
- Van den Ban AW and Hawkins HS. 1998. *Agricultural extension- Chapter* 10, BSL, CBS Publishers and Distributors.

I. Course Title : Communication for Livestock Development

II. Course Code : EXT 602

III. Credit Hours : (1+1)

IV. Theory

Unit I

Communication- meaning, concept, purpose and process of communication- Models and theories of communication: Aristotle, Berlo, Osgood Schramm, Shanon and Weaver, Johari window, New Comb, Westley and McLean, etc. Critical analysis of models and theories of communication. Recent developments in communication theories and models.

Unit II

Types of communication-intrapersonal, interpersonal, verbal and non-verbal; Criteria of effective communication, Determinants of communication- Empathy, credibility, fidelity, distortion, feedback and barriers to effective communication; Group and mass communication. Key communicators and their role in livestock development. Organizational Communication - formal- informal; downward-upward- horizontal; Problems in organizational communication.

Unit III

Business Communication: Relevance and importance in livestock business development. Features of business communication, Guidelines for business communication, formal and informal business communication, Various types of business communication (Letters, Reports, Proposals, Manuals, Outreach writing (Advertisements, Pamphlets, Signs, Press Release, etc.). Effective business communication.

Unit IV

ICT-concept, importance and types of tools and applications; Role and significance of ICT tools in Animal Husbandry Development - Use and importance of Social Media in livestock development. Overview of emerging technologies.

V. Practical

Exercises in improving communication skills (Speaking skill – Public speaking, Persuasive speech, Informative speech, etc.) Exercises on Listening, Exercises on Reading, Exercises on Non-verbal communication, Writing of Business Communication, Identification of key communicators, Communication barriers, stortion and fidelity in livestock development. Identification of different social media tools used for livestock development; Comparative study of different tools and their areas of applications in animal husbandry sector; Hands on experience in writing blogs; ICT tools in Animal Husbandry Extension delivery system; Analysis of web portals – KVK portals, Knowledge portal, ICAR, SAUs, etc.

VI. Suggested Reading

- Bhagat Amit K. *Communication as a Management Tool: Principles and Practices*. Akhand Publishing House, New Delhi. 2012
- Cragan FJ and Wright WD. 1999. *Communication in Small Groups – Theory, Process, Skills*. Wadsworth Publ.
- Mcquail D and Windahl S. 1993. *Communication Models for the Study of Mass Communications*. Longman Publ.
- Ray GL. 2011. *Extension, Communication and Management*. Kalyani Publishers, Ludhiana.
- Rogers EM and Shoemaker FF. 1971. *Communication of Innovations: A Cross – Cultural Approach*. The Free Press.
- Roloft Michael F. 1981. *Interpersonal Communication*. Sage Publ.

- Ruben Brent D. *Communication and Human Behaviour*. McMillan Publishing Company. New York. 1984.
- Sehgal MK and Khetrapal V. 2008. *Business Communication*. EXcel Books. New Delhi.
- Srinivasa Raju Melkote and H Leslie Steeves. 2001. *Communication for Development Theory and Practice for empowerment and social justice*. Sage Publications
- Andres D and Woodard J. 2013. *Social media handbook for agricultural development practitioners*. Publication by FHI360 of USAID. http://ictforag.org/toolkits/social/SocialMedia 4AgHandbook.pdf
- Barber J, Mangnus E and Bitzer V. 2016. *Harnessing ICT for agricultural extension*. KIT Working Paper 2016: 4. https://213ou636sh0ptphd141fqei1-wpengine.netdna-ssl.com/sed/wp-content/uploads/sites/2/2016/11/KIT_WP2016-4_Harnessing-ICT-for-agricultural-eXtension.pdf
- Bheenick K and Bionyi I. 2017. *Effective Tools for Knowledge Management and Learning in Agriculture and Rural Development*. CTA Working paper. https://publications.cta.int/media/publications/downloads/1986_PDF.pdf
- FAO 2011. *E-learning methodologies a guide for designing and developing e-learning courses*. Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/015/i2516e/i2516e.pdf
- George T, Bagazonzya H, BallantyneP, Belden C, Birner R, Del CR and Treinen S. 2017. *ICT in agriculture: connecting smallholders to knowledge, networks, and institutions*. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/12613 16
- Mayer RE. 2005. *The Cambridge handbook of multimedia learning*. New York: University of Cambridge.
- Mittal N, Surabhi, Gandhi, Sanjay and Gaurav T. 2010. *Socio-Economic Impact of Mobile Phones on Indian Agriculture*. ICRIER Working Paper No. 246, Indian Council for Research on International Economic Relations (ICRIER), New Delhi.
- Saravanan R and Suchiradipta B. 2016. *Social media policy guidelines for agricultural extension and advisory services, GFRAS interest group on ICT4RAS, GFRAS*: Lindau, Switzerland. www.g-fras.org/en/knowledge/gfras-publications.html?download=415:social-media-policy-guidelines-for-agricultural-eXtension-and-advisory-services
- Saravanan R. 2010. (Ed.) ICTs for Agricultural EXtension: Global EXperiments, Innovations and EXperiences, New India Publishing Agency (NIPA), New Delhi. http://www.saravananraj. net/wp-content/uploads/2014/12/32_India_ICTs-for-Agricultural-EXtension_Saravanan.pdf
- World Bank. 2017. *ICT in Agriculture (Updated Edition): Connecting Smallholders to Knowledge, Networks, and Institutions*. Washington, DC: World Bank. https://openknowledge. worldbank.org/handle/10986/27526

I. Course Title : Diffusion and Adoption of Innovations

II. Course Code : EXT 603

III. Credit Hours : (2+1)

IV. Theory

Unit I

Concept, meaning, importance of diffusion. Elements in diffusion process; Models and theories of diffusion.

Unit II

Concept, meaning, importance of adoption. Steps in adoption process. Adoption models; Stages in diffusion-adoption process; Innovation- Decision Process, Adopter categories and their characteristics. Factors influencing adoption. Attributes of innovations, Factors affecting the rate of adoption and sources of information. Consequences of innovations.

Unit III

Adopter categories and their characteristics. Identification and evaluation of innovations in livestock sector – Attributes, Reason for adoption, Non-adoption and Discontinuance, Consequences. Diffusion and adoption of livestock sectoral innovations.

Unit IV

Agricultural Innovation System – Origin of innovation system - Concepts and elements; Innovation vs Invention, Innovation and types of innovation; Innovations in livestock sector; Role of enabling environment; Methodologies for AIS Diagnosis; Capacity Development in AIS.

V. Practical

Identification of adopter categories in the selected village, Study on attributes of innovation of selected dairy farming technologies/ sheep/ goat/ poultry farming technologies. Identification of sources of information at different stages of adoption on selected livestock technologies; Study of factors increasing or retarding the rate of adoption; Consequences of adoption of livestock technologies; Case studies in of Agricultural Innovation System, Presentation of reports on adoption and diffusion of innovations

VI. Suggested Reading

- Brown Lawrence A. 1981. *Innovation Diffusion: A New Perspective. Communication for Social Change*. Sage Publ.
- Cragan FJ and Wright WD. 1999. *Communication in Small Groups – Theory, Process, Skills*. Wadsworth Publ.
- Dasgupta. 1989. *Diffusion Agricultural Innovations in Village India*.
- Hall A, Sulaiman RV, Beshah T, Madzudzo E and Puskur R. 2009. *Agricultural innovation system capacity development: Tools, principles or policies*? Capacity.org (37): 16-17. http://www.capacity.org/en/journal/practice_reports/tools_principles_or_policies
- ILRI. 2014. *Innovation Platform practice briefs. International Livestock Research Institute.* https://clippings.ilri.org/2014/02/03/ipbrief1/
- Leeuwis C and van den Ban A W. 2004. *Communication for rural innovation: Rethinking agricultural extension*. John Wiley and Sons. Methuen.
- OECD. 2012. *Innovation for Development. A Discussion of the Issues and an Overview of Work of the OECD Directorate for Science, Technology and Industry*. https://www.oecd.org/innovation/inno/50586251.pdf
- Ray GL. 2005. *Extension Communication and Management*. Kalyani Publishers, AA. 1987.

- Rogers EM. 2003. *Diffusion of Innovations*. Free Press.
- Wiley Eastern. Jalihal KA and Veerabhadraiah V. 2007. *Fundamentals of Extension Education and Management in Extension*. Concept Publ. Co.
- World Bank. 2006. *Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems*. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/7184
- World Bank. 2012. *Agricultural Innovation Systems: An Investment Source book*. Washington DC, World Bank. http://siteresources.worldbank.org/INTARD/Resources/335807-1330620492317/9780821386842.pdf

I. Course Title : Programme Planning and Evaluation

II. Course Code : EXT 604

III. Credit Hours : 1+1

IV. Theory

Unit I

Genesis and importance of programme planning. Objectives, principles and steps in programme planning process. Role of animal husbandry extension agencies and stakeholders in planning and implementation of Animal Husbandry Extension programmes.

Unit II

Participatory Programme planning: Meaning, Role and Benefits; Stakeholders Participation in Development - Identify Key Stakeholders, Examine Stakeholder's Interests and Impact of the Project, Assess Stakeholder Power and Interest, Outline a Stakeholder Participation Strategy.

Unit III

Meaning and Scope of Monitoring; Basic Concepts and Elements in Monitoring; Types of Monitoring; Techniques of Monitoring; What is Evaluation? Appraisal vs. Monitoring vs. Evaluation vs. Impact Assessment – Major differences; Types of Evaluation, Evaluation Designs.

Unit IV

Project Management Techniques- Gantt chart, Programme Evaluation and Review Technique (PERT). Critical Path Method (CPM). Project formulation. Project appraisal in terms of social benefit analysis, logical frame work. Various stakeholdersin livestock development; stakeholder analysis, and report writing.

V. Practical

Preparation of comprehensive livestock development programme for a village.
Developing instruments for monitoring and evaluation of on-going development programme at village level (Logical Frame Work). Participatory techniques (RRA, PRA, Case study, etc.). SWOT analysis of a livestock development programme.

VI. Suggested Reading

- Bagno lB. 2014. *Conducting participatory monitoring and evaluation*. Pages 81-85 in FAO, Decision tools for family poultry development.
- Baker H. 1984. *The program planning process*. Pages 50-64 in D. Blackburn (ed.), Extension handbook. Guelph, Ontario, Canada: University of Guelph.
- Baum WC and Tolbert SM. 1985. *Investing in Development: Lessons of the World BankExperience*, Oxford University Press.
- Bennett CF. 1979. *Analyzing impacts of extension programs*. Washington, D.C., USA: U.S. Department of Agriculture.
- Choudhary S. 1988. *Project Management*, New Delhi: Tata McGraw Hill.
- Dale R. 2004. *Evaluating Development Programmes and Projects*, New Delhi, India: Sage Publications
- Fear FA. 1988. *Community needs assessment: A crucial tool for adult educators*. Paper presented at the MAACE Midwinter Conference, February 1988, Lansing, Michigan, USA.
- GFRAS. 2017. *The New Extensionist Learning Kit*. 13 Learning Modules for Extension Professionals. Lausanne, Switzerland, Global Forum for Rural Advisory Services GFRAS.
- Harold Kerzner. 2013. *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*. Wiley
- Hoffman V, Christinck A and Lemma M. (eds.). 2009. *Rural Extension*. Margraf Publishers GmbH.
- Leagans JP. 1961. *Programme planning to meet people's needs. In: Extension education in community development, Directorate of Extension*, Ministry of Food and Agriculture, Government of India, New Delhi.
- Mukherjee N. 2002. *Participatory Learning and Action with 100 field Methods*. Concept Publishing Company, New Delhi.
- Rietbergen MJ and Narayan D. 1997. *Participatory tools and techniques: A resource kit for participation and social assessment*. Washington, D.C., USA: The World Bank. Accessed at: www.fao.org/ag/ againfo/ programmes/ en/ lead/ toolbox/ Refer/ STkHold.htm
- Roling N. 1988. *Extension science: information systems in agricultural development*, Cambridge University Press.
- Scott Bercun. 2008. *Making Things Happen – Mastering Project Management*. O'Reilly Publishers
- Somesh K. 2002. *Methods for Community Participation - A Complete Guide for Practitioners*. Vistar Publications New Delhi.
- Suvedi M and Kaplowitz MD. 2016. *Process Skills and Competency Tools – What Every Extension Worker Should Know – Core Competency Handbook*. Urbana, IL, USAID-MEAS.
- Van den Ban AW and Hawkins HS. 2002. *Agricultural extension*, CBS Publishers and Distributors, New Delhi.

I. Course Title : Research Methodology

II. Course Code : EXT 605

III. Credit Hours : 2+1

IV. Theory

Unit I

Concept, nature and scope of research in social sciences. Types of research-fundamental, applied and action research, experimental and non-experimental research. Identification of concepts, constructs, variables. Hypothesis– importance, selection criteria (qualities of a workable hypothesis), formulation and testing of hypothesis. Selection and formulation of research problem.

Unit II

Measurement and levels of measurement; Research designs- exploratory, experimental, and ex-post-facto research design. Sampling -Sampling methods-probability and non-probability sampling. Sources of errors.

Unit III

Methods of data collection– survey method, observation method, interview/ questionnaire method, case study, content analysis, sociometry, focus group discussion, projective techniques, Online tools of data collection, Reliability and validity of measuring instruments.

Unit IV

Social statistics – designs in data analysis, Parametric and Non-Parametric statistical methods. Data analysis and interpretation and inference, Report writing. Review of studies in social research.

V. Practical

Construction of data collection tools, GPS-enabled data collection, Development of online tools of data collection (Google Forms, Survey Monkeys, etc.) Application of statistical software for data analysis and interpretation. Creative scientific thinking, selecting a research problem and working it out with all the steps; report writing and presentation of the reports.

VI. Suggested Reading

- Arlene Fink (Ed). 2003. *The Survey Kit* (10 booklets). Sage Publ.
- Babbie E. 2008. *The basics of social research*. 4th ed. Belmont, CA, USA; Thompson Wordsworth.
- Creswell JW. 2009. *Research design: Qualitative, quantitative, and mixed methods approaches*. Third edition. Thousand Oaks: Sage Publications.
- Creswell John W. 1994. *Research Design – Qualitative and Quantitative Approaches*. University of Nebraska, Lincoln.
- Creswell JW. 2012. *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Fourth edition. Boston, MA: Pearson.
- Edwards AL. 1969. *Techniques of Attitude Scale Construction*. Vakil, Feffer and Simons
- Garrett HE. 1966. *Statistics in Psychology and Education*. International Book Bureau, Hyderabad.
- Goode WJ and Hatt PK. 1952. *Methods in Social Research*. McGraw-Hill.
- Guilford JP. 1971. *Psychometric Methods*. TATA McGraw Hill.
- Henerson EM, Morris LL. and Gibbon CT. 1987. *How to Measure Attitudes*. Sage Publ.
- Kerlinger FN and Lee HB. 2000. *Foundations of Behavioral Research*. Orlando, FL: Harcourt College Publishers.
- Kumar R. 2014. *Research Methodology: A Step –by - Step Guide for Beginners*. Fourth Edition. Thousand Oaks, California: Sage Publications.
- Miller Delbert C. 1991. *Handbook of Research Design and Social Measurement*. Indiana

University. Sage Publ.
- NeumanWL. 2006. *Social Research Methods: Qualitative and Quantitative Approaches*. Toronto: Pearson.
- Oppenheim AN. 1979. *Questionnaire Design and Attitude Measurement*. Heinemann Educational Books.
- Sekaran U and Bougie R. 2013. *Research Methods for Business A Skill-Building Approach*. 6th Edition, Wiley, New York.
- Sivakumar PS, Sontakki BS, Sulaiman RV, Saravanan R and Mittal N. (eds). 2017. *Good Practices in Agricultural Extension Research. Manual on Good Practices in Extension Research and Evaluation. Agricultural Extension in South Asia*. Centre for research on innovation and science and policy (CRISP), Hyderabad. India.

I. Course Title : Social Psychology and Group Dynamics

II. Course Code : EXT 606

III. Credit Hours : 1+1

IV. Theory

Unit I

Concepts, scope and importance of psychology and social psychology in animal husbandry extension, Perception - nature, laws and selectivity in perception, factors in perception, importance of perception in extension work, Attitude - nature, theories, measurement and change of attitude towards livestock farming, Importance of attitude scales in livestock research and development.

Unit II

Motivation– nature, characteristics, theories, types and techniques of motivating farmers, Learning- principles, theories of learning and experiential learning and adult learning (andragogy).

Unit III

Intelligence- nature, theories and measurement, Personality- nature, traits, types, biological and socio-cultural determinants of personality, Group and individual behaviour.

Unit IV

Concept and types of groups; Group behaviour and dynamics: structures - attraction, coalition, communication and power; group mobilisation – social capital, group decision making, Factors affecting group performance; Conflict management in groups; Group belongingness, Community Mobilization, Importance of coordination among livestock development organisations.

V. Practical

Study of groups and group dynamics (*eg.*: Self Help Groups (SHGs), Milk Cooperative Societies, Commodity groups and Farmer producer Company/ organization (FPO), Joint Liability Group (JLG), youth clubs, etc.).Exercises on measurement of motivation, perception and personality traits.

VI. Suggested Reading

- Cragan FJ and Wright WD. 1999. *Communication in Small Groups – Theory, Process, Skills*. Wadsworth Publ.
- Donelson R. Forsyth, *Group Dynamics* 2018 7th Edition, Cengage Learning
- Joseph Bohac and Stan Dekoven 2013. *Group Dynamics*. Vision Publishing (Ramona, CA)
- Kagan J and Havemann E. 1980. *Psychology – An Introduction*. Harcourt Brace Javanovich Inc.
- Morgan CT, King RA and Robinson NM. 1979. *Introduction to Psychology*. Tata McGraw-Hill.
- Napier RW and Gershenfeld MK. 2006. *Groups – Theory and Experience*. AITBS Publ.
- Robert A Baron. *Social Psychology*. 2016. 13th Edition Pearson Education
- Secord PF and Backman CW. 1964. *Social Psychology*. McGraw-Hill.

I. Course Title : Livestock Entrepreneurship

II. Course Code : EXT 607

III. Credit Hours : 1+2

IV. Theory

Unit I

Entrepreneurship - Role of Entrepreneurship in Economic Development of the country and current scenario and future prospects; Factors influencing Entrepreneurship (Internal factors, External factors, Political factors, Socio-Cultural Environment, Legal and Technological Environment); Role of Government and Non-Government agencies in promoting entrepreneurship in India- eg: Atal Innovation Mission, Startup India, Mudra Bank Scheme, Dairy Entrepreneurship Development Scheme, Agri-Clinics and Agri-Business Centers (ACABC), Entrepreneurship Development and Employment Generation (EDEG), etc.

Unit II

Livestock -Business Plan: Business Idea Generation, Brainstorming and evaluation of ideas, Competition, Scalability of the product, Price feasibility, Distribution and logistics, Ease of technology, Opportunities and threats, Internal strengths and weaknesses (SWOT analysis) Government regulations and statutory compliances, Sources of financial assistance.

Unit III

Livestock Business Evaluation: Evaluating financial feasibility, Cost of production and marketing, Project cost determination and fund requirement, Assessing working capital requirement, Non-fund based requirements (BG, LC), Cost of capital sources and cost of finance. Technical feasibility, Patents, Make or buy decision, Plant size and location, Machinery requirement, Outsourcing requirements, Project report and appraisal techniques- Net present value, Payback period, Break even analysis, CB Ratio.

Unit IV

Consumer Behaviour: Consumer behaviour- Definition, Consumer and customers, Buyers and users, Consumer behaviour and its applications in livestock marketing; Consumer behaviour models; Consumer motivation, Consumer perception, Consumer behaviour and marketing communications, Consumer decision-making process, Organizational buying behaviour, Modern marketing information system (marketing intelligence, communicating and acting on marketing intelligence).

V. Practical

Exposure visits to commercial livestock enterprises- Dairy, Poultry, Meat/ Dairy/ Feed Processing Units. Analysis of successful cases of livestock entrepreneurship, Development of livestock business plans, Presentation of livestock business development plans, Study of consumer behavior, Critical analysis of livestock markets/ super markets/ malls.

VII. Suggested Reading

- Khanka SS. 1999. *Entrepreneurial Development*. S. Chand and Co.
- Gupta CB. 2001. *Management Theory and Practice*. Sultan Chand and Sons.
- Grover I. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public
- Nandan H. 2013. *Fundamentals of Entrepreneurship*, PHI publishers
- Reading material of Course AEM-202 Agri-*Business and Entrepreneurship Development*. http://www.manage.gov.in/pgdaem/studymaterial/aem202.pdf
- Hisrich RD, Peters MP and Shepherd A. 2007. *Entrepreneurship*, 6th Edition, Tata McGraw Hill
- Singh D. 1995. *Effective Managerial Leadership*. Deep and Deep Publ.
- Tripathi PC and Reddy PN. 1991. *Principles of Management*. Tata McGraw Hill.
- Desai V. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House.

I. Course Title : **Human Resource Management in Animal Husbandry Sector**

II. Course Code : **EXT 608**

III. Credit Hours : **1+1**

IV. Theory

Unit I

Concept, importance and functions of human resource management in animal husbandry sector. Process of management- planning, organizing, staffing, directing, coordination, reporting and budgeting. Principles, levels and types of organizations.

Unit II

Supervision- meaning, process and techniques. Work motivation. Job efficiency and job satisfaction.

Unit III

Organizational communication. Organizational climate. Conflict management.

Unit IV

Training– models, methods, Identification of training needs, Training evaluation and developing strategies for human resource development in animal husbandry sector. Capacity need assessment and personnel management in animal husbandry organizations.

V. Practical

Training needs assessment farmers/ extension personnel, Development of training modules, Organization and evaluation of a training programme

VI. Suggested Reading

- Khanka SS. 1999. *Entrepreneurial Development*. S. Chand and Co.
- Gupta CB. 2001. *Management Theory and Practice*. Sultan Chand and Sons.
- BJ Lathi, Parag Narkhede and Vivek Yawalkar 2015. *Human Resource Management*, Prashant Publications.
- Noe RA, Hollenbeck JR, Gerhart B and Wright PM. 1997. *Human Resources Management: Gaining a competitive advantage.*
- Grover I. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public.
- Nandan H. 2013. *Fundamentals of Entrepreneurship*, PHI publishers.
- Reading material of Course AEM-202 *Agri-Business and Entrepreneurship Development*. http://www.manage.gov.in/pgdaem/studymaterial/aem202.pdf
- Hisrich RD, Peters MP and Shepherd A. 2007. *Entrepreneurship*, 6th Edition, Tata McGraw Hill.
- Singh D. 1995. *Effective Managerial Leadership*. Deep and Deep Publ.
- Tripathi PC and Reddy PN. 1991. *Principles of Management*. Tata McGraw Hill.
- Vasanta Desai. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House.

I. Course Title : Gender Empowerment and Livestock Development

II. Course Code : EXT 609

III. Credit Hours : 1+0

IV. Theory

Unit I

Gender and empowerment: meaning and importance in livestock sector, Gender related concepts and importance of empowering women in livestock development; Need and focus on gender sensitization, Gender in community diversity and its implication for empowerment.

Unit II

Gender perspectives in development of women, Social characteristics, Roles, Responsibilities, Resources, Constraints, Legal issues and opportunities; Economical, educational and other parameters with special reference to livestock development.

Unit III

Gender tools and methodologies: Dimensions and methodologies for empowerment; Gender budgeting; Gender analysis framework- context, activities, Resources and programme action profile; Technologies and empowerment, Gender specific technologies, Household technology interface, Socio-cultural interface and women as consumers of technologies.

Unit IV

Policies and programmes in empowering women in general and livestock development in specific eg: UJJAWALA, Pradhan Mantri Mahila Shakti Kendra, One Stop Centre Scheme, Mahila E-haat, STEP, etc.

V. Suggested Reading

- Grover I and Grover D. 2002. *Empowerment of Women*. Agrotech Publ. Academy.
- Porter F, Smyth I and Sweetman C. 1999. *Gender Works: Oxfarm Experience in Policy and Practice*. Oxfarm Publ.
- Raj MK. 1998. *Gender Population and Development*. Oxford Univ. Press.
- Sahoo RK and Tripathy SN. 2006. *SHG and Women Empowerment*. Anmol Publ.
- Sinha K. 2000. *Empowerment of Women in South Asia. Association of Management Development Institution in South Asia*, Hyderabad.
- Thakur Joshi S. 1999. *Women and Development*. Mittal Publ. Vishwanathan M. 1994. Women in Agriculture and RD. Rupa Books.
- Ramkumar S, Garforth C, Rao SVN and Waldie K. (Ed). 2001. *Landless Livestock Farming-Problems and Prospects*. RAGACOVAS, Pondicherry.
- Seth Mira 2001. *Women and Development – Indian Experience*. Sage Publ.
- Samanta RK. (Ed). *Women in Agriculture – Perspectives, Issues and Experiences*. MD Publ.
- Waldie K and Ramkumar S. 2002. *Landless Women and Dairying – Opportunities for Development within a Poverty Perspective*. RAGACOVAS, Pondicherry.
- *Gender and empowerment: Definitions, approaches, and implications for policy* http://genderandenvironment.org/resource/gender-and-empowerment-definitions-approaches-and-implications-for-policy/
- Njuki, J., Waithanji, E., Bagalwa, N. and Kariuki, J. 2013. *Guidelines on integrating gender* in livestock projects and programs. Nairobi, Kenya: ILRI.
- https://cgspace.cgiar.org/bitstream/handle/10568/33425/GenderInLivestock.pdf
- http://wcd.nic.in/womendevelopment/national-policy-women-empowerment

I. Course Title : Farm Journalism

II. Course Code : EXT 610

III. Credit Hours : 1+1

IV. Aim of the course

To sensitize students about the role of print, electronic, digital and internet media for promoting animal husbandry sector.

V. Theory

Unit I

Concept of farm journalism and communication. Journalism as a means of mass communication and its role in livestock development. Opportunities, strength and limitations. Ethics and principles of journalism for effective writing.

Unit II

Writing skills –Principles of writing - art of writing, News items, News stories, feature articles, Success stories, Magazines, bulletins, folders, etc. Fundamentals of lay-out in writing. Writing of research papers and popular articles in journals, Farm magazines and e-journals. Methods and techniques of broadcasting of farm programmes. Writing scripts for radio and televisions.

Unit III

Rapport building with different categories of clients involved in veterinary and animal husbandry extension programmes. Art of speaking. Importance of listening and reading. Writing for press news. Relations with press media. Event management, Organization of press meet. Qualities of a good public relations manager. Role and importance of art of speaking, listening and reading skills

Unit IV

Types of internet based media- Writing for web- concepts, Writing for social media (Blogs, etc.) – Ethics and values. Development of Multimedia Modules.

VI. Practical

Designing and preparation of news stories, feature articles, success stories related to animal husbandry. Designing and preparation of Magazines, Pamphlets, folders, popular research articles, radio, T.V. scripts. Visit to Agricultural Technology Information Centre (ATIC) centre to record the activities of preparation, editing and publication of news articles and research publications.

VII. Suggested Reading

- Bhaskaran C, Prakash R and Kishore Kumar N. 2008. *Farm Journalism in Media Management*. Agro-Tech Publ. Academy.
- Chattergee PC. 1991. *Broadcasting in India*. Sage Publ.
- Chiranjeev A. 1999. *Electronic Media Management*. Authors Press.
- D'Souza YK.1998. *Principles and Ethics of Journalism and Mass Communication*. Commonwealth Publ.
- Defleur ML and Dennis EE. 2001. *Understanding Mass Communications*. Goyalsaab Publ.
- Jaico Publ. Malhan PN. 2004. *Communication Media: Yesterday, Today and Tomorrow*. Directorate of Publication Division, New Delhi.
- Jain SC. 2006. *International Marketing Management*. CBS Publ.
- Keval J Kumar. 2004. *Mass Communication in India*.
- Mehta DS. 1992. *Mass Communication and Journalism in India*. Allied Publ.
- Panigrahy D. 1993. *Media Management in India*. P. K. Biswasroy (Ed.). Kanishka Publ.
- Singh AK 2014. *Agricultural Extension and Farm Journalism*, Agrobios Publications

I. Course Title : Statistics for Social Sciences

II. Course Code : SSS 600

III. Credit Hours : 2+1

IV. Theory

Unit 1

Descriptive statistics- measures of central tendency, Measures of dispersion, Coefficient of variance, Standard error, Skewness and kurtosis, Contingency tables, Normal distribution, Test of significance – One sample t test, Independent t test, paired t test, ANOVA and z - one tailed and two tailed tests.

Unit 2

Population versus sample, Sampling errors, Sample size determination, Survey instruments, Open ended and closed ended questions, and online survey tools.

Unit 3

Dependency among the variables, correlation- Pearson, Spearman and Kendall, point biserial correlation, Regression analysis, Assumptions, Multiple linear Regression, Regression diagnostics-outlier, Multicollinearity, Heteroscedasticity and autocorrelation, logit/ probit model.

Unit 4

Scaling Techniques: Ranking, Rating and Paired Comparison. Scaling techniques - Likert, Thurston and Guttman Scales. Construction and standardization; Knowledge test, Test of reliability and validity. Non-parametric tests- Signed Rank, Rank sum and Kruskal-Wallis tests. Test for independence and homogeneity. Multivariate techniques – cluster analysis, discriminant analysis and Factor analysis: Different rotations and interpretation of results.

V. Practical

Exercises on different statistical tools and their interpretations

VI. Suggested Reading

- Cunningham BJ. 2012. *Using SPSS: An Interactive Hands-on approach*
- Edwards Allen L. 1969. *Techniques of Attitude Scale construction*. Vakils, Feffer and Simons Pvt. Ltd, Bombay
- Gupta SC and VK Kapoor. 2007. *Fundamentals of Mathematical Statistics*. Sultan Chand and Sons.
- Hair Joseph F, William C Black, Barry J Babin and Rolph E. Anderson. 2010. Multivariate *Data Analysis*. Pearson Pub.
- Hogg RV, AT Craig and JW. Mckean. 2005. *Introduction to Mathematical Statistics*, Pearson Education.
- Sukhatme PV, BV Sukhatme, S Sukhatme and C Ashok. 1984. *Sampling Theory of Surveys with Applications*, Lowa State University Press, Lowa, USA.

Course Title with Credit Load
Ph.D. in Veterinary Extension Education

Course Code	Course Title	Revised Credits
RPE 700	Research and Publication Ethics	1+1 #
EXT 701	Organizational Leadership and Management	2+0
EXT 702	Recent Trends in Research Techniques in Social Sciences	2+1
EXT 703	Training for Development	1+1
EXT 704	Policies and Regulations in Livestock Sector	1+0
EXT 705	Educational Technology	2+1
EXT 706	Dynamics of Social Change	2+0
EXT 707	Monitoring and Evaluation of Livestock Development Programmes	2+1
EXT 708	Theory Constructions in Social Sciences	1+0
EXT 709	Facilitation for Development	2+1
EXT 710	Managing Extension Organizations	2+1
EXT 711	Doctoral Seminar-I	1+0
EXT 712	Doctoral seminar-II	1+0
EXT 713	Doctoral Research	0+75

Mandatory Major course for all Ph D students. Other Core Courses to the extent of 10 credits are to be taken from remaining 700 series courses listed above

List of specified Minor subjects (Departments)

Major Subject	Minor subjects (Departments)*
Veterinary Extension Education	Animal Nutrition, Poultry Science, Livestock Production Management, Public Health and Epidemiology, Livestock Economics, Statistics, LPT.

*The Minor courses may be taken from any number of disciplines/ departments listed against major discipline limiting to credits prescribed as decided by the Chairman of Advisory Committee of the student.

Minor courses may also be taken from the disciplines/ departments other than those listed above on the recommendations of advisory committee, if essentially required as per the research problem with the concurrence of Head of the Department and Concerned Authorities.

Course Contents
Ph.D. in Veterinary Extension Education

I. Course Title : Organizational Leadership and Management

II. Course Code : EXT 701

III. Credit Hours : 2+0

IV. Theory

Unit I

Organizational Leadership – Introduction, Definition, Importance, Distinguishing differences between leadership and management within an organization, Theories of leadership, Current trends in leadership development, Competencies needed to be an effective leader and develop strategies for improving effective leadership potential.

Unit II

Concept, Approaches and functions of management, Principles and process of organization, hierarchy of organization, departmentalisation, Authority and responsibility. Components of individual behaviour in organization, Organizational climate, Decision making by consensus and participation by subordinates, Organization development– history, nature, characteristics, assumptions and process, Organization development interventions.

Unit III

Organizational communication, Communication network, Essentials of organizational communication. Conflict – types and management, Leadership and its role in conflict resolution, Morale in organizations, organizational factors affecting morale, attitude and productivity, methods of improving moral and evaluation of morale. Performance appraisal processes.

Unit IV

Supervision– principles, techniques and functions of supervision. Qualities of supervisor, supervisor-subordinate relationship and interaction process. Changing organizational structure and system, changing organizational climate and interpersonal style, issues and choice involved in making organizational climate effective.

V. Suggested Reading

- Bhattacharyya DK. 2011. *Organizational Change and Development*, Oxford University Press.
- Hellriegel D, Sloccum JW and Woodman. 2001. *Organizational Behaviour.*
- Luthans F. 2002. *Organizational Behaviour*. Tata McGraw-Hill, New York
- Newstrom JW and Davis K. *Organizational Behaviour: Human behaviour at Work*. Tata-McGraw Hill, New Delhi.
- Peter MS. 1998. *The Fifth Discipline: The Art and Practice of Learning Organization*. Random House, London.
- Pradip NK. 1992. *Organisational Designs for Excellence*. Tata McGraw Hill, New Delhi.
- Shukla Madhukar. 1996. *Understanding Organisations*. Prentice Hall of India, New Delhi.
- Thomas GC and Christopher GW. 2013. *Organizational development and change* (10^{th}edition), South-Western college publishing.
- Wendell LF and Cecil HB. 1999. *Organisational Development: Behavioural Science Interventions for Organization Improvement*, Pearson. 368 pp.
- Gary A Yukl. 2013. *Leadership in Organizations* (8^{th} edition), Pearson
- Anita Satterlee. 2018. *Organizational Management and Leadership* (3rd edition, Synergistics Inc.
- Patricia D Witherspoon. 1997. *Communicating Leadership: An Organizational Perspective*, Allyn and Bacon, Inc.

I. Course Title : **Recent Trends in Research Techniques in Social Sciences**

II. Course Code : **EXT 702**

III. Credit Hours : **2+1**

IV. Theory

Unit I

Importance and relevance of scales, Tests, Index, Quotient in social science research. Techniques of attitude scale construction, viz., paired comparison, equal appearing interval, successive interval, summated ratings, scalogram analysis.

Unit II

Measurement of reliability and validity of tests and scales. Sociometry. Qualitative, quantitative and mixed methods of research. Critical incidence techniques. Q-sort technique, Observation techniques, Case studies, etc.

Unit III

Experimental and quasi experimental research designs and randomized control trials. Delphi techniques, Propensity score matching, Content analysis and projective techniques.

Unit IV

Multivariate analysis, Systems analysis, Conjoint analysis, Panel data analysis, Principal component analysis, Discriminant analysis, Non-parametric tests and their application in extension research.

V. Practical

Exercises on scaling techniques, attitude scale construction – Paired Comparison, Equal Appearing interval, Summated Rating Scale, Critical Incident Technique, Exercise on construction of Knowledge Test. Assessing the reliability and validity of measuring instruments Exercise on observation skills.

VI. Suggested Reading

- Babbie E. 2008. *The basics of social research* (4th Edition), Belmont, CA, USA; Thompson Wordsworth.
- Creswell JW. 2009. *Research design: Qualitative, quantitative, and mixed methods approaches*. Third edition. Thousand Oaks: Sage Publications.
- Creswell JW. 2012. *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th edition). Boston, MA: Pearson.
- Kerlinger FN and Lee HB. 2000. *Foundations of Behavioral Research*. Orlando, FL: Harcourt College Publishers.
- Kumar R. 2014. *Research Methodology: A Step- by- Step Guide for Beginners*. (4th Edition). Thousand Oaks, California: Sage Publications.
- Malhotra NK. 2010. *Marketing research: An applied orientation. Sixth Edition*. Upper Saddle River NJ: Prentice Hall.
- Neuman WL. 2006. *Social Research Methods: Qualitative and Quantitative Approaches*. Toronto: Pearson.
- Sekaran U and Bougie R. 2013. *Research Methods for Business A Skill-Building Approach*. (6th Edition), Wiley, New York.
- Sivakumar PS, Sontakki BS, Sulaiman RV, Saravanan R and Mittal N. (eds). 2017. *Good Practices in Agricultural Extension Research. Manual on Good Practices in Extension Research and Evaluation. Agricultural Extension in South Asia*. Centre for research on innovation and science and policy (CRISP), Hyderabad. India.

I. Course Title : Training for Development

II. Course Code : EXT 703

III. Credit Hours : 1+1

IV. Aim of the course

To impart knowledge on planning, implementation and evaluation of various training programmes.

V. Theory

Unit I

Concept of training and education. Role of institution, Organization, Trainer and participants in success of training programme. Training infrastructure for extension personnel and livestock farmers.

Unit II

Planning, Development and execution of training programmes. Concept of need Assessment; Approaches in need Analysis- Performance Analysis, Task Analysis, Competency Study; Needs Survey.

Unit III

Training curriculum design and development. Training models, Methods and methodologies and strategies - Evaluation of Training (Kirkpatric model, CIPP Model, Logic Model, etc.), and follow-up of training programmes. Training Transfer– Barriers and factors effecting transfer of training (training design, trainee characteristics, Trainer capabilities, Training environment, Organization role, etc.).

Unit IV

Training, Capacity building, Capacity development and HRD-Meaning and differences; Need and principles of capacity development; Types and levels of capacities. Approaches in Capacity Development -Informative approach, Participatory approach, Experimental approach/ Experiential, Performance based approach; Capacity Development Strategies - Academic strategy, Laboratory strategy, Activity strategy, Action strategy, Personal development strategy, Organizational development strategy.

VI. Practical

Exercise on Training Need Assessment. Development of training modules. Organization of training programmes for farmers, Evaluation of training programmes. Impact assessment of training programmes. Analysis of training institutions. Studies on training transfer.

VII. Suggested Reading

- Bentaya GM and Hoffmann V (Eds). 2011. *Rural Extension Volume 3 -Training Concepts and Tools*, Margraf Publishers GmbH, Scientific books, KanalstraBe 21; D-97990, weikersheim, 191 pp.
- DFID. 2003. *Promoting Institutional and Organisational Development. A Source Book of Tools and Techniques*, Department for International Development, United Kingdom
- FAO 2010. FAO. *Capacity Assessment Approach and Supporting Tools* - Discussion Draft, Food and Agriculture Organisation of the United Nations
- FAO 2012. *Capacity Development: Learning Module 2*. FAO Approaches to Capacity Development in Programming. Processes and Tools, Food and Agriculture Organisation of the United Nation
- GFRAS. 2012. *The New Extensionist: Roles, Strategies, and Capacities to Strengthen Extension and Advisory Services*, Global Forum for Advisory Services
- GFRAS. 2015. *The New Extensionist: Core Competencies for Individuals*, GFRAS Brief 3.

- Horton D. 2002. *Planning, Implementing, and Evaluating Capacity Development*. ISNAR Briefing Paper 50.
- Maguire. 2012. *Module 2: Agricultural Education and Training to Support Agricultural Innovation Systems. Overview. Agricultural Innovation Systems: An Investment Sourcebook.* The World Bank.
- Mishra DC. 1990. *New Directions in Extension Training. Directorate of Extension,* Ministry of Agriculture, Govt. of India, New Delhi.
- OECD/ DAC. 2006. *The Challenge of Capacity Development: Working Towards Good Practice,* Organisation for Economic Cooperation and Development.
- Pretty JN, Gujit I, Thompson J, and Scoones I. 1995. *A Trainer's Guide for Participatory Learning and Action*. IEED Participatory Methodology Series.
- Rolf PL and Udai P. 1990. *Training for Development*, (3rdedn) by (West Hartford, Kumarian Press, 1990, pp. 333.
- Rolf PL and Udai P. 1992. *Facilitating Development: Readings for Trainers, Consultants and Policy-makers,* New Delhi: Sage Publications, pp. 359

I. Course Title : Policies and Regulations in Livestock Sector

II. Course Code : EXT 704

III. Credit Hours : 1+0

IV. Theory

Unit I

Concept, importance of development of policies and its framework. State, National and Global policies related to livestock sector. World Trade Organization in relation to livestock sector. Impact of WTO on Indian international trade of food products of animal origin, Intellectual Property Rights in relation to animal husbandry.

Unit II

HACCP, Sanitary and phyto-sanitary measures to protect the animals' life and health, Food safety uses in relation to animal husbandry sector. Introduction to Agreement on Technical Barriers to Trade (ATBT).

Unit III

Indian livestock sector related policies, National Livestock Policy, Regional Trade Agreements (RTAs) and Indian Livestock sector; Case studies – Impact of global trade agreements on livestock sector. Food safety acts and institutional arrangements for implementation; Agriculture Produce and Livestock Marketing (APLM) Act. Livestock products pricing policy. Government of India Systems, viz., Sanitary Import Permit System for livestock products

Unit IV

Animal welfare - Philosophical bases of animal welfare; Evolution of basic animal welfare principles; Animal Welfare laws- legislations in veterinary and animal sciences.

V. Suggested Reading

- Jessica Vapnek Megan Chapman. 2010. *Legislative and regulatory options for animal welfare* (FAO Legislative Study 104) http://www.fao.org/docrep/013/i1907e/i1907e00.pdf
- Richard A Sprenger 2018. The HACCP Handbook (7th Edition)
- Sara E Mortimore and Carol A. Wallace. 2015. HACCP: *A food industry briefing*, Second Edition Sara E. Mortimore and Carol A Wallace
- World Society for the Protection of Animals. 2007. *Universal Declaration on Animal Welfare* https://www.worldanimalprotection.ca/sites/default/files/ca_-_en_files/case_for_a_udaw_tcm22-8305.pdf
- https://awbi.org/awbi-pdf/APL.pdf
- https://www.petaindia.com/wp-content/uploads/2017/05/Prevention-of-Cruelty-to-Animals-Dog-Breeding-and-Marketing-Rules-2017.pdf
- https://www.wto.org/

I. Course Title : Educational Technology

II. Course Code : EXT 705

III. Credit Hours : 2+1

IV. Theory

Unit I

Educational Technology – Meaning, Nature, Scope Concepts and Components of Educational Technology- Basics of Teaching and Learning- Theories of teaching and learning. Curriculum development at macro and micro levels. Formulation of instructional objectives. Teaching Competencies –Need and Importance in teaching – competency mapping and development.

Unit II

Preparation of course outline for instructions, lesson planning. Designing instructions for theory and practical, Innovative Teaching Methods/ methodologies – Student Centric and Teacher Centric; Instructional tools and devices in class room instruction, computer aided learning. Understanding learner's behaviour, learning styles, motivating learners. Measurement of learning outcomes.

Unit III

Students' counselling, guidance and mentoring – concepts, types and importance in higher education- Student evaluation – meaning and methods, construction of measuring instrument – question banking. Performance appraisal of teachers – meaning and methods, construction of assessment instruments. Use of library for effective learning.

Unit IV

Emerging Educational Technologies- Open and Distance Learning (ODL) for quality Veterinary Education; Concepts of ODL – Implications to Veterinary Education. Online Education - Synchronous and Asynchronous learning – models – eLearning, Massive Open Online Courses – SWAYAM, Open Education Resources (OERs), RLOs, Digital Initiatives in Education, viz., Swayam Prabha, National Digital Library, National Academic Depository, E-Shodh Sindhu, E Acharya, EVidhwaan, Agriculture Education Portal, e-KrishiShiksha, KrishiKosh, CeRA, National Educational Alliance for Technology (NEAT) etc.

V. Practical

Preparation of lesson plans, Planning and preparation of instructional aids, Individual classroom instructional exercises, Micro Teaching Exercise, Development and testing of student evaluation instrument, Development of performance appraisal instrument for teachers., Critical analysis of different online education platforms.

VI. Suggested Reading

- Aggarwal JC. 2000. *Essential of Educational Technology: Teaching Learning Innovations in Education*. New Delhi: Vikas Publishing House.
- Alston, Antoine JW, Wade Millerand, David L Williams. 2003. *The future role of instructional technology in agricultural education in North Carolina and Virginia*. Journal of Agricultural Education, Volume 44, Number 2, 2003.
- Breslow L, Pritchard DE, DeBore J, Stump GS, Ho AD, Seaton DT. 2013. *Studying Learning in the Worldwide Classroom Research into edX's First MOOC*.
- Davies IK. 1971. *The Management of Learning*. New York: McGraw-Hill Publications.
- Fred Percival and Phil Race. 2005. *Handbook of Educational Technology 3rd Edition*. New Jersey: Nichols Publishing Company.
- Holz-Clause MS and Guntuku D. 2010. *Global Agricultural Knowledge Initiative: Strengthening the global competence of students, faculty and extension agents.*
- Kumar KL. 2000. *Educational Technology*. New Delhi: New Age International Publishers.

- Leith GO *et al*.1966. *A Hand Book of Programmed Learning and Birmingham*.
- Mangal SK. 2002. *Foundation of Educational Technology*. Ludhiana: Tondan Publication. 137.
- Mangal SK. 2006. *Essentials of Educational Technology*. New Delhi: Prentcile-Hall Publications.
- Mithra, Shiv K. 1968. *Proceeding of Symposium on Educational Technology*. IPAL, NCERT. P.4.
- Purabi Jain. March 1968. *Educational Technology*. New Delhi: Dominant Publishers and Distributers.
- Sampath K, Panneerselvam A, Santhanam M. 2001. *Introduction to Educational Technology*. New Delhi: Sterling Publishers Pvt. Ltd.
- Sharma RA. 2007. *Educational Technology and Management*. Agra: Vinod Pustak Mandir.

I. Course Title : Dynamics of Social Change

II. Course Code : EXT 706

III. Credit Hours : 2+0

IV. Theory

Unit I

Definition of change, development, social and cultural change. Dimensions, characteristics, Types, rate and directions of social change. General conditions of social change. New dynamics in social change.

Unit II

Concept, importance and problems of planned change. Role of change agents. Approaches of change agents towards planned change. Acceptance and rejection to planned change in animal husbandry. Techniques for accelerating change.

Unit III

Theories of change: Darwin, Kurt, Lewin and Ogburn: Process of change, assessment of resources, fiXation of change objective, evaluating change effect. Barriers to change-psychological, Social and economic, Stimulants to change: psychological, social and economic.

Unit IV

Social Change and its implication with reference to livestock development. Temporal changes in livestock development – national and global, Climate change and its impact on livestock development.

V. Suggested Reading

- Chandra Shekhar. 2009. *Dynamics of Social Change*. Popular Prakashan.
- Johannes Dragsbaek Schmidt, Jacques Hersh. 2000. *Globalization and Social Change*, Routledge.

John Solomos, Les Back. 1995. *Race*, *Politics*, *and Social Change*, Routledge.

I. Course Title : Monitoring and Evaluation of Livestock Development Programmes

II. Course Code : EXT 707

III. Credit Hours : 2+1

IV. Theory

Unit I

Monitoring, evaluation and impact assessment - Importance and scope in livestock based developmental programmes; Approaches and Types of Monitoring Indicators- Approaches to Monitoring Indicators, Types of Monitoring Indicators; Indicators of Monitoring in Development Programmes - Capability Indicators, Performance Indicators; Monitoring and Progress Reporting; Evaluation: Data Collection Methods - Conventional Methods, Participatory Methods; Evaluation Approaches; Challenges in Programme Evaluation.

Unit II

Conceptual framework, result framework and logic models; Quantitative and qualitative indicators – characteristics and their selection criteria; indicators and information systems for sustainable livestock development - Testing and improving indicators; Integration of M and E systems into development programs.

Unit III

Difference between outcome and impact; Types of impact assessment: Climate impact assessment; Demographic impact assessment; Development impact assessment; Ecological and environmental impact assessment; Economic and fiscal impact assessment; Risk assessment; Social impact assessment; Strategic impact assessment; technology assessment, Project evaluation, Public participation and consultation.

Unit IV

Impact assessment methods: Formative and summative evaluation, Types-within-without; before-after; case study; social auditing; performance audit; quantifying the impact parameters.

V. Practical

Development of M and E plans and procedures for livestock developmental programmes using participatory approach. Developing indicators (social and economic) and information system for sustainable livestock development; analysis of different reports, conducting impact assessment exercises, case studies, data generation, report writing.

VI. Suggested Reading

- Carlson GA, Miranowski J and Zilberman D. 1998. *Agricultural and Environmental Resource Economics*. OXford Univ. Press. 63
- Hanley N, Shogren J and White B. 2007. *Environmental Economics in Theory and Practice*. Palgrave, London.
- Kolstad C. 1999. *Environmental Economics*. OXford Univ. Press.
- Little IMD and Mirlees JA. 1974. *Project Appraisal and Planning for Developing Countries*. OXford and IBH Publ.
- Prato T. 1998. *Natural Resource and Environmental Economics*. Iowa State Univ. Press.

Sterner T. 2003. *Policy Instruments for Environmental and Natural Resource Management. Resources for the Future*. The World Bank and SIDA

I. Course Title : Theory Constructions in Social Sciences

II. Course Code : EXT 708

III. Credit Hours : 1+0

IV. Theory

Unit I

Importance of theory construction in EXtension. Hypothesis, Theory, Principle and Law; Meaning, elements, Ideal Criteria, Functions, Types of theories. Definitions: Meaning, types and Rules.

Unit II

Generalizations: Meaning, Classification. Relationship: Meaning Types.

Unit III

Terminologies used in theory constructions: AXiom, Postulate, Proposition, Theorem, Fact, Concept, Construct, Probability and Measurement Basic Derived.

Unit IV

Steps in theory building - AXiomatic techniques, Historical approaches and scientific application. Theoretical concept in social sciences. Test of Theory: Applying appropriate statistical tests.

V. Suggested Reading

- Blalock HM. 1969. *Theory Construction: Form verbal to Mathematical Formulations*. Prentice Hall.
- Dubin R. 1978. *Theory Building*. The Free Press, New York.
- Hage J. 1973. *Techniques and Problems of Theory Constructions in Sociology*. John Wiley and Sons
- Jack P Gibbs. 1972. *Sociological Theory Construction*. The Dryden Press, Illionis.
- Stinchombe AL. 1968. *Construction of Sociological Theories*. Harcourt, Brace and World.
- Wionton CA. 1974. *Theory and Measurement in Sociology*. John Wiley and Sons.

I. Course Title : Facilitation for Development

II. Course Code : EXT 709

III. Credit Hours : 2+1

IV. Theory

Unit 1

Facilitation for development in the AIS; Understanding facilitation for development; Importance of facilitation as a core function of eXtension within the Agricultural Innovation Systems (AIS); Basic principles of facilitation for development; Desired attributes of facilitator for development- Cognitive attributes, Emotional attributes (Emotional intelligence), Social, behavioural and attitudinal attributes; Technical skills of a facilitator for development- Design processes, Facilitation techniques and tools, the art of questioning and probing, Process observation and documentation, Visualisation.

Unit 2

Facilitating Change in Individuals, Groups And Organisations - Self-discovery to realize our potentials, Tools for self-discovery, formulating a personal vision, Taking responsibility for your own development; Understanding the dynamics of human interaction, Group dynamics and power relations, Managing relationships, Shared vision and collective action, Tools for team building; Organizational change process, Organisational learning to adapt to changing environments, Enhancing performance of organisations, Leadership development, Tools for organisational change.

Unit 3

Facilitating Operational Level Multi-Stakeholder Engagements - Defining stakeholders, Development of collective and shared goals, Building trust and accountability, Tools for stakeholder identification and visioning; Visualising innovation platforms (IPs), Why are IPs important?, Different models of IPs for multi-stakeholder engagement, policy engagement platforms, Generating issues and evidence for policy action, Advocacy for responsive policy processes.

Unit 4

Brokering Strategic Partnerships, Networking And Facilitation- Brokering linkages and strategic partnerships, Identification of critical links, Knowledge brokering, Creating linkages with markets, Learning alliances and networking, Coordination of pluralistic service provision within the AIS, The concept of action learning and reflective practitioners, Networking; Facilitating Capacity Development-Facilitate participation and learning in development programs and projects. Virtual platforms-skills for strengthening dialogue, collaboration, shared commitment amongst diverse actors and stakeholders.

V. Suggested Reading

- Account Ability 2005. AA 1000, *Stakeholder Engagement Standard Exposure draft*. http://www.empresa.org/doc/AA1000_STHEngagement.pdf
- Anonymous..n.d. *Facilitation Tools for Meetings and Workshops*. https://seedsforchange.org.uk/tools.pdf
- Clarke S, Blackman R and Carter I. 2004. *Facilitation skills workbook -Training material for people facilitating small group discussions and activities using PILLARS Guides*. Tearfund, England. https://www.tearfund.org/~/media/files/tilz/fac_skills_english/facilitation_e.pdf
- Davis S. 2014. Using the Socratic Method as a Learning Facilitator https://facilitatoru.com/training/using-the-socratic-method-as-a-learning-facilitator/

- Hanson L and Hanson C. *Transforming participatory facilitation: Reflections from practice.* http://pubs.iied.org/pdfs/G01950.pdf
- Jost C, Alvarez S and Schuetz T. 2014. CCAFS *Theory of Change Facilitation Guide*. CGIAR Research Program on Climate Change, Agriculture and Food Security. https://cgspace.cgiar.org/bitstream/handle/10568/41674/CCAFS%20TOC%20facilitation%202014%20FINAL.pdf
- Kennon N, Howden P and Hartley M. 2002. *Who really matters? A stakeholder analysis tool.* Extension Farming Systems Journal volume 5 number 2. https://www.csu.edu.au/__data/assets/pdf_file/0018/109602/EFS_Journal_vol_5_no_2_02_Kennon_et_al.pdf
- Koutsouris A. 2012. *Exploring the emerging facilitation and brokerage roles for agricultural extension education*. AUA Working Paper Series No. 2012-4. Agricultural University of Athens. Department of Agricultural Economics and Rural Development. http://aoatools.aua.gr/RePEc/aua/wpaper/files/2012-4_koutsouris.pdf
- Krick T, Forstater M, Monaghan P, Sillanpaa M. 2005. *The Stakeholder Engagement Manual*: Volume 2, the Practitioner's Handbook on Stakeholder Engagement. AccountAbility, United Nations Environment Programme, Stakeholder Research Associates Canada Inc.
- Linden J. 2015. *Innovation in Layer Housing: From Drawing Board to Reality*. http://www.thepoultrysite.com/articles/3494/innovation-in-layer-housing-from-drawing-board-to-reality/
- Lindynorris. *How to Develop Your Personal Vision Statement: A Step-by-Step Guide to Charting Your Future With Purpose and Passion* http://static1.squarespace.com/static/5765deb1be659449f97fcbf5/t/5770b309579fb313164a7a37/1467003657818/LINDYNORRIS.COM+-+How+to+Develop+a+Personal+Vision+Statement.pdf
- Lundy M, Gottret MV and Ashby J. *Learning alliances: An approach for building multistakeholder innovation systems*. http://documents.worldbank.org/curated/en/564521467995077219/pdf/103509-BRI-PUBLIC-ADD-series-ILAC-brief.pdf
- Makini FW, Kamau GM, Makelo MN, Adekunle W, Mburathi GK, Misiko M, PaliM, and Dixon J. 2015. *Operational Field Guide for Developing and Managing Local Agricultural Innovation Platforms*. Australian Centre for International Agricultural Research https://www.aciar.gov.au/file/103711/download?token=EPYmwXnE
- Mind Tools. n.d. *The Role of a Facilitator-Guiding an Event through to a Successful Conclusion*. https://www.mindtools.com/pages/article/RoleofAFacilitator.htm
- Mittal N, Sulaiman RV and Prasad RM. 2016. *Assessing Capacity Needs of Extension and Advisory Services A Guide for Facilitators*. Agricultural Extension in South Asia. http://www.aesanetwork.org/assessing-capacity-needs-of-extension-and-advisory-services-a-guide-for-facilitators/
- Mulema AA. 2012. *Organisation of innovation platforms for Agricultural Research and Development in the Great Lakes Region of Africa*. Graduate Theses and Dissertations. Paper 12631. https://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=3638 and context=etd
- Nederlof S, Wongtschowski M and Van der Lee (eds.). 2011. *Putting Heads Together-Agricultural Innovation Platform in Practice.* KIT Publishers.
- Ngwenya H and Kibwika P. 2016. *NELK Module 7 Introduction to Facilitation for Development*, *New Extensionist Learning Kit (NELK)*, Global Forum for Rural Advisory Services (GFRAS) http://www.g-fras.org/en/knowledge/new-extensionist-learning-kit-nelk.html#module-7-introduction-for-facilitation-for-development
- Otim RL. 2013. *Facilitation Skills Training Manual: A facilitator's handbook*. United States Agency for International Development (USAID). https://publiclab.org/system/images/photos/000/020/662/original/FACILITATION_SKILLS_TRAINING_Manual.pdf
- Partridge K, Charles J, Wheeler D, Zohar A. 2005. *The Stakeholder Engagement Manual: Volume 1. The Guide to Practitioners' Perspectives on Stakeholder Engagement*. Stakeholder

Research Associates Canada Inc., 355 Division Street Cobourg Ontario Canada K9A 3R5.
- Pye-Smith C. 2012. *Agricultural extension: A Time for Change. Linking knowledge to policy and action for food and livelihoods.* https://cgspace.cgiar.org/handle/10568/75389
- Steinlin M and Jenkins CW. *Knowledge Sharing for Change- Designing and Facilitating Learning Process with a Transformational Impact.Ingenious Peoples Knowledge.* http://www.fsnnetwork.org/sites/default/files/ipk_trainingmanual_midres.pdf
- Tallia AF, Holly J, Lanham HJ, McDaniel RR Jr., and Benjamin F Crabtree BF. 2013. *7 Characteristics of Successful Work Relationships.* https://www.aafp.org/fpm/2006/0100/p47.pdf
- Van Rooyen A, Swaans K, Cullen B, Lema Z and Mundy P. 2013. *Facilitating Innovation Platforms in: Innovations platforms practice* brief 10. https://assets.publishing.service.gov.uk/media/57a08a28ed915d3cfd000602/Brief10.pdf
- Villet VV. 2015. *Motivation Theory by David McClelland.* https://www.mindtools.com/pages/article/human-motivation-theory.htm

I. Course Title : Managing Extension Organizations

II. Course Code : EXT 710

III. Credit Hours : 2+1

IV. Theory

Unit 1

Management- An Over view - Management and Extension management – Meaning, concept, nature and importance; Management, administration and supervision - meaning, definition and scope; Approaches to management, Principles, functions and levels of management; Qualities and skills of a manager; Interpersonal relations in the organization; Reporting and budgeting; Extension Management in public, private sector and other sectors - Extension management (POSDCORB) in public sector, Department of Agriculture, Agricultural Technology Management Agency (ATMA), Krishi Vigyan Kendra (KVK), SAUs, ICAR Institutes, Private sector, Cooperatives, NGOs, FPOs, etc. Organisational Structure, Relations between different units- Challenges in management.

Unit 2

Concepts in Management - Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions; Human Resource Management: Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development; Dealing with fund and staff shortages in different extension organizations (KVK, ATMA, etc.); Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles; Authority and responsibility, Delegation and decentralization, line and staff relations.

Unit 3

Challenges of co-ordination in extension organizations; Managing interdepartmental coordination and convergence between KVK, ATMA and line departments; Co-ordinating pluralism in extension services; Challenges in managing public-private partnerships (PPPs) at different levels in agricultural development in general and extension in particular; Performance appraisal – Meaning, Concept, Methods.

Unit 4

Motivation and Communication- Managing work motivation – Concept, Motivation and Performance, Approaches to motivation, team building; Organizational Communication – Concept, Process, Types, Networks, Barriers to Communication; Mentoring, Time management, Team work and team-building strategies; Modernization of information handling; Supervision and Control - Supervision – Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision; Managerial Control – Nature, Process, Types, Techniques of Control, Observation, PERT and CPM, Management Information Systems (MIS): Concept, tools and techniques, MIS in extension organisations.

V. Practicals

- Simulated exercises on techniques of decision making
- Study the structure and function of agro-enterprises, Designing organizational structure/organograms
- Group activity on leadership development skills
- Simulated exercise to understand management processes
- Field visit to extension organizations (ATARI, KVKs, NGOs), FPOs, dairy cooperatives to understand the functions of management
- Practical exercises on PERT and CPM

- Group exercise on development of short term and long term plans for agro-enterprises
- Developing model agriculture-based projects including feasibility study, financial planning and cost-benefit analysis

VI. Suggested Reading

- Bitzer V. 2016. *Incentives for enhanced performance of agricultural extension systems*, KIT Working Paper 2016-6, Royal Tropical Institute, Amsterdam https://www.kit.nl/wp-content/uploads/2018/08/Incentives-for-enhanced-performance-of-agricultural-extension-systems.pdf
- Bitzer V, Wennik B and de Steenhuijsen B. 2016. *The governance of agricultural extension systems*, KIT Working Paper 2016-1 Royal Tropical Institute, Amsterdam. https://www.kit.nl/wp-content/uploads/2018/08/The-governance-of-agricultural-extension-systems.pdf
- Chand S. *Modern Management Theory: Quantitative, System and Contingency Approaches to Management.* http://www.yourarticlelibrary.com/management/modern-management-theory-quantitative-system-and-contingency-approaches-to-management/25621
- Daniel RG, James AFS and Freeman RE. 2003. *Management* (6th Edition). Pearson India.
- Fahimifard SM and Kehkha AA. 2009. *Application of Project Scheduling in Agriculture* (Case Study: Grape Garden Stabilization) American-Eurasian *J. Agric. and Environ. Sci.*, **5**(3): 313-321. https://www.idosi.org/aejaes/jaes5(3)/3.pdf
- Gabathuler E, Bachmann F and Klay A. 2011. *Reshaping Rural Extension Learning for Sustainability: An integrated and learning based advisory approach for rural extension with small scale farmers*- Chapter 4. Margraf Publishesrs, Kanalstr.
- GFRAS 2017. Module 3: *Agricultural Extension Programme Management*, *The New Extensionist Learning Kit*, *Global Forum for Rural Advisory Services* (GFRAS) http://www.g-fras.org/fr/component/phocadownload/category/70-new-extensionist-learning-kit-nelk.html?download=564:nelk-module-3-agricultural-extension-programme-management-textbook
- Gupta CB. 2001. *Management Theory and Practice.* Sultan Chand and Sons, New Delhi.
- Hoffmann V, Gerster BM, Christnick A and Lemma M. 2009. *Rural Extension Volume 1*- Chapter 7. Margraf Publishesrs, Kanalstr.
- HRM. 2013. *Current Trends in Human Resource Management* https://corehr.wordpress.com/2013/08/21/current-trends-in-human-resource-management/
- Koontz H and Weihrich H. 2015. *Essentials of Management: An International, Innovation and Leadership perspective*. Mcgrow Hill Education (India) Private Ltd.
- MANAGE. 2008. *Project Management in Agricultural Extension*, AEM-203, Post Graduate Diploma in Agricultural Extension Management (PGDAEM), National Institute of Agricultural Extension Management, Hyderabad http://www.manage.gov.in/pgdaem/studymaterial/aem203.pdf
- Mind Tools. *Core Leadership Theories: Learning the Foundations of Leadership*
- *Why are some leaders successful, while others fail?* Available online https://www.mindtools.com/pages/article/leadership-theories.htm
- Qamar KM. 2005. *Modernizing National Agricultural Extension Systems: A Practical Guide for Policy-Makers of Developing Countries*, Food and Agriculture Organization of the United Nations http://www.fao.org/uploads/media/modernizing%20national.pdf
- Swanson BE, Bentz RP and Sofranko AJ. 1997. *Improving Agricultural Extension. A Reference Manual*. Food and Agriculture Organization of the United Nations, Rome.
- Van den Ban AW and Hawkins HS. 1998. *Agricultural extension*- Chapter 10, BSL, CBS Publishers and Distributors.

List of Journals

- *Communicator*
- *Development communication*
- *Indian Dairyman*
- *Indian journal of Adult Education*
- *Indian Journal of Dairy Science*
- *Indian Journal of Extension Education*
- *Indian Journal of Psychology*
- *Indian Journal of Public Administration*
- *Journal of Dairy Research*
- *Journal of Extension Systems*
- *Journal of Rural Development*
- *Journal of Training and Development*
- *The Indian Journal of Animal Sciences*
- *The Indian Veterinary Journal*
- *Journal of Agriculture Extension and Education*
- *Indian Journal of Animal Research*
- *Indian Journal of Gender of Studies*
- *Kurukshetra*
- *Yojana*
- *Economic and Political weekly*
- *Indian Farming*

e-Resources

- www.informaworld.com (Journal of Agricultural Education and EXtension)
- www.blackwellpubllishing.co (International Journal of Training and Development)
- www.blackwellpubllishing.co Educational Measurement: Issue and Practices
- www.academicjournals.net (International Journal of Dairy Science)
- www. cipav.org.co (Livestock Research for Rural Development)
- www.joe.org Journal of EXtension

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Basic Veterinary Sciences

– Veterinary Physiology

Course Title with Credit Load
M.V.Sc. in Veterinary Physiology

Course Code	Course Title	Credit Hours
VPY 601	Physiology of Digestion	2+1
VPY 602	Cardiovascular and Respiratory Physiology	2+1
VPY 603	Renal Physiology and Body Fluid dynamics	2+1
VPY 604	Haematology	2+1
VPY 605	Growth and Environmental Physiology	2+0
VPY 606	Physiology of Animal Reproduction	2+1
VPY 607	Clinical Physiology	1+1
VPY 608	Neuromuscular Physiology	2+0
VPY 609	Endocrinology of Domestic Animals	2+0
VPY 610	Instrumentation and Research Techniques in Veterinary Physiology	0+2
VPY 611	Physiology of Wild Life	1+0
VPY 612	Masters Seminar	1+0
VPY 613	Masters Research	0+30

Course Contents
M.V.Sc. in Veterinary Physiology

I. Course Title : Physiology of Digestion

II. Course Code : VPY 601

III. Credit Hours : 2+1

IV. Theory

V. Unit I

Basic characteristics and comparative physiology of digestive system of monogastric and polygastric animals. Appetite andcontrol of feed intake.

Unit II

Gastro-intestinal motility, secretary functions of gastro-intestinal tract, their regulation and gastro-intestinal hormones.

Unit III

Digestion, absorption and metabolism of carbohydrate, protein and fat in simple and compound stomach. Absorption of water and electrolytes.

Unit IV

Development of ruminant stomach, rumen microbiology and rumen environment. Ruminantmicrobial digestion, its advantages and disadvantages. Fate of rumen fermentation products. Rumino-reticularmotility, its significance and control. Digestion in birds.

VI. Suggested Reading

- *Dukes' Physiology of Domestic Animals*, 13th Edn. William O Reece, Howard H Erickson, Jesse P Goff, Etsuro E Uemura. 2015.
- *Cunningham's Textbook of Veterinary Physiology* 5th Edn. Bradley G. Klein 2012
- *Digestive Physiology and Nutrition of Ruminants* by D C Church, 1975
- *The Rumen Microbial. Ecosystem*. 2nd Edn. Ed. by. P.N. HOBSON and C.S Stewart 1997
- Hungate RE. 1966. *Rumen and its Microbes*. Acad. Press. N.Y.
- *Rumen Microbiology*, Burk A Dehority. 2003. Nottingham University Press

I. Course Title : Cardiovascular and Respiratory Physiology

II. Course Code : VPY 602

III. Credit Hours : 2+1

IV. Theory

Unit I

Functional anatomy of heart and properties of cardiac muscle, Origin and propagation of cardiac impulses. Rhythmic eXcitation of heart, Electrophysiology of heart, Cardiac cycle, Cardiac sounds.

Unit II

Cardiac output and its measurements, Factors affecting cardiac output. Venous return and its regulation. Regulation of the cardiac functions.

Unit III

Normal electrocardiogram, Electrocardiographic interpretation in common cardiac disorders. Cardiac murmurs and cardiac arrhythmias. Echocardiography.

Unit IV

Circulation - coronary, systemic and pulmonary circulation and their regulation. Regional circulation. Pathophysiology of circulation. Hemodynamics. Arterial pressure. Capillary eXchanges. Lymphatic circulation.

Unit V

Respiration, Mechanism of ventilation, Transport and eXchange of respiratory gases at alveolar and tissue level, Respiratory adjustments at high altitude, Stress and eXercise. Pulmonary volumes and capacities. Neural and chemical control of respiration. Respiration in birds.

V. Suggested Reading

- Guyton and Hall *Textbook of Medical Physiology* 13th Edn John E. Hall Ph.D. 2015
- *Ganong's Review of Medical Physiology*, 26th Edn Kim E. Barrett, Susan M. Barman, Scott Boitano, Heddwen Brooks, 2019
- *Dukes' Physiology of Domestic Animals*, 13th Edn. William O. Reece, Howard H. Erickson, Jesse P. Goff, Etsuro E. Uemura 2015.
- *Cunningham's Textbook of Veterinary Physiology* 5th Edn. Bradley G. Klein 2012.

I. Course Title : Renal Physiology and Body Fluid Dynamics

II. Course Code : VPY 603

III. Credit Hours : 2+1

IV. Theory

V. Unit I

An overview of nephron structure and function. Renal function in mammals.

Unit II

Renal haemodynamics. Glomerular filtration, Tubular reasbsorption and secretion. Urine formation- stages and factors affecting different stages.

Unit III

Role of kidney in acid-base balance, Physiology of micturition, Endocrine control of renal function- Renin angiotensin aldosterone system. Non excretory functions of kidney.

Unit IV

Excretory system in birds.

Unit V

Body fluids – various body fluid compartments, Different types of body fluids and their functions, Composition of different body fluids and their regulation.

VI. Suggested Reading

- Guyton and Hall *Textbook of Medical Physiology* 13th Edn John E Hall Ph.D.. 2015
- *Ganong's Review of Medical Physiology*, 26th Edn Kim E Barrett, Susan M Barman, Scott Boitano, Heddwen Brooks. 2019.
- *Dukes' Physiology of Domestic Animals*, 13th Edn. William O Reece, Howard H Erickson, Jesse P Goff, Etsuro E Uemura. 2015.
- *Cunningham's Textbook of Veterinary Physiology* 5th Edn. Bradley G Klein. 2012.
- Klahar S. 1983. *The Kidney and Body Fluids in Health and Diseases*. Plenum Press.

I. Course Title : Hematology

II. Course Code : VPY 604

III. Credit Hours : 2+1

IV. Theory

Unit I

Hematopoietic stem cells, Blood cells and hematological indices, Anaemia, Different types of anaemia, Polycythemia and their effect on circulation in mammals and birds. Fate of erythrocytes. Porphyrias.

Unit II

Resistance of the body to infection, Leukocytes, tissue macrophage system and inflammatory response.

Unit III

Haemoglobin and its types, Iron binding proteins in blood, Haemoglobin disorders. Hemophilias. Immunity, Ommunoglobulins complement system.

Unit IV

Hemostasis and coagulation factors, Role of platelets, Fibrinolysis. Conditions causing bleeding disorders. Blood groups, transfusion of blood.

V. Suggested Reading

- Jain NC. 1993. *Essentials of Veterinary Hematology*. Lea and Febiger.
- *Schalm's Veterinary Hematology* 6th Ed - D Weiss J Wardrop, Wiley-Blackwell. 2010.
- *Guyton and Hall Textbook of Medical Physiology* 13th Edn John E Hall Ph.D. 2015.
- *Cunningham's Textbook of Veterinary Physiology* 5th Edn. Bradley G Klein. 2012.
- *Dukes' Physiology of Domestic Animals*, 13th Edn. William O Reece, Howard H Erickson, Jesse P Goff, Etsuro E Uemura. 2015.

I. Course Title : Growth and Environmental Physiology

II. Course Code : VPY 605

III. Credit Hours : 2+0

IV. Theory

Unit I

Growth - Introduction and Concepts. Hormonal regulation of growth. Growth promoters.

Unit II

Minerals - Classification-functions and disorders. Chelated minerals, nanominerals.

Unit III

Vitamins - Classification-functions and disorders. Synthetic vitamins.

Unit IV

Environment - Introduction and concepts. Weather and climate. Homeothermy, Poikilothermy. Hibernation and estivation. Thermoregulation, thermal stress. Effect of environment on production and reproduction.

V. Suggested Reading

- Samuel Brody. 1945. *Bioenergetics and growth*. Reinhold Publishing Corp., New York
- Hossner KL. 2005. *Hormonal Regulation of Farm Animal Growth*. CABI.
- McDowell LR. 1989. *Vitamins in Animal Nutrition*. Academic Press.
- Underwood EJ. 1977. *Trace Elements in Human and Animal Nutrition*. Academic Press.
- ESE Hafez. 1968. *Adaptation of Domestic Animals*. Lea and Febiger.
- *Dukes' Physiology of Domestic Animals*, 13th Edn. William O Reece, Howard H Erickson, Jesse P Goff, Etsuro E Uemura 2015.

I. Course Title : Physiology of Animal Reproduction

II. Course Code : VPY 606

III. Credit Hours : 2+1

IV. Theory

Unit I

Functional histomorphology of male and female reproductive system. Development of male and femalesex organs in different domestic animals. Neuro-endocrine reflexes.

Unit II

Puberty and its endocrine control. Sexual cycles and mating behaviours in females, oogenesis, folliculogenesis and ovulation. Secretions of female reproductive tract in different species of animals. Endocrine regulation of female reproduction.

Unit III

Male mating behaviour, Spermatogenesis, Spermiogenesis, Spermatogenic cycles. Spermatozoa- structure and composition, Maturation and transportation. Secretions of male reproductive tract. Endocrine regulation of male reproduction.

Unit IV

Transport of male and female gametes, Fertilization, implantation. Early embryo development and maternal recognition of pregnancy. Hormones of pregnancy. Placentation, parturition and Uterine Involution. Avian reproduction and formation of egg.

V. Suggested Reading

- *Reproduction in Farm Animals*, 7th Edn ESE Hafez, B Hafez. 2013.
- *McDonald's Veterinary Endocrinology*, Pineda and Doley. Iowa State University Press, Ames, 2003.
- *Physiology of Reproduction and Artificial Insemination*, Salisbury GW and Demark NL. WB Saunders, 1978.
- *Dukes' Physiology of Domestic Animals*, 13th Edn. William O Reece, Howard H Erickson, Jesse P Goff, Etsuro E Uemura. 2015.

I. Course Code : Clinical Physiology

II. Course Title : VPY 607

III. Credit Hours : 1+1

IV. Theory

V. Unit I

Introduction and basic concepts of understanding of alteration in system functions Relationship of cardiovascular, renal, respiratory systems and liver in healthy domestic animals and compensatory mechanisms during failure/ disorder of one or other systems Clinical Haematology and enzymology.

Unit II

Metabolism of carbohydrate, protein, lipid, vitamin and minerals in health and disease of various species of domestic animals and poultry.

Unit III

Evaluation of common endocrine disorders – pituitary, thyroid, parathyroid, pancreas in domestic animals (with reference to species and profile). Reproductive function alterations in male and female domestic animals during stress- productive, environmental, nutritional.

Unit IV

Clinical evaluation of Gastrointestinal tract; Clinical evaluation of Special Senses; Neuromuscular disorders and clinical correlation; Assessment of acid base and electrolyte balance.

VI. Suggested Reading

- *Clinical Biochemistry of Domestic Animals* 6th Edn, Jiro Jerry Kaneko, John W Harvey, Michael L Bruss, Academic Press. 2008.
- *Hawk's Physiological Chemistry*. Oser BL Tata McGraw-Hill. 1976.
- *Clinical Biochemistry: An Illustrated Colour* TeXt. Allan Gaw; Michael Murphy; Robert Cowan; Denis O'Reilly; Michael Stewart; James Shepherd, 2004
- *Clinical Physiology of Acid Base and Electrolyte Disorders*. Rose BD. McGraw-Hill. 1989.
- *Clinical Physiology: An Examination Primer*. 1st Edn, Ashis Banerjee, Cambridge University Press. 2005.
- *Textbook of Veterinary Physiological Chemistry* 3rd Edn, Larry R Engelking. 2014.
- *Practical Clinical Biochemistry: Methods and Interpretations*. 4th Edn. Chawla Ranjna. 2014.

I. Course Title : Neuromuscular Physiology

II. Course Code : VPY 608

III. Credit Hours : 2+0

IV. Theory

Unit I

Functional anatomy, types and classification of muscles, of muscles. Properties of skeletal muscle, Contractile elements, Membrane and action potential, Molecular mechanism of muscle contraction, Myoneuronal junction and transmission of impulse, Smooth muscle contraction.

Unit II

Length and tension relationship, Force and velocity relationship. Skeletal muscle energetics, Metabolism and lactate shuttle. Exercise, adaptation to training and performance.

Unit III

Classification of nervous system. Neuron and its classification, Properties. Development of action potential and transmission of nerve impulse in nerve and synapse. Regulatory centres in brain. Reflexes. Functions of Cerebrum, Cerebellum, Hypothalamus, Limbic system.

Unit IV

Receptors and its types. Special senses.

V. Suggested Reading

- *Guyton and Hall Textbook of Medical Physiology* 13th Edn John E Hall Ph.D. 2015.
- *Ganong's Review of Medical Physiology*, 26th Edn Kim E Barrett , Susan M Barman, Scott Boitano, Heddwen Brooks, 2019.
- *Dukes' Physiology of Domestic Animals*, 13th Edn. William O Reece, Howard H Erickson, Jesse P Goff, Etsuro E Uemura. 2015.
- *Cunningham's Textbook of Veterinary Physiology* 5th Edn. Bradley G. Klein. 2012.
- *Fundamentals of Neurophysiology*. Smith RF Springer Verlag. 1978.

I. Course Title : Endocrinology of Domestic Animals

II. Course Code : VPY 609

III. Credit Hours : 2+0

IV. Theory

Unit I

Methods of study of bioregulation including methods of endocrine analysis. Manipulation and disruption of biorhythms in homeostatic and natural ecosystem.

Unit II

Hormonal relationship in animal production. Concepts in hormone function, classification and methods of study, Hormonal assay, Mechanism of hormone synthesis, Release and transport. Mechanisms of hormone action, Target cell interactions.

Unit III

Genetic and genomic approaches in endocrinology. Animal models and alternate uses of animal model. Regulation and metabolism of hypothalamic, hypophyseal, thyroid and adrenal hormones.

Unit IV

Gonadal and placental hormones, their regulation and mechanism of action. Hormonal principles of pineal gland and its role in production.

Unit V

Endocrine control of carbohydrate and calcium homeostasis. Hormones and adaptation to environment. Hormonal regulation of gastro-intestinal activity. Prostaglandins. Hormones in fertility regulation and production augmentation. Avian endocrinology.

V. Suggested Reading

- *McDonald's Veterinary Endocrinology*, Pineda and Doley. Iowa State University Press, Ames, 2003
- *General Endocrinology*. Turner CD and Bagnara JT, WB Saunders. 1976
- *Canine and Feline Endocrinology and Reproduction*, 3rd Edition, Edward C Feldman, Richard W Nelson. 2003.
- *Applied Animal Endocrinology* 2nd Edn. E James Squires. 2010

I. Course Title : Instrumentation and Research Techniques in Veterinary Physiology

II. Course Code : VPY 610

III. Credit Hours : 0+2

IV. Aim of the course

Training in various techniques for application in research in AnimalPhysiology

V. Suggested Reading

- *Hawk's Physiological Chemistry*. Oser BL Tata McGraw-Hill. 1976.
- *Varley's Practical Clinical Biochemistry* Alan H Gowenlock
- *Handbook of Radioimmunoassay*. Abraham GE Marcel Dekker. 1977.
- *Electrocardiograms: A Systematic Method of Reading Them* Armstrong ML. 1978
- *Rumen Microbiology,* Burk A Dehority 2003 Nottingham University Press

S. No.	Topic	No. of Lectures
1.	Design and types of research laboratory	1
2.	Maintenance of research equipments	1
3.	Imparting knowledge about preparation of various solutions	1
4.	Basic principles and concepts of pH	1
5.	Determination of pH of various solutions and biological samples	1
6.	Basic principles and concepts of ECG	1
7.	Recording of ECG in animals	1
8.	Basic principles and concepts of physiograph and its accessories for *in-vitro* live tissue eXperiments	1
9.	Recording of blood pressure by physiograph and sphygmomanometer	1
10.	Recording of pulse rate by physiograph	1
11.	Recording of respiratory volumes by spirometer	1
12.	Neuro muscular eXperimental physiology using physiograph	1
13.	Physical and chemical principles of chromatography	1
14.	EXtraction of active compounds from biological samples	1
15.	Protein separation and isolation methods – basic concepts	1
16.	Methods of protein determination	1
17.	Electrophoresis	1
18.	Thin layer chromatography	1
19.	Gas liquid chromatography	1
20.	Basic concepts of mineral estimation	1
21.	Flame photometry	1
22.	Laws of colorimetry	1
23.	Spectrophotometry	1
24.	Organ bath – Applications in eXperimental physiology	1
25.	EXperiments using organ bath	1
26.	Enumeration of ruminal microflora	1
27.	Estimation of VFA	1
28.	Estimation of ammonia nitrogen	1
29.	Estimation of body water	1
30.	*In-vitro* rumen studies	1
31.	ELISA for estimation of various hormones	1
32.	RIA for estimation of various hormones	1
	Total	32

I. Course Title : Physiology of Wild Life

II. Course Code : VPY 611

III. Credit Hours : 1+0

IV. Theory

Unit I

Overview of Indian forests – Identification of sex in wild animals and birds - Blood collection methods in wild animals – Hematology - Common clinical biochemical estimations.

Unit II

Body temperature measurement techniques – Measurement of stress - Measuring senescence.

Unit III

Reproduction management in wild animals - Understanding sound mechanics and communication methods – Ethology of wild animals - Government policies for wild life protection.

V. Suggested Reading

Standard text books and Government policies pertaining to wild life.

Course Title with Credit Load
Ph.D. in Veterinary Physiology

Course Code	Course Title	Credit Hours
RPE 700	Research and Publication Ethics*	1+1
VPY 701	Applied physiology of body fluidsand electrolytes	2+1
VPY 702	Physiology of animal behaviour	2+0
VPY 703	Recent trends in ruminant digestion	2+1
VPY 704	Recent trends in neuroendocrinology	2+1
VPY 705	Myophysiology and kinesiology	2+0
VPY 706	Avian physiology	2+1
VPY 707	Physiology of lactation	2+1
VPY 708	Recent trends in environmental physiologyand growth	2+1
VPY 709	Cellular and molecular physiology	2+0
VPY 710	Recent trends in immuno-physiology	2+1
VPY 711	Physiology of stress	2+0
VPY 712	Recent trends in reproductive physiology	2+1
VPY 713	Doctorate Seminar-I	1+0
VPY 714	Doctorate Seminar-II	1+0
VPY 715	Doctorate Research	0+75

*Compulsory Major course for Doctorate programme. The other 10 credits can be registered from remaining 700 Series courses listed above.

Suggested list of specified Minor subjects (Departments)

Major Subject	Minor subjects (Departments)*
Veterinary Physiology	Animal Nutrition, Biochemistry, Gynaecology and Obstetrics, Animal Genetics and Breeding, Biotechnology, Surgery and Radiology, Livestock Production Management, Pharmacology and Toxicology, Anatomy, Medicine, poultry science, pathology.

*The Minorl courses may be taken from any number of disciplines/ departments listed against major discipline limiting to credits prescribed as decided by the Chairman of Advisory Committee of the student.

Minor courses may also be taken from the disciplines/ departments other than those listed above on the recommendations of advisory committee, if essentially required as per the research problem with the concurrence of Head of the Department and Concerned Authorities.

Course Contents
Ph.D. in Veterinary Physiology

I. Course Title : Applied Physiology of Body Fluids and Electrolytes

II. Course Code : VPY 701

III. Credit Hours : 2+1

IV. Theory

Unit I

Volume and composition of body fluids, Exchange of water and electrolytes between body compartments and transport mechanisms, Blood and external environment. Osmolarity and osmolality of body fluids.

Unit II

Regulation of volume and osmolarity of extracellular fluid. Regulation of pH and acid base balance. Formation and composition of cerebrospinal fluid and lymph.

Unit III

Clinical implications of change in electrolytes and body fluids. Functional consideration of plasma volume and its composition. Diuresis and endocrine control of renal functions.

Unit IV

Clinical feature in fluid and electrolyte imbalances, clinicopathological indictors of fluid and electrolyte imbalances. Physiological basis of fluid therapy.

S. No.	Topic	No. of Lectures/ Practicals
Theory		
1.	Body fluid compartments-Extracellular and Intracellular fluid compartment (ECF and ICF), Volume of ECF and ICF. Composition of various body fluids	1
2.	Total Body water, Water requirement, daily intake and loss of water from the body	1
3.	Different transport mechanisms for exchange of water and electrolytes-Active and passive transport, filtration, diffusion and osmosis	1
4.	Exchange of nutrients and other substances between blood and interstitial fluid. Capillary pressure, interstitial fluid pressure, exchange of fluids through capillary membrane	1
5.	Principles of osmosis and osmotic pressure, osmotic equilibrium between ICF and ECF, Tonicity of body fluids	1
6.	Composition of synovial fluid and peritoneal fluid	1

I. Course Title : Physiology of Animal Behaviour
II. Course Code : VPY 702
III. Credit Hours : 2+0
IV. Theory

Unit I

Introduction to animal ethology. Neurophysiological basis of animal behaviour.

Unit II

Behaviour in relation to changes in the environment. Feeding, Grazing, Stall feeding and rumination behaviour.

Unit III

Sexual behaviour in female and male animals. Maternal behaviour. Milk let down.

Unit IV

Social behaviour, Communication in animals, Animal temperament. Responses of dogs and horses to training.

I. Course Title : Advances in Ruminant Digestion
II. Course Code : VPY 703
III. Credit Hours : 2+1
IV. Theory

Unit I

Introduction to rumen bacteria, protozoa and fungi. Development and natural fluctuation in rumen microbial population. Salivary secretion and its regulation.

Unit II

Microbial ecology and physiology of feed degradation within the rumen. Metabolism of nitrogen containing compounds.

Unit III

Degradation of carbohydrate, fat and protein by rumen microbes, Microbe- microbe interaction. Protected nutrients and other feed additives.

Unit IV

Genetics and biotechnology of rumen microbes, rumen anaerobic fungi, their role and interaction with other rumen microbes. Probiotics supplementation, etc. Rumen flow rate and rumen volume.

I. Course Title : Advances in Neuro-endocrinology

II. Course Code : VPY 704

III. Credit Hours : 2+1

IV. Theory

Unit I

Neuroendocrine integrating mechanism. Structure of hypothalamus, pituitary gland, limbic and other neural pathways and endocrine functions.

Unit II

Neural control of oXytocin, adrenocorticotropic hormone, aldosterone, thyrotropic hormone, growth hormone, gonadotrophins, Hypothalamic releasing factors and the neuro-vascular link between brain and anterior pituitary.

Unit III

Role of afferent impulses from genitals and other regions in reproductive system. Influence of hormones on brain activity.

Unit IV

Effects of drugs on neuro-endocrine system. Neuro-endocrine mechanisms in birds. Interaction of nervous, endocrine and immune system in animal production and reproduction.

I. Course Title : Myophysiology and Kinesiology

II. Course Code : VPY 705

III. Credit Hours : 2+0

IV. Theory

Unit I

Morphology of muscle; Chemical composition of muscle; Electrical phenomena and iron influXes; Muscle contraction and irritability; Neuromuscular transmission; Excitation contraction coupling; Mechanical properties of skeletal muscle; Types of chemical muscle fibres; Coordination among muscles.

Unit II

Thermal properties of muscles; Chemical correlates of contraction.

Unit III

Molecular basis of muscular contraction of skeletal muscle; Energetics of Muscle Contraction; Electromyogram; Pathophysiology of muscles; Myocardium – electrical properties; Myocardium – mechanical properties; Pacemaker tissue; Endurance of muscle.

Unit IV

Lever systems of body joints; Synovial fluid formation and its physiology; Principles of Kinesiology and its application in work physiology.

I. Course Title : Avian Physiology
II. Course Code : VPY 706
III. Credit Hours : 2 + 1

Unit I

Digestive and urinary system.

Unit II

Blood, cardiovascular and respiratory system.

Unit III

Reproductive and endocrine system.

Unit IV

Nervous system and musculo-skeletal system.

I. Course Title : Physiology of Lactation
II. Course Code : VPY 707
III. Credit Hours : 2+1

Unit I

Functional anatomy, histology and cytology of mammary gland in domestic animals.

Unit II

Development of mammary gland, Hormonal control of mammogenesis.

Unit III

Process of lactation, Initiation of milk secretion, Hormonal control of lactation. Biochemical and histological changes in mammary gland during lactation. Mechanism of galactopoiesis.

Unit IV

Neural control of lactation, Milk let down, Milk ejection and inhibition of milk ejection. Induced lactation. Composition of milk in animals.

I. Course Title : Advances in Ecosystem, Environmental Physiology and Growth
II. Course Code : VPY 708
III. Credit Hours : 2+1
IV. Theory

Unit I

Ecology of farm animals, Biological rhythms, Mammalian circadian rhythms, their regulation. Components of physical environment, Biometeorology and principles of thermoregulation in mammals and birds.

Unit II

Physiological response of farm animals to heat and cold. Effect of various climatic components on health and production (growth and egg production), reproduction and climatic adaptation.

Unit III

Concept and definitions of cellular, prenatal and postnatal growth - Patterns in

animals.

Unit IV

Factors affecting growth - Nutrition, Hormones, Vitamins, Antibiotics, Environment. Ageing and senescence. Growth anomalies.

I. Course Title : Cellular and Molecular Physiology
II. Course Code : PHY 709
III. Credit Hours : 2+0
IV. Theory

Unit I

Cell membrane, Organelles and their functions. DNA synthesis and replication.

Unit II

Physiology of cell signaling. Basic classification and characterization of membrane receptors. Intracellular/ nuclear receptors.

Unit III

Major signaling pathways: SPs associated with second messengers; Cell signaling and apoptosis.

Unit IV

Cell cycle and Checkpoints in Cell Cycle Regulation. Regulators of the Cell cycle, cyclin-dependent kinases (CDKs) Signaling defects. Modern methods to study signaling.

I. Course Title : Advances in Immuno Physiology
II. Course Code : VPY 710
III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction, History, Body defense, Organs of immune system, Ontogeny and phylogeny of immune system, Vertical transmission of immunity in animals.

Unit II

Immunoglobulins – Basic structure and functions, Hematopoiesis, T-cell and B- cell-evolution, Development and their functions, Cytokines-sources and actions, MHC, genetic organization of immunoglobulin, MHC and complement system.

Unit III

Immune-endocrine interactions, Immune-reproduction, Ageing, Stress and other physiological functions, Immune modulation.

Unit IV

Hypersensitivity, diseases related to immune system, dysfunction, autoimmune disorders and their genesis, immunodeficiency.

I. Course Title : Physiology of Stress

II. Course Code : VPY 711

III. Credit Hours : 2+0

IV. Theory

Unit I

Definition of stress, Various types of stresses, Their effect on animal production and reproduction.

Unit II

Physico-chemical changes of blood composition due to exercise and work. Energy utilization and requirement of muscles during work and exercise.

Unit III

Capacity of work under field and controlled laboratory conditions, Factors that regulate it.

Unit IV

Effect of various stresses on endocrine status of animals, Endurances in animals.

Unit V

Energy partitioning in lactating animals under stress, Physiological basis of ameliorative measures to combat stress in lactating animals.

I. Course Title : Advances in Reproductive Physiology

II. Course Code : VPY 712

III. Credit Hours : 2+1

IV. Theory

Unit I

Estrus synchronization, Superovulation and Embryo transfer in farm animals.

Unit II

Seminal plasma proteins; Sexing of spermatozoa; Cryopreservation of semen.

Unit III

Collection and grading of oocytes; IVM, IVF and IVC; Cryopreservation of embryos; sexing of embryos; Micromanipulation of gametes and embryos.

Unit IV

Transgenic animals; applications of stem cells and nano technology in reproduction.

Note: The course teachers shall conduct the above practicals by utilizing facilities from semen/ IVF lab in the university/ college, if not available in the department.

List of Journals

- *Acta Endocrinologica*
- *Advances in Clinical Chemistry*
- *Advances in Reproductive Physiology*
- *Advances in Veterinary Sciences*
- *American Journal of Clinical Nutrition*
- *American Journal of Physiology*
- *American Journal of Veterinary Research*
- *Animal Nutrition and Feed Technology*
- *Animal Reproduction Science*
- *Animal Sciences*
- *Annual Review of Physiology*
- *Buffalo Journal*
- *Domestic Animal Endocrinology*
- *Indian Journal of Animal Reproduction*
- *Indian Journal of Animal Nutrition*
- *Indian Journal of Animal Physiology*
- *Indian Journal of Animal Research*
- *Indian Journal of Animal Science*
- *Indian Veterinary Journal*
- *Journal of Endocrinology*
- *Journal of Physiology*
- *Journal of Reproduction and Fertility*
- *Neuroendocrinology*

e-Resources

- http://intl-joe, endocrinology-journals.org (Journal of Endocrinology)
- http://intl-ajpcon.physiology.org (American Journal of Physiology)
- http://arjournals.annualreviewes.org (Annual Review of Physiology)
- www.jneurosci.org (Journal of Neuroscience)
- www3.interscience.wiley.com (Journal of Physiology and Animal Nutrition)
- http://jp.physioc.org. (Journal of Physiology)
-

I. Course Title : Research and Publication Ethics

II. Course Code : RPE 700

III. Credit Hours : 1+1

IV. Theory

RPE 01: Philosophy and Ethics

- Introduction to philosophy: definition, nature and scope, concept, branches
- Ethics: definition, moral philosophy, nature of moral judgements and reactions

RPE 02: Scientific Conduct

- Ethics with respect to science and research
- Intellectual honesty and research integrity
- Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
- Redundant publications: duplicate and overlapping publications, salami slicing
- Selective reporting and misrepresentation of data

V. RPE 03: Publication Ethics

- Publication ethics: definition, introduction and importance
- Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc.
- Conflicts of interest
- Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
- Violation of publication ethics, authorship and contributorship
- Identification of publication misconduct, complaints and appeals
- Predatory publishers and journals

VI. Practice

RPE 4: Open Access Publishing

- Open access publications and initiatives
- SHERPA/ RoMEO online resource to check publisher copyright and self-archiving policies
- Software tool to identify predatory publications developed by SPPU
- Journal finder/ journal suggestion tools, viz., JANE, Elsevier Journal Finder, Springer Journal Suggested, etc.

RPE 05: Publication Misconduct

A. Group Discussions

- Subject specific ethical issues, FFP, authorship
- Conflicts of interest
- Complaints and appeals: examples and fraud from India and abroad

B. Software tools

- Use of plagiarism software like Tumitin, Urkund and other open source software tools

RPE 06: Databases And Research Metrics

A. Databases

- Indexing databases
- Citation databases: Web of Science, Scopus, etc.

B. Research Metrics

- Impact Factor of journal as per Journal Citation Report, SNIP, SIR, IPP, Cite Score
- Metrics: h-index, g index, i10 index, altmetrics

Common Courses

I. Course Title : Technical Writing and Communications Skills

II. Course Code : PGS 601

III. Credit Hours : 0+1

IV. Aim of the course

- To equip the students/ scholars with skills to write dissertations, research papers,etc.
- To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

V. Theory

Scientific Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, materialand methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations, etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article. Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers. Plagiarism – importance in scientific writing.

VI. Practicals

- Exercises on Various forms of scientific writings - theses, technical papers, reviews, manuals
- Writing of abstracts, summaries, précis, citations
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion)
- Editing and proof-reading
- Writing of a review article
- Communication Skills
- Exercises on plagiarism

VII. Suggested Reading

- Abhishek Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
- Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
- Collins' Cobuild English Dictionary. 1995. Harper Collins.
- Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed. Holt, Rinehart and Winston.
- Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.
- James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
- Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
- Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
- Richard WS. 1969. *Technical Writing*. Barnes and Noble.
- Robert C. (Ed.). 2005. *Spoken English*: Flourish Your Language.
- Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S. Chand and Co.

I. Course Title : Agricultural Research, Research Ethics and Rural Development Programmes

II. Course Code : PGS 602

III. Credit Hours : 1+0

IV. Aim of the course

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

V. Theory

Unit I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), Partnership with NARS, Role as a partner in the global agricultural research system, Strengthening capacities at national and regional levels; International fellowships for scientific mobility.

Unit II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

Unit III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

VI. Suggested Reading

- Bhalla GS and Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.
- Punia MS. *Manual on International Research and Research Ethics*. CCS, Haryana Agricultural University, Hisar.
- Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.
- Singh K. 1998. *Rural Development - Principles Policies and Management*. Sage Publ.

I. Course Title : Basic Concepts in Laboratory Techniques

II. Course Code : PGS 603

III. Credit Hours : 0+1

IV. Aim of the course

To acquaint the students about the basics of commonly used techniques in laboratory.

V. Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/ chemicals. Weighing and preparation of solutions of different strengths and their

dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taXonomy.

VI. Suggested Reading

- Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
- Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

I. Course Title : Intellectual Property and its Management in Agriculture

II. Course Code : PGS 604

III. Credit Hours : 1+0

IV. Aim of the course

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

V. Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, Geographical indications, Designs and layout, Trade secrets and Traditional knowledge, Trademarks, protection of plant varieties and farmers' rights and bio- diversity protection; Protectable subject matters, Protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

VI. Suggested Reading

- Erbisch FH and Maredia K. 1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
- Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
- *Intellectual Property Rights: Key to New Wealth Generation. 2001.* NRDC and Aesthetic Technologies.
- Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.
- Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
- Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.
- The Indian Acts - *Patents Act, 1970 and amendments; Design Act*, 2000; Trademarks Act, 1999; *The Copyright Act, 1957 and amendments;* Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; *National Biological Diversity Act*, 2003.

I. Course Title : Library and Information Services

II. Course Code : PGS 605

III. Credit Hours : 0+1

IV. Aim of the course

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

V. Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

Restructured and Revised
Syllabi of Post-graduate Programmes
Vol. 3

Veterinary Clinical Subjects

– Animal Reproduction Gynaecology and Obstetrics
– Veterinary Surgery and Radiology
– Veterinary Medicine

Contents

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Veterinary Clinical Subjects

– Animal Reproduction Gynaecology and Obstetrics

Course Title with Credit Load
M.V.Sc. in Animal Reproduction Gynaecology and Obstetrics

Course Code	Course Title	Credit Hours
VGO 501	General Gynaecology*	2+1
VGO 502	Female Infertility in Farm Animals*	2+1
VGO 503	Veterinary Obstetrics*	2+1
VGO 504	Andrology and Male Infertility*	2+1
VGO 505	Semen Preservation and Artificial Insemination	2+1
VGO 506	Basics of Reproductive Biotechnology*	2+1
VGO 507	Clinical Practice-I*	0+3
VGO 508	Clinical Practice-II*	0+3
VGO 509	Canine and Feline Reproduction	2+1
VGO 510	Caprine and Ovine Reproduction	2+1
VGO 511	Equine Reproduction	2+1
VGO 512	Camel Reproduction	2+1
VGO 513	Elephant Reproduction	2+1
VGO 514	Wild and Zoo Animal Reproduction	2+1
VGO 515	Porcine Reproduction	2+1
VGO 516	Ultrasonography In Animal Reproduction	1+2
VGO 590	Special Problem	0+1
VGO 591	Master's Seminar	1+0
VGO 599	Master's Research	30

*Core Courses

Course Contents
M.V.Sc. in Animal Reproduction Gynaecology and Obstetrics

I. Course Title : General Gynaecology

II. Course Code : VGO 501

III. Credit Hours : 2+1

IV. Theory

V. Unit I

Functional anatomy, puberty and sexual maturity, Role of hypothalamic-pituitary-gonadal axis in attainment of puberty and sexual maturity, Endocrine regulation of estrous cycle. Role of pineal gland, endogenous opioids and neuropeptides in reproduction.

Unit II

Folliculogenesis, Oogenesis and ovulation and associated endocrine pattern, manipulation of follicular waves, Synchronization of estrus and ovulation and induction of ovarian activity.

Unit III

Gamete transport, Fertilization, Implantation and maternal recognition of pregnancy.

Unit IV

Embryonic and fetal development, Placentation, Fetal circulation and gestation, position of fetus in the uterus, age characteristics of fetus.

Unit V

Pregnancy diagnosis: Clinical, Ultrasonographic, Endocrinological and other diagnostic laboratory tests.

Unit VI

Lactation and artificial induction of lactation.

VI. Practical

Clinical examination of female genitalia. Biometry of female genital organs. Rectal and vaginal examination to diagnose cyclic phases of estrous cycle. Fern pattern of cervical mucus and exfoliated vaginal cytology. Pregnancy diagnosis in large and small animals by various methods. Estimation of age of the fetus. Use of ultrasound/ RIA/ ELISA in gynaecology. Synchronization of estrus and ovulation in farm animals.

VII. Suggested Reading

- Perry T Cupps. 2009. *Reproduction in Domestic Animals*. Academic Press.
- Hafez ESE and B Hafez. 2013. *Reproduction in Farm Animals*. Wiley-Blackwell.
- Mauricio Pineda and Michael P Dooley. 2008. *McDonald's Veterinary Endocrinology* and Wiley-Blackwell.
- David Noakes, Timothy Parkinson and Gary England 2018. *Veterinary Reproduction and Obstetrics*. Saunders Ltd.
- Roberts SJ. 2005. *Veterinary Obstetrics and Genital Diseases*. Scientific Book Agency.

I. Course Title : Female Infertility in Farm Animals

II. Course Code : VGO 502

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction to infertility, classification, economic impact. Anatomical causes of infertility, congenital and hereditary causes and acquired defects.

Unit II

Nutritional causes of infertility. Importance of body condition score. Negative energy balance, its prevention and amelioration.

Unit III

Managemental and environmental causes of infertility. Out of season breeding.

Unit IV

Infectious causes of female infertility, Specific and non-specific infections; It's diagnosis, treatment, prevention and control.

Unit V

Ovarian dysfunction; Anoestrus, Cystic ovarian degeneration, Anovulation, Delayed ovulation and luteal insufficiency; causes, diagnosis and treatment.

Unit VI

Repeat breeding; its causes, diagnosis and treatment.

Unit VII

Early embryonic death (EED); it's causes, Diagnosis and therapeutic management.

Unit VIII

Abortion; causes, diagnosis and prevention of abortion.

Unit IX

Interactions in immunological mechanisms and infertility.

V. Practical

Record keeping, herd fertility assessment and management, diagnosis and treatment of infertility in female animals, use of uterine swabs for bacterial and fungal culture, histo-pathological evaluation of uterine biopsy, white side test, endometrial cytology and hormone assay. Use of ultrasonography in diagnosis of infertility. Immuno- diagnostic techniques.

VI. Suggested Reading

- Laing JA. 1979. *Fertility and Infertility in Domestic Animals*. English Language Book Soc. and Bailliere Tindall.

Morrow DA. 1986. *Current Therapy in Theriogenology*. WB Saunders.

- David Noakes. Timothy Parkinson and Gary England 2018. *Veterinary Reproduction and Obstetrics*. Saunders Ltd.
- Roberts SJ. 2005. *Veterinary Obstetrics and Genital Diseases*. Scientific Book Agency.

I. Course Title : Veterinary Obstetrics

II. Course Code : VGO 503

III. Credit Hours : 2+1

IV. Theory

Unit I

Parturition; stages of parturition, Mechanism of initiation of parturition, Hormonal profiles associated with parturition, Transition cow, Onset of postpartum ovarian activity.

Unit II

Principles of handling of dystocia, Obstetrical procedures: Mutations, Fetotomy, caesarean section. Obstetrical anaesthesia and analgesia, epidural anesthesia.

Unit III

Fetal and maternal dystocia; causes, diagnosis and management.

Unit IV

Uterine torsion; causes, diagnosis and its correction. Caesarean section, anaesthesia for caesarean section, ovariohysterectomy.

Unit V

Diseases and accidents during gestation and around parturition.

Unit VI

Etiology, diagnosis and treatment of ante-partum and post-partum uterine and vaginal prolapse.

Unit VII

Induction of parturition and elective termination of pregnancy.

Unit VIII

Involution of uterus following normal and abnormal parturition.

Unit IX

Care of dam and the newborn.

V. Practical

Pelvimetry of different species of farm animals. Diagnosis and correction of abnormal fetal presentation, position and posture in phantom box. Epidural anesthesia, episiotomy, ovariohysterectomy and caesarean operation. Management of incomplete cervical dilation. Fetotomy operations. Detorsion of uterus. Management of cervico-vaginal and uterine prolapse. Handling of clinical cases of dystocia.

- David Noakes, Timothy Parkinson and Gary England 2018. *Veterinary Reproduction and Obstetrics*. Saunders Ltd.
- Roberts SJ. 2005. *Veterinary Obstetrics and Genital Diseases*. Scientific Book Agency.
- Sloss V and Dufty JH. 1980. *Handbook of Bovine Obstetrics*. Williams and Wilkins.

I. Course Title : Andrology and Male Infertility

II. Course Code : VGO 504

III. Credit Hours : 2+1

IV. Theory

Unit I

Structure and function of reproductive tract of male.

Unit II

Sexual behavior and examination of bulls for breeding soundness.

Unit III

Spermatogenesis, Seminiferous epithelial cycle, Spermatogonial wave, Structure of spermatozoa, Semen and its composition. Mechanism of sperm motility.

Unit IV

Diseases transmitted through semen. Factors affecting semen quality, semen culture, tests for assessment of sperm motility, sperm survival and fertilizing capacity of spermatozoa.

Unit V

Causes of infertility; hereditary, congenital, infectious, nutritional and hormonal. Pathological and functional disturbances of epididymis, vas deferens and accessory sex glands.

Unit VI

Impotentia coeundi and impotentia generandi. Testicular hypoplasia and degeneration; causes and affect on semen and fertility. Coital injuries and vices of male animals.

Unit VII

Influence of seminal plasma proteins in modulating fertility. Heat stress and it's effect on sperm production.

Unit VIII

Screening of the breeding bulls to be selected for semen collection.

V. Practical

General and rectal examination for biometrics of male genitalia and accessory sex glands. Breeding soundness evaluation of male animals. Semen evaluation for sperm abnormalities, fertility and determination of other biochemical constituents of seminal plasma, Microbiological load of Examination, diagnosis and semen. treatment of infertile male animals.

VII. Suggested Reading

- Hafez ESE and B Hafez. 2013. *Reproduction in Farm Animals*. Wiley-Blackwell.
- Mann T and Lutwak-Mann C. 1981. *Male Reproductive Function and Semen*. Springer-Verlag.
- Morrow DA. 1986. *Current Therapy in Theriogenology*. WB Saunders.
- Roberts SJ. 2005. *Veterinary Obstetrics and Genital Diseases*. Scientific Book Agency.
- Salisbury GW, VanDemark NL and Lodge JR. 1978. *Physiology of Reproduction and Artificial Insemination of Cattle*. WH Freeman and Co.

I. Course Title : Semen Preservation and Artificial Insemination

II. Course Code : VGO 505

III. Credit Hours : 2+1

IV. Theory

Unit I

History of artificial insemination. Methods of semen collection.

Unit II

Semen evaluation; macroscopic, microscopic, biochemical and microbiological tests.

Unit III

Semen preservation. Extenders for preservation of semen at different temperatures. Semen additives for enhancement of motility and fertilizing capacity of spermatozoa. Dilution of semen.

Unit IV

Cryopreservation of semen. Effect of cryopreservation on spermatozoa, semen quality and fertility. Liquid Nitrogen (LN2) cylinders; it's handling, care and maintenance.

Unit V

Thawing protocols of frozen semen. Factors affecting post-thaw semen quality.

Unit VI

Ideal protocol for AI in different species of animals. Factors affecting success of AI.

Unit VII

Biosecurity and biosafety guidelines for frozen semen stations, semen processing laboratories and quarantine stations. Minimum standards and standard operating procedures for artificial insemination, Quality testing of straws and sheath for use in artificial insemination.

V. Practical

Instrumentation in semen laboratory, Minimum standards of protocols and Standard operating procedures for semen production, Computer assisted semen analysis (CASA), Collection and evaluation of semen. Preparation of extenders. Preservation of semen; room temperature, refrigeration and cryopreservation. Handling and evaluation of processed semen. Practice of AI techniques.

VI. Suggested Reading

- Hafez ESE and B Hafez 2013. *Reproduction in Farm Animals*. Wiley-Blackwell.
- Enos Johnson Perry 2013. *Artificial Insemination of Farm Animals*. Jodhpur: AXis Books (India).
- Salisbury GW, VanDemark NL and Lodge JR. 1978. *Physiology of Reproduction and Artificial Insemination of Cattle*. WH Freeman and Co.

I. Course Title : Basics of Reproductive Biotechnology

II. Course Code : VGO 506

III. Credit Hours : 2+1

IV. Theory

Unit I

Embryo transfer technology: selection of donors and recipients.

Unit II

Synchronization, super-ovulation, surgical and non-surgical collection of embryos and evaluation of embryos.

Unit III

Cryopreservation of embryos, transfer of embryos to donors. Sexed semen production, sexing of embryos. Guidelines for export and import of bovine germplasm. Guidelines and standards regarding embryo production.

Unit IV

In-vitro culture of granulosa cells, cumulus cells, luteal cells and oviductal cells. Recovery of bovine oocytes; from abattoir ovaries and live animals, *in-vitro* fertilization, *in-vitro* maturation, micromanipulation of embryos.

Unit V

Immuno-neutralization of hormones. Immunomodulation of fertility.

V. Practical

Synchronization of estrus in donors and recipients, superovulation, surgical and non-surgical collection and transfer of embryos. Collection of oocytes from slaughter house genitalia. *In-vitro* fertilization, *in-vitro* maturation and cryopreservation of embryos. Sexing of embryos.

VI. Suggested Reading

- Ian Gordon. 2017. *Reproductive Technologies in Farm Animals*. Wallingford, Oxfordshire CABI.
- Hafez ESE and B Hafez. 2013. *Reproduction in Farm Animals*. Wiley-Blackwell.
- B Singh, SK Gautam and MS Chauhan. 2012. *Textbook of Animal Biotechnology*, Pearson Education.
- Heiner Niemann, Christine Wrenzycki. 2018. *Animal Biotechnology 1: Reproductive Biotechnologies*. Springer.
- Heiner Niemann, Christine Wrenzycki. 2018. *Animal Biotechnology 2*. Springer International Publishing AG.
- Troy L Ott, Zhihua Jiang. 2010. *Reproductive Genomics in Domestic Animals*. John Wiley.
- Marcelo Marcondes Seneda, Katia Cristina Silva-Santos LS Rafagnin Marinho. 2016. *Biotechnology of Animal Reproduction*, Nova Science Pub. Inc; UK Ed.
- Tacia Gomes Bergstein-Galan. 2018. *Reproduction Biotechnology in farm animals*. Avid Science.

I. Course Title : Clinical Practice-I

II. Course Code : VGO 507

III. Credit Hours : 0+3

IV. Practical

Clinical examination of animals affected with reproductive disorders, Use of diagnostic techniques for diagnosis and institution of required therapy. Acquaintance with different equipment used for handling reproductive disorders, Client management, Public relations, Code of conduct, Database management, Maintenance of case records.

V. Suggested Reading

- Morrow DA. 1986. *Current Therapy in Theriogenology*. WB Saunders.
- Zemjanis R 1970. *Diagnostic and Therapeutic Techniques in Animal Reproduction*. Williams and Wilkins; Second Edition.

I. Course Title : Clinical Practice-II

II. Course Code : VGO 508

III. Credit Hours : 0+3

IV. Aim of the course

Hands-on training on diagnosis and treatment of reproductive disorders in animals at VCC.

V. Practical

Clinical examination of animals affected with reproductive disorders, use of diagnostic techniques for diagnosis and institution of required therapy. Acquaintance with different equipment used for handling reproductive disorders, Client management, Public relations, Code of conduct, Database management, Maintenance of case records.

VI. Suggested Reading

- Morrow DA. 1986. *Current Therapy in Theriogenology*. WB Saunders.
- Zemjanis R. 1970. *Diagnostic and Therapeutic Techniques in Animal Reproduction*. Williams and Wilkins; Second Edition.

I. Course Title : Canine and Feline Reproduction

II. Course Code : VGO 509

III. Credit Hours : 2+1

IV. Theory

V. Unit I

Development of reproductive system. Anatomy of male and female reproductive system. Canine and feline estrous cycle, endocrinology of estrous cycle.

Unit II

Breeding management, pregnancy, pregnancy diagnosis; clinical, ultrasonographic, endocrinological and other diagnostic laboratory tests.

Unit III

Parturition, fetal and maternal dystocia; causes, diagnosis and management. Induction of parturition and caesarean section, periparturient disorders.

Unit IV

Medical termination of pregnancy in dogs and cats, management of psudopregnancy, pyometra and it's management. Infertility and it's management in dogs and cats.

Unit V

Postpartum care of dam and lactation. Neonatal care.

Unit VI

Population control in dogs; surgical and non surgical methods.

Unit VII

Reproductive physiology of male dogs, semen collection techniques, semen evaluation, freezing of semen, artificial insemination techniques, male reproductive disorders and it's management.

VI. Practical

Exfoliative vaginal cytology, determination of ovulation time, demonstration of semen collection and artificial insemination, predicting time of parturition using hormonal assay, management of dystocia using clinical cases, castration, ovariohystrectomy, caesarean section, surgical procedure related to reproductive disorders in both male and female dogs and cats.

VII. Suggested Reading

- Edward C Feldman, Richard William Nelson. 2003. *Canine and Feline Endocrinology and Reproduction*. Elsevier Health Sciences, Saunders.
- Shirley Dianne Johnston, Margaret V Root Kustritz, Patricia Schultz Olson. 2001. *Canine and Feline Theriogenology*. Saunders Publ.
- Margaret V, Root Kustritz. 2009. *Clinical Canine and Feline Reproduction*: Evidence-Based Answers. John Wiley and Sons.
- Phyllis A. Holst MS. 2010. *Canine Reproduction: The Breeder's Guide 3rd Edition*. DOGWISE.
- Cheryl Lopate. 2012. *Management of Pregnant and Neonatal Dogs, Cats, and Exotic Pets*. John Wiley and Sons.
- Jovi R Otite. 2015. *Reproduction in the Dog a Tropical Approach*. Xlibris Corporation.

I. Course Title : Caprine and Ovine Reproduction

II. Course Code : VGO 510

III. Credit Hours : 2+1

IV. Aim of the course

To impart knowledge and training about reproduction in sheep and goat.

V. Theory

Unit I

Caprine and ovine estrous cycle, endocrinology of estrous cycle, Seasonal breeding activity in sheep and goat, Artificial control of oestrus in sheep and goat.

Unit II

Breeding management, methods for advancing sheep breeding season, Induction of multiple births in sheep. Artificial insemination, pregnancy and parturition, Dystocia and it's management.

Unit III

Reproductive disorders and it's management.

Unit IV

Reproductive physiology of males, semen collection techniques, semen evaluation, freezing of semen, male reproductive disorders and it's management.

VI. Practical

Demonstration of semen collection and artificial insemination, management of dystocia using clinical cases, castration, ovariohystrectomy, caesarean section, surgical procedure related to reproductive disorders in both male and females.

VII. Suggested Reading

- Mauricio Pineda and Michael P Dooley. 2008. *McDonald's Veterinary Endocrinology and Reproduction*. Wiley-Blackwell.
- Lindsay DR and Pearce DT. 2011. *Reproduction in Sheep*, Cambridge University Press, Cambridge, London.
- Selected articles from journals.

I. Course Title : Equine Reproduction

II. Course Code : VGO 511

III. Credit Hours : 2+1

IV. Theory

Unit I

Anatomy and physiology of the mare and stallion.

Unit II

Manipulation of estrus in the mare, estrous cycle, broodmare management, Use of ultrasound in breeding management.

Unit III

Infertility and it's management.

Unit IV

Pregnancy diagnosis and management of the pregnant mare. Fetal development, abortion, induced parturition and dystocia.

Unit V

Neonatal management and common neonatal diseases, orphan foal management, foal management during the first siX months.

Unit VII

Semen collection, semen preservation, artificial insemination and embryo transfer.

V. Practical

Visit of equine/ stud farm, overall management of an equine breeding program, handling the cases of reproductive disorders, artificial insemination, semen collection, semen preservation, breeding record keeping and analysis.

VI. Suggested Reading

- Mauricio Pineda and Michael P Dooley. 2008. *McDonald's Veterinary Endocrinology and Reproduction*. Wiley-Blackwell.
- McKinnon, Squires, Vaala and verner. 2011. *Equine Reproduction* (2nd Ed). Wiley- Blackwell.
- Juan Samper, Jonathan Pyocock and Angus McKinnon. 2007. *Current Therapy in Equine Reproduction*. Saunders.
- Steven Brinsko Terry Blanchard Dickson Varner James Schumacher Charles Love. 2010. *Manual of Equine Reproduction* (3rd Ed). CV Mosby.
- John Dascanio and Patrick McCue. 2014. *Equine Reproductive procedures*. John Wiley and Sons, Inc.
- Selected articles from journals.

I. Course Title : Camel Reproduction

II. Course Code : VGO 512

III. Credit Hours : 2+1

IV. Theory

Unit I

Male reproductive organs, male reproductive physiology and sexual behavior, puberty and sexual maturity, seasonal changes, copulation, semen collection and it's characteristics.

Unit II

Female reproductive organs, female reproductive physiology and sexual behavior, oestrous cycle, external signs of oestrus, pregnancy and foetal development, pregnancy diagnosis and parturition.

Unit III

Age of sexual maturity, breeding season, conception rate, calving interval, reproductive longevity.

Unit IV

Early embryonic mortality, reproductive problems in the female, reproductive problems in the male.

Unit V

Artificial insemination, nutrition and reproduction, embryo transfer in camel.

VI. Practical

Management of dystocia in clinical cases, castration, ovariohystrectomy, caesarean section, surgical procedure related to reproductive disorders in both male and females.

VII. Suggested Reading

- H Merkt, D Rath, B Musa, MA El-Naggar. 1990. *Reproduction in Camels*. FAO.
- Muhammad Jamshed Khan. 2011. *Equine and Camel Production: An Approach towards Better Management*. LAP LAMBERT Academic Pub.
- Selected articles from journals.

I. Course Title : Elephant Reproduction

II. Course Code : VGO 513

III. Credit Hours : 2+1

IV. Theory

V. Unit I

General introduction, Elephas maximus, domestic and wild elephants.

Unit II

Male genital system, Accessory sex glands, Hormonal control and semenology.

Unit III

Female reproductive system, Ovaries, fallopian tubes, Uterus, vagina and external genitalia. Oestrous cycle, Hormonal regulation of estrous cycle, Mating behaviour and act of copulation.

Unit IV

Pregnancy, Gestation length and parturition. Neonatal care of elephant calves.

Unit V

Musth in elephants, behavioral patterns, pre-musth, violent- musth and post-musth phases, controlling elephants in musth using drugs/ hormones, anti androgens. Artificial insemination and cryopreservation of gametes.

VI. Practical

Management of dystocia in clinical cases, surgical procedure related to reproductive disorders in both male and females.

VII. Suggested Reading

- Brown JL, Paris S, Prado-Oviedo NA, Meehan CL, Hogan JN, Morfeld KA and Carlstead KA. 2016. *Reproductive Health Assessment of Female Elephants in North American Zoos and Association of Husbandry Practices with Reproductive Dysfunction in African Elephants* (Loxodonta africana). PLOS ONE | DOI:10.1371 journal pone 014573.
- Ortolani A, Leong K, Graham L, Savage A. 2005. *Behavioral indices of estrus in a group of captive African Elephants* (Loxodonta africana). Zoo Biol. 24:311-329.
- Rasmussen LE, Schmidt MJ, Henneous R, Groves D, Daves GD. Jr. 1982. *Asian bull elephants: flehmen-like responses to extractable components in female elephant estrous urine.* Science. 217: 159-162.
- Sukumar R. 2006. *A brief review of the status, distribution and bioilogy of wild Asian elephants Elephas maximus*. Int. Zoo Yb. 40: 1-8.

  Thitaram C. 2009. *Elephant reproduction: Improvement of breeding efficiency and development of a breeding strategy*. Ph.D. Thesis, Utrecht University, The Netherlands

- Vidya TNC and Sukumar R. 2005. *Social and reproductive behaviour in elephants. Current sci.* **89**: 1200-1207.
- Selected articles from journals.

I. Course Title : Wild and Zoo Animal Reproduction

II. Course Code : VGO 514

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction to reproduction, Pattern of estrous cycle, Optimal breeding time with emphasis on tiger, deer, monkey and crocodile.

Unit II

Gestational length, parturition and pregnancy diagnosis.

Unit III

Sexual behavior and major reproductive disorders in wild and zoo animals, contraception techniques for deer.

V. Practical

Management of dystocia in clinical cases, castration, observation of estrus behavior, pregnancy diagnosis, surgical procedure related to reproductive disorders in both male and females.

VI. Suggested Reading

- GR Smith, JP Hearn and Wellcome Trust (London, England). 1988. *Reproduction and disease in captive and wild animals*, New York: Oxford University Press.
- Ian Gordon. 1997. *Controlled reproduction in horses, deer and camelids*. CAB International.
- Mauricio Pineda and Michael P Dooley. 2008. *McDonald's Veterinary Endocrinology and Reproduction*. Wiley-Blackwell.
- Paul A Rees. 2011. *An Introduction to Zoo Biology and Management*. Wiley-Blackwell.
- R Eric Miller, Murray E Fowler. 2014. *Fowler's Zoo and Wild Animal Medicine*. Saunders.
- Selected articles from journals.

I. Course Title : Porcine Reproduction

II. Course Code : VGO 515

III. Credit Hours : 2+1

IV. Theory

V. Unit I

Anatomy and physiology of boar and sow.

Unit II

Oestrus cycle in sow, manipulation of oestrus cycle, methods for detection of oestrus, endocrinology of pregnancy and parturition.

Unit III

Infertility in sow and its management.

Unit IV

Pregnancy diagnosis and management of pregnant sow.

Unit V

Fetal development, abortion, induced parturition, dystocia, stages of parturition and mastitis-metritis complex in sow.

Unit VI

Neonatal management and common neonatal diseases, care of piglets.

Unit VII

Breeding boar selection and management, semen collection, semen preservation, natural service, artificial insemination, embryo transfer and IVF.

VI. Practical

Visit of swine farm, breeding management in sows, handling the cases of reproductive disorders, caesarean section, castration, sexual behaviour, vaginal cytology, pregnancy diagnosis, dystocia, semen collection, semen preservation, artificial insemination, embryo transfer and record keeping.

VII. Suggested Reading

- Colin T Whittemore, Ilias Kyriazakis. 2008. *Whittemore's Science and Practice of Pig Production*. John Wiley and Sons Press.
- *Control of Pig Reproduction*. Proceedings of the Eighth International Conference on Pig Reproduction, Alberta, Canada, June 2009 by Heriberto Rodríguez Martínez, Jeff L Vallet, Adam J Ziecik, Nottingham University Press. 2009.
- DJA Cole, GR Foxcroft, Butterworth-Heinemann. 2013. *Control of Pig Reproduction*. Technology and Engineering Press.
- Mauricio Pineda and Michael P Dooley. 2008. *McDonald's Veterinary Endocrinology and Reproduction*. Wiley-Blackwell.
- *Pig Reproduction: Problems, Practices and Principles*. Proceedings of a Conference Held at Christ Church, Oxford University, 16-18 December, 1998.
- Sergi Bonet, Isabel Casas, William V Holt, Marc Yeste. 2013. *Boar Reproduction: Fundamentals and New Biotechnological Trends*. Springer Science and Business Media.
- Selected articles from journals.

I. Course Title : Ultrasonography in Animal Reproduction

II. Course Code : VGO 516

III. Credit Hours : 1+2

IV. Theory

Unit I

Basic principle of ultrasonography, physics of ultrasonography, A-mode, B-mode and M-mode ultrasonography, artifacts, principle of Doppler ultrasonography.

Unit II

Trans-abdominal ultrasonography, transrectal ultrasonography, follicular dynamics and luteal characteristics in large and small ruminants, luteal blood flow studies.

Unit III

Use of ultrasonography in pregnancy diagnosis, infertility management, uterine involution, luteal cyst and follicular cyst, blood flow studies in uterine and foetal arteries. Determination of gestational age in small animals by measuring gestational sac diameter, crown rump length and body diameter. Detection of foetal resorption and mummification. Prediction of parturition time, fetal viability by detecting fetal heart rate, foetal number and sex determination.

Unit IV

Testicular and male accessory sex gland ultrasonography.

V. Practical

Use of ultrasonography in different stages of reproductive cycle. Use of ultrasonography in diagnosis of clinical cases associated with reproductive disorders in both male and females.

VI. Suggested Reading

- MAM Taverne and AH Willemse. 1989. *Diagnostic ultrasound and animal reproduction*. Dordrecht; Boston: Kluwer Academic.
- J Ginther. 1998. *Ultrasonic imaging and animal reproduction*. Cross Plains, Wis.: Equiservices Pub.
- Selected articles from journals.

I. Course Title : Special Problem

II. Course Code : VGO 590

III. Credit Hours : 0+1

IV. Aim of the course

To expose students to research techniques related to sub discipline of the subject and submission of written project with references.

V. Practical

Student will carry out research on allotted project and submit the project report.

VGO 591 Master's Seminar 1+0
VGO 599 Master's Research 30

Minor Courses for M.V.Sc. Degree programme

Courses of any one department/ discipline from the list given below:

- Veterinary Pathology
- Veterinary Pharmacology
- Veterinary Physiology
- Veterinary Biochemistry
- Veterinary Bacteriology
- Veterinary Immunology

Course Title with Credit Load
Ph.D. in Animal Reproduction Gynaecology and Obstetrics

Course Code	Course Title	Credit Hours
VGO 601	Advances in Gynaecology and Infertility* Management	2+1
VGO 602	Advances in Veterinary Obstetrics	1+1
VGO 603	Advances in Andrology and Male Infertility*	2+1
VGO 604	Reproductive Biotechnology	1+1
VGO 605	Semenology	1+1
VGO 606	Clinical Practice-I*	0+3
VGO 607	Clinical Practice-II*	0+3
VGO 690	Special Problem	0+2
VGO 691	Doctoral Seminar-I	1+0
VGO 692	Doctoral Seminar-II	1+0
VGO 699	Doctoral Research	75

*Core Courses

Course Contents
Ph.D. in Animal Reproduction Gynaecology and Obstetrics

I. Course Title : Advances in Gynaecology and Infertility Management

II. Course Code : VGO 601

III. Credit Hours : 2+1

IV. Theory

V. Unit I

Neuro-endocrine control of reproduction, follicular development, ovulation fertilization and implantation. Embryonic and fetal development.

Unit II

Maternal recognition of pregnancy advances in early diagnosis of pregnancy.

Unit III

Embryonic losses, abortion and their prevention.

Unit IV

Seasonal breeders, Synchronization and induction of estrus and ovulation in seasonal breeders, Assisted Reproductive Technology (ART) to increase reproductive efficiency in farm animals.

Unit V

Effect of stress, nutrition and immunological factors on fertility.

Unit VI

Onset of postpartum ovarian activity and factors affecting it.

Unit VI

Diagnostic and therapeutic approaches in infertility; principles of hormone therapy in reproductive disorders, laparoscopy, ultrasonographic diagnosis of ovarian/ uterine dysfunction, reproductive disorders, vaginal and uterine cytology.

VI. Practical

Clinical examination of female animals. Use of ultrasonography in ovarian function (follicular image pattern, follicular dynamics) and in early pregnancy diagnosis and infertility. Utility of uterine culture, uterine cytology and uterine biopsy (histopathological examination) in infertility investigation. Laparoscopy in diagnosis of ovarian and uterine dysfunction. ELISA/ RIA of hormones and interpretation of results. Use of assisted reproductive technology (ART) to enhance reproductive efficiency in farm animals.

VII. Suggested Reading

- Hafez ESE and B Hafez. 2013. *Reproduction in Farm Animals*. Wiley-Blackwell.
- Mauricio Pineda and Michael P Dooley. 2008. *McDonald's Veterinary Endocrinology* and Wiley-Blackwell.
- David Noakes, Timothy Parkinson and Gary England. 2018. *Veterinary Reproduction and Obstetrics*. Saunders Ltd.
- Roberts SJ. 2005. *Veterinary Obstetrics and Genital Diseases*. Scientific Book Agency.
- Morrow DA. 1986. *Current Therapy in Theriogenology*. WB Saunders.
- Selected articles from journals.
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I. Course Title : Advances in Veterinary Obstetrics

II. Course Code : VGO 602

III. Credit Hours : 1+1

IV. Theory

Unit I

Conceptus and its development. Factors influencing gestation period and birth weight.

Unit II

Anomalies of conceptus, teratogens and effect of stress on conceptus development.

Unit III

Mechanism of initiation of parturition. Use of tocolytic drugs.

Unit IV

Induction of parturition and termination of abnormal pregnancies. Obstetrical analgesia and anesthesia.

Unit V

Pre-treatment evaluation of the dam suffering from dystocia. Management of maternal and fetal dystocia, hydrallantois, hydramnion, fetal mummification, fetal maceration, uterine inertia and uterine torsion.

Unit VI

Fetotomy, caesarean section and ovairo-hysterectomy. Retention of fetal membranes and management.

Unit VII

Neo-natal physiology and post-natal adaptations. Assessment of neonatal viability, care of the newborn.

Unit VIII

Involution of uterus, post-partum ovarian dysfunction and their manipulation. Care of the postpartum dam.

V. Practical

Obstetrical operations in fetal dystocia; mutations, fetotomy, cesarean section, ovario-hysterectomy; induction of parturition, obstetrical analgesia and anaesthesia.

VII. Suggested Reading

- David Noakes, Timothy Parkinson and Gary England. 2018. *Veterinary Reproduction and Obstetrics*. Saunders Ltd.
- Roberts SJ. 2005. *Veterinary Obstetrics and Genital Diseases*. Scientific Book Agency.
- Sloss V and Dufty JH. 1980. *Handbook of Bovine Obstetrics*. Williams and Wilkins.
- Selected articles from journals.

I. Course Title : Advances in Andrology and Male Infertility

II. Course Code : VGO 603

III. Credit Hours : 2+1

IV. Theory

Unit I

Spermatogenesis, Spermatogenic waves, Sperm passage in male genitalia, biochemical milieu of male genitalia. Correlation between motility and fertilizing capacity of spermatozoa. Seminiferous eipithelial cycle, Theory of sperm motility and ultrastructure of sperm. Sperm passage in female reproductive tract; capacitation and acrosome reaction.

Unit II

Separation of motile and immotile spermatozoa.

Unit III

Sperm plasma membrane and its permeability and binding properties: acrosome and lysosomal enzymes, sperm nucleus and nuclear proteins. Mitochondria and their role in sperm metabolism. Flagellum and the mechanochemical basis of motility and cyclic nucleotides.

Unit IV

Biochemistry of seminal plasma and accessory sex gland secretions. Electrolytes, proteins, Enzymes and amino acids in seminal plasma. Fructose and other sugars, Lipids, Cholesterol, Steroid hormones and Prostaglandins in seminal plasma.

Unit V

Fructolysis index. Aerobic and anaerobic metabolism of spermatozoa.

Unit VI

Markers of fertility in males, sperm chromatin structure assay, Anti-sperm antibodies. Karyotyping to identify sperm defect and DNA mapping for parentage.

V. Practical

Breeding soundness evaluation of bulls, biochemical tests of semen for evaluation of fertility, semen culture for diagnosis of venereal diseases, diagnosis and treatment of genital pathological condition. Computer assisted semen analysis (CASA), Semen evaluation for assessment of fertilizing capacity of spermatozoa: cervical mucus penetration test, sperm capacitation test, hypo osmotic swelling test and zona free hamster egg penetration test. Anti-sperm antibody assay. Collection of preputial washings and semen for bacterial load and venereal pathogens.

VI. Suggested Reading

- Hafez ESE and B Hafez. 2013. *Reproduction in Farm Animals*. Wiley-Blackwell.
- Enos Johnson Perry. 2013. *Artificial Insemination of Farm Animals*. Jodhpur: AXis Books (India).
- Roberts SJ. 2005. *Veterinary Obstetrics and Genital Diseases*. Scientific Book Agency.
- Selected articles from journals.

I. Course Title : Reproductive Biotechnology

II. Course Code : VGO 604

III. Credit Hours : 1+1

IV. Theory

Unit I

Micromanipulation, Intracytoplasmic Sperm Injection (ICSI), Sexing of embryos.

Unit II

Stem cell biotechnology, Semen sorting for production of sexed semen.

Unit III

Cloning, Biopharming, Transgenic Animals and Chimeras.

Unit IV

Transgenic animals and chimeras. Gene expression in oocyte and embryo, Identification of cellular organelles of Gamete.

Unit V

Principle and application of PCR technique in animal reproduction.

V. Practical

Micromanipulation of embryos, Sexing of embryos, Stem cell production.

VI. Suggested Reading

- Hafez ESE and B Hafez. 2013. *Reproduction in Farm Animals*. Wiley-Blackwell.
- B Singh, SK Gautam and MS Chauhan. 2012. *Textbook of Animal Biotechnology*, Pearson Education.
- Heiner Niemann, Christine Wrenzycki. 2018. *Animal Biotechnology 1: Reproductive Biotechnologies*. Springer.
- Heiner Niemann, Christine Wrenzycki. 2018. *Animal Biotechnology* 2. Springer International Publishing AG.
- Ian Gordon. 2017. *Reproductive Technologies in Farm Animals*. Wallingford, Oxfordshire CABI.
- Troy L Ott, Zhihua Jiang. 2010. *Reproductive Genomics in Domestic Animals*. John Wiley.
- Marcelo Marcondes Seneda, Katia Cristina Silva-Santos, LS Rafagnin Marinho. 2016. *Biotechnology of Animal Reproduction*, Nova Science Pub. Inc; UK Ed.
- Tacia Gomes Bergstein-Galan. 2018. *Reproduction Biotechnology in farm animals*. Avid Science.
- Selected articles from journals.

I. Course Title : Semenology

II. Course Code : VGO 605

III. Credit Hours : 1+1

IV. Theory

Unit I

Contribution of gonads and accessory sex glands to semen ejaculate. Factors affecting semen production. Morphology of sperm and their defects. Biochemical composition of semen.

Unit II

Metabolism of sperm. Role of seminal plasma proteins. Species variation in seminal characteristics. Factors affecting motility and fertilizing capacity of spermatozoa.

Unit III

Use of semen additives and activators. Sperm cryodamage, Commercial extenders used for bovine semen. Microbial contamination of semen and measures for its prevention. Transmission of venereal diseases through semen and their prevention.

Unit IV

Thawing protocols for frozen semen. Post-thaw evaluation of motility and fertilizing capacity of spermatozoa. Quality control and quality assurance of semen, antisperm antibodies. Flow cytometric assessment of sperm quality.

Unit V

Sperm vitrification, freeze drying of sperm and sperm encapsulation.

Unit VI

Criteria for gradation of semen stations.

V. Practical

Semen evaluation. Estimation of bacterial load and enzymes in semen. Morphological defects of sperm. *In-vitro* tests for sperm function i.e. BCMPT, HOST, etc. Physical and enzymatic changes in semen following cryopreservation. Tests to assess acrosomal integrity, Mitochondrial activity, DNA damage, binding assays, etc. Fluorescent probe based assessment of sperm quality. Comet assay, Sperm chromatin structure assay, TUNEL assay.

VI. Suggested Reading

- Salisbury GW, VanDemark NL and Lodge JR. 1978. *Physiology of Reproduction and Artificial Insemination of Cattle*. WH Freeman and Co.
- Hafez ESE and B Hafez. 2013. *Reproduction in Farm Animals*. Wiley-Blackwell.
- Selected articles from journals.

I. Course Title : Clinical Practice-I

II. Course Code : VGO 606

III. Credit Hours : 0+3

IV. Practical

Clinical examination of animals affected with reproductive disorders, use of diagnostic techniques for diagnosis and institution of required therapy. Acquaintance with different equipment used for handling reproductive disorders, client management, public relations, code of conduct, database management, Maintenance of case records.

VI. Suggested Reading

- Morrow DA. 1986. *Current Therapy in Theriogenology*. WB Saunders.
- Zemjanis R. 1970. *Diagnostic and Therapeutic Techniques in Animal Reproduction*. Williams and Wilkins; Second Edition.
- Selected articles from journals.

I. Course Title : Clinical Practice-II

II. Course Code : VGO 607

III. Credit Hours : 0+3

IV. Practical

Clinical examination of animals affected with reproductive disorders, use of diagnostic techniques for diagnosis and institution of required therapy. Acquaintance with different equipment used for handling reproductive disorders, client management, public relations, code of conduct, database management, Maintenance of case records.

V. Suggested Reading

- Morrow DA. 1986. *Current Therapy in Theriogenology*. WB Saunders.
- Zemjanis R. 1970. *Diagnostic and Therapeutic Techniques in Animal Reproduction*. Williams and Wilkins; Second Edition.
- Selected articles from journals.

I. Course Code : VGO 690

II. Course Title : Special Problem

III. Credit Hours : 0+2

V. Practical

Student will carry out research on allotted project and submit the project report.

VGO 691 DOCTORAL SEMINAR-I 1+0

VGO 692 DOCTORAL SEMINAR-II 1+0

VGO 699 DOCTORAL RESEARCH75

Minor Courses for Ph.D. Degree programme

Courses of any one department/ discipline from the list given below:

- Veterinary Pathology
- Veterinary Pharmacology
- Veterinary Physiology
- Veterinary Biochemistry
- Veterinary Bacteriology
- Veterinary Immunology

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Veterinary Clinical Subjects

– Veterinary Surgery and Radiology

Course Title with Credit Load
M.V.Sc. in Veterinary Surgery and Radiology

Course Code	Course Title	Credit Hours
VSR 501	Clinical Practice-I*	0+3
VSR 502	Clinical Practice-II*	0+3
VSR 503	Principles of Surgery*	2+1
VSR 504	Anaesthesia And Analgesia*	2+1
VSR 505	Diagnostic Imaging Techniques*	2+1
VSR 506	Soft Tissue Surgery	2+1
VSR 507	Orthopaedic Surgery*	2+1
VSR 508	Anaesthesia of Zoo, Wild, EXotic and Laboratory Animals	1+1
VSR 509	Urogenital Surgery	1+1
VSR 510	Ophthalmology	1+1
VSR 511	Dentistry and Oral Surgery	1+1
VSR 512	Camel Surgery	1+1
VSR 513	Elephant Surgery	1+1
VSR 587	Clinical Case Conference	0+1
VSR 588	Special Problem in Radiology	0+2
VSR 589	Special Problem in Anaesthesia	0+2
VSR 590	Special Problem in Surgery	0+2
VSR 591	Masters Seminar	1+0
VSR 599	Masters Research	0+30

*Core Courses

Course Contents
M.V.Sc. in Veterinary Surgery and Radiology

I. Course Title : Clinical Practice-I
II. Course Code : VSR 501
III. Credit Hours : 0+3
IV. Practical

Basic requirements and designing surgical and general veterinary hospital, Developing different proformas required in hospital facility, Assessing surgical patients and documentation, Preparation of surgical team and duties of team members, Surgical suite maintenance and sterilization, Acquaintance with different equipment like inhalant anaesthesia machine, Radiography systems, Ultrasonography, Endoscopy, Electro-surgery, Cryosurgery and physiotherapy equipment, Client management, Public relations, code of conduct, Management of surgical affections, Hospital database management, Attending surgical cases, Disaster management.

I. Course Code : VSR 502
II. Course Title : Clinical Practice-II
III. Credit Hours : 0+3
IV. Practical

Application of different equipment like inhalant anaesthesia machine, Computerized radiography system, Ultrasonography, Electro-surgery, Cryosurgery, Physiotherapy and endoscopy and Physiotherapy equipment, Client management and Counselling, public relations, Code of conduct, Management of surgical affections, Hospital management, Database management, Attending surgical cases, Disaster management.

I. Course Title : Principles of Surgery
II. Course Code : VSR 503
III. Credit Hours : 2+1
IV. Theory
V. Unit I

Classification of wounds, wound healing, mechanism of wound repair, local and systemic factors affecting wound healing, current concepts of inflammation and management, thermal, electrical and chemical injuries and their management.

Unit II

Asepsis, sterilization and disinfection and principles and practice of antimicrobial therapy in surgical patients.

Unit III

Shock, classification, pathophysiology, diagnosis, treatment and monitoring, surgical stress and its systemic effects, haemorrhage and haemostasis, acid-base balance, fluid therapy and blood transfusion, metabolism of the surgical patient.

Unit IV

Principles and clinical applications of laser surgery, cryosurgery, electrosurgery, physiotherapy.

Unit V

Minimally invasive surgical procedures which includes laproscopy and endoscopy, principles of microscopic surgery-vessel and nerve anastomosis, application of computers in surgery.

VI. Practical

Identification and handling of surgical instruments, preparation of surgical pack, surgical team and surgical patients, surgical facilities and equipment, introduction to clinical skill laboratory, practice of different suturing patterns and repair of different wounds, using drains, bandages and bandaging techniques, monitoring of traumatized surgical patient, operation theatre conduct.

I. Course Title : Anaesthesia And Analgesia

II. Course Code : VSR 504

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction and history of anaesthesia, General consideration for anaesthesia in animals, Properties of ideal anaesthetic agent, Types of anaesthesia, Anaessthetic triad, Preanaesthetic evaluation of patient and selection of anaesthesia.

Unit II

Preanaesthetic medication (anticholinergics, sedatives, tranquilizers, alpha-2 agonist, narcotics), Muscle relaxants and neuromuscular blocking agents.

Unit III

General anaesthetics and factors affecting their uptake, Distribution and metabolism; Injectable anaesthetic agents (properties, dosage and usage); Combinations of injectable agents and neuroleptanalgesia, Inhalation anaesthetic agents (properties, methods of administration, dosage and usages), Inhalation anaesthesia equipment and breathing circuits, artificial ventilation.

Unit IV

Post-operative care of the surgical patient, operating room emergencies, cardio-pulmonary arrest and resuscitation, monitoring of anaesthetic recovery.

Unit V

Local anaesthetics, their mechanisms, local and regional nerve blocks, spinal analgesia, intravenous regional anaesthesia, peri-operative and post-operative pain and its management.

V. Practical

Inhalation anaesthesia equipment, circuits and vaporizers, artificial ventilation, use of various pre-anaesthetic and anaesthetic agents in small and large animals, anaesthetic triad, balanced anaesthesia, total intravenous anaesthesia, regional and local nerve blocks using local anaesthetics, alpha-2 agonists and their combinations in domestic animals, monitoring of anaesthesia, reversal of sedation and analgesia induced by alpha-2 agonists, practice of anaesthesia in clinical cases; record keeping in anaesthesia and euthanaia.

I. Course Title : Diagnostic Imaging Techniques

II. Course Code : VSR 505

III. Credit Hours : 2+1

IV. Theory

V. Unit I

Regulations regarding establishment and handling of X-ray units. Requirements for establishment of X-ray units, conventional and digital X-ray machine, X-ray films, Cassettes, screen, X-ray production, Qualities of X-rays, Image formation and dark room procedures, Image plate, Formation of radiograph technique chart, Artifacts and their prevention, Radiographic quality Contrast, Density and details), radiographic accessories, radiographic positioning for different organs/ parts in small and large animals.

Unit II

Plain and contrast radiographic techniques of small and large animals, fluoroscopy/ C-arm, principles of radiographic interpretation,

Unit III

Principles of radiation therapy, medical radioisotope curves, radiation laws and regulations. Radiation hazards and monitoring of radiographic exposure to personnel and protection.

Unit IV

Basic physics of ultrasound waves and image formation, scanning principles of ultrasound, transducers, equipment controls, modes of display, terminology used for echotexture and USG artifacts, application of ultrasound in small and large animals.

Unit V

Doppler techniques echocardiography and its application, introduction to nuclear imaging techniques, computerized tomography, magnetic resonance imaging, positron emission tomography technique.

VI. Practical

Acquaintance with imaging equipment, computed radiography and digital radiography systems, dark room processing techniques and X-ray film handling, formulation of technique chart with fixed kVp and variable mAs, radiographic artefacts and their prevention, basics of radiographic interpretation of diseases, PACS, radiography positioning of different regions in domestic animals, contrast radiographic techniques, interpretation of radiographs, practice of ultrasonographic imaging and report writing.

I. Course Title : Soft Tissue Surgery

II. Course Code : VSR 506

III. Credit Hours : 2+1

IV. Theory

Unit I

Skin, adnexa, integument, appendages, horn, tail, sinus affections of equine and bovine, teat affections, principles of plastic and reconstructive surgery, different types of skin grafts.

Unit II

Surgical approaches/ affections of ear, oral cavity, larynx and pharynx, salivary glands, oesophagus, abdomen, rumen, reticulum, omasum, abomasum, stomach, intestines, rectum, anus, liver and biliary system, pancreas and porto-systemic shunts.

Unit III

Abdominal hernia, diaphragmatic hernia, perineal hernia, ventral, femoral and umbilical hernia, ritcher hernia, hiatal hernia, omental hernia, pre-pubic tendon rupture, use of biological and synthetic grafts for hernia repair, laparoscopic repair of hernia.

Unit IV

Principles of thoracic surgery, Functional anatomy of respiratory system, diseases of upper and lower respiratory system, functional anatomy of cardiovascular system and common affections of heart.

Unit V

Affections of pituitary, adrenals, thyroid, parathyroid glands, Principles of neurosurgery and common surgical affections of nervous system and special sense organs.

Unit VI

Haemolymphatic system, bone marrow, spleen, tonsils, lymph nodes and lymphatics, thymus.

VII. Practical

Practice of various surgical techniques of skin and adnexa, alimentary system, hernias, respiratory system, affections of horn, tail and teat, endoscopy techniques, instrumentation, use of rigid/ flexible endoscopes in companion and farm animals.

I. Course Title : Orthopaedic Surgery

II. Course Code : VSR 507

III. Credit Hours : 2+1

IV. Theory

Unit I

Bone structure and function, growth, Response to injury, Fractures and luXations, classification of fracture, Fracture healing.

Unit II

Biomechanics of fracture healing, Considerations for selection of fiXation techniques, Treatment of fractures of different bones in companion and farm animals, Diseases of bone.

Unit III

Various affections of the joints, ligaments and tendons and their treatment.

Unit IV

Spinal affections and injury to aXial skeleton.

Unit V

Conformation of the limb, anatomy of hoof, anatomical, conformational and pathological causes of lameness and allied surgical conditions of fore and hind limbs, rehabilitation of orthopaedic patient.

V. Practical

Application of Plaster of Paris cast, fiberglass cast, Roberts Jones bandage, modified Schroeder Thomas splint, Coaptation splint, sling application, practice of IM pinning, wiring, bone plating, inter locking nailing, eXternal skeletal fiXation, arthrotomy, tenotomy, eXamination of limbs for lameness, desmotomy, nerve blocks, injections in joints, operations for arthritis, hoof surgery and corrective shoeing.

I. Course Title : **Anaesthesia of Zoo, Wild, Exotic and Laboratory Animals**

II. Course Code : **VSR 508**

III. Credit Hours : **1+1**

IV. Aim of the course

To learn about basic and practical knowledge of chemical immobilization, sedation and anaesthesia of laboratory exotic, captive and free ranging wild animals,animals.

V. Theory

Unit I

General consideration in chemical restraint of captive and free ranging wild animals, handling of birds with minimum stress, physical examination, blood sampling, crop washes, faecal sampling.

Unit II

Methods of administration of anaesthesia in captive, free ranging animals, birds and laboratory animals.

Unit III

Local and general anaesthesia in exotic species, wild animals, birds, zoo animals and laboratory animals.

Unit IV

Anaesthetic emergencies and complications.

Unit V

Diagnostic interpretation, haematology and biochemistry analysis, avian diagnostic endoscopy

VI. Practical

Familiarization with capture and anaesthetic equipments, local anaesthetic techniques, use of various preanaesthetic and anaesthetic agents in laboratory animals, birds, monitoring of patient during general anaesthesia, familiarization of various diseases in exotic birds like tumours, foreign body, crop stasis, crop tear, crop fistula, toe necrosis, feather cyst, excision of uropygieal gland, rhinolith, pharyngostomy, ingluviotomy, ventriculotomy and orthopedic injuries, visits to zoos and wild life sanctuaries for practical on wild and zoo animals.

I. Course Title : Urogenital Surgery

II. Course Code : VSR 509

III. Credit Hours : 1+1

IV. Theory

V. Unit I

Surgical anatomy of urinary and reproductive tract in male and female animals, Congenital anomalies of organs of male and female urinary and reproductive system.

Unit II

Principals of urinary tract surgery, Pathophysiology, Diagnosis and surgical management of affections of kidney, ureter, urinary bladder and urethra, Medical dissolution and prevention of Canine uroliths, Feline urologic syndrome, Surgical management of urolithiais in ruminants and its prevention, management of uroperitoneum and renal failure.

Unit III

Pathogenesis, Clinical symptoms, Diagnosis and surgical management of vaginal and uterine prolapse, Rectovaginal fistula, Pneumovagina, Vaginal tumours, pyometra, Cysts of Gartner's canal and vestibular glands.

Unit IV

Surgical conditions of penis, Prepuce, Prostate and testicles, Cryptorchidism, Inguinal and scrotal hernia, Affections of teat and udder.

Unit V

Indications, Techniques and postoperative complications of episiotomy, Ovariectomy, ovariohysterectomy and caesarean section, Pyomerta and its surgical treatment.

Unit VI

Castration, Vasectomy, Cauda epididymectomy and penile deviation.

VI. Practical

Hands-on-training of techniques of centesis of urinary bladder in companion and farm animals, Different types of catheters used in urogenital surgery, Retrograde catheterization of urethra and urinary bladder, Normograde catheterization of urethra on clinical cases of urinary retention, Pudendal nerve block for penis examination in ruminants, Diagnostic techniques and surgical management of the affections of kidney, Ureters, Urinary bladder, Urethra, Uro-hydropropulsion, Restraint and anaesthesia for urogenital tract surgery, Cystotomy, Tube cystostomy, Nephrotomy, Ureterocolostomy, Urethrotomy, Urethrostomy, Castration, Vasectomy, Penile deviation, Epididymectomy, Amputation of penis, Episiotomy, Ovariohysterectomy, Tubectomy, Caesarean section, Management of phimosis, Paraphimosis, Venereal granuloma, Vaginal and uterine prolapse, Rectovaginal fistula and pneumovagina, Bladder and uterine marsupialization.

I. Course Title : Ophthalmology

II. Course Code : VSR 510

III. Credit Hours : 1+1

IV. Theory

Unit I

Anatomy and physiology of eye and its adnexa, Ophthalmic examination and diagnosis, Diagnostic instrumentation, Anaesthesia and surgery.

Unit II

General consideration for eye surgery in companion and farm animals, Therapeutic agents for eye diseases and surgery of eye lids, lacrimal apparatus, naso-lacrimal duct.

Unit III

Diseases of conjunctiva, cornea, sclera, iris, orbit, lens, vitreous and aqueous humor, retina and optic nerve, eye tumours, enucleation, exenteration.

Unit IV

Ocular manifestations of systemic diseases.

Unit V

Neuro-ophthalmology and ocular emergencies

V. Practical

Ophthalmic instrumentation, examination of the eye and its adnexa, anaesthesia, preparation of patient, suture materials for eye surgery, canthotomy, tarsorrhaphy, keratoplasty, anterior chamber paracentesis, flushing of naso-lacrimal duct, iridectomy, phacoemulsification and implantation of foldable lens, surgical treatment of entropion and ectropion, cherry eye, Schirmer tear test, use of fluorescein dye in corneal ulcer, glaucoma surgery, eye worm removal.

I. Course Title : Dentistry and Oral Surgery

II. Course Code : VSR 511

III. Credit Hours : 1+1

IV. Theory

Unit I

Anatomy, development of teeth (odontogenesis), dentition and ageing of different species.

Unit II

Clinical examination of oral cavity, Dental anesthesia and pain management, Dental radiography.

Unit III

Diseases of oral cavity and teeth, Congenital and developmental anomalies of oral cavity, Abnormal tooth eruption, Irregular wear of teeth in companion and farm animals, occlusion and malocclusion, Mandibular fracture, Malformation of mandible, maxilla (cleft palate).

Unit IV

Acquired diseases of teeth (halitosis, dental caries, fracture of teeth, dental materials and dental radiography), Oronasal fistula, Maxilla and mandibular fractures repair, Orthodontics, Tumors and Other acquired condition of oral cavity.

Unit V

Exodontics, Restorative dentistry, Periodontal disease, Tooth extraction, Gum diseases. Endodontics, Pulpectomy, Root Canal therapy (RCT), Current techniques in dentistry.

V. Practical

Oral examination, Modified triadian system of tooth numbering in various species, Dental chart for companion and farm animals, Dentistry instrumentation, Dental radiography procedure, Periodontal probing, Scaling/ teeth cleaning, Tooth extraction, Malpractices in equine dentistry, Periodical maintenance of oral hygiene, Corrective procedures, Malocclusion, Treatment strategies congenital malformations of maxilla and mandible, oral surgery.

I. Course Title : Camel Surgery

II. Course Code : VSR 512

III. Credit Hours : 1+1

IV. Theory

Unit I

Introduction to special surgical anatomy of important parts, i.e. Mandible, Soft palate, Chest pad, saddle region, Male urinary system, tail, etc., Restraint and positioning for various surgical procedures and radiography of different parts.

Unit II

Use of local anaesthesia, Various nerve blocks and regional anaesthesia used to treat diverse surgical disorders, Preanaesthetics, Tranquilizers, Sedatives and general anaesthetics used for camel surgery.

Unit III

Surgical affections of head and neck region: Laceration and infected wounds of nostril skin, Infection of turbinate, Actinobacillosis, Dental affections, Removal of canines in furious camels, Torticollis, Fracture of mandible and maXilla, Soft palate injuries, Ophthalmic affections, Salivary fistula, Stenson's duct ligation, Oesophageal obstruction.

Unit IV

Surgical affections of thoraX and abdominal region: Saddle gall, Hernia, Chest pad wounds and enlargements, Foreign bodies in compartment, Intestinal obstruction, Obstructive urolithiasis, Rupture of urethra, Subcutaneous infiltration of urine, CystorrheXis.

Unit V

Surgical affections of musculo-skeletal system: diagnosis of lameness in camels, management of long bone and digital fractures, upward fiXation of patella, sprains, arthritis.

Unit VI

Sheath abscess, Necrosis of penis, Phimosis, Paraphimosis, Preputial prolapse, Various types of tumours, Gangrene and tumours of udder, Necrosis of tail, Punctured foot, prolapse of digital cushion, Foot injuries, Kumri, Kapali, etc.

V. Practical

Restraint and anaesthesia (Local, regional, sedation and general anaesthesia), Preparation of sites, Surgical anatomy of important surgical affections, Special instruments used for camel restraining and surgery, Observing and assisting in diverse surgical procedures on clinical cases in camels, Practice of interdental wiring for repair of mandibular fractures in specimen mandibles, Clinical and radiographic diagnosis of lameness, Protection of wounds of chest pad and foot using special bandages, Radiography of different part of camels and postoperative care of diverse surgical affections of camels.

I. Course Title : Elephant Surgery

II. Course Code : VSR 513

III. Credit Hours : 1+1

IV. Theory

Unit I

Basic surgical anatomy of Asian elephants and comparison with other farm animals.

Unit II

Drug administration techniques in captive and wild elephants, Anaesthetic management of captive and wild elephants for various surgical and managerial conditions.

Unit III

Principles of soft tissue surgery in elephants, Cyst, Bursitis, Gall, Haematoma, Abscess, etc.

Unit IV

Management and treatment of fractures and arthritis in elephants.

Unit V

Pedicure, corrective foot care and maintenance of healthy feet of captive elephants housed in different establishments in different seasons.

Unit VI

Hoisting of recumbent elephants, Surgical methods of birth control in elephants, limitations and risks of abdominal surgery in elephants (eg. Caesarian section, Castration, Hernia, etc., Soft tissue surgery like episiotomy, vestibulotomy, etc.)

V. Practical

Familiarity with clinical examination procedures, Body weight estimation, Signs of health and diseases, Signs of localized lesions, etc., Familiarity with physical and chemical restraint procedures, Drug administrations by various routes-IM, IV, SC, sub-conjuctival, oral, per rectal, etc., foot examination and foot care procedures, visit to elephant camps and attending clinical procedures, surgeries, etc.

I. Course Title : Clinical Case Conference
II. Course Code : VSR 587
III. Credit Hours : 0+1
IV. Practical

Present seminar on unusual/ interesting clinical cases done in the semester. Compile them from presentation to follow up and also submit the write up in soft or hard copy.

I. Course Title : Special Problem in Radiology
II. Course Code : VSR 588
III. Credit Hours : 0+2
IV. Practical

Investigative radiological problems in clinical or experimental models, didactic and interpersonal learning-teaching, problem solving self-learning strategies in problems related to radiology.

I. Course Title : Special Problem in Anaesthesia
II. Course Code : VSR 589
III. Credit Hours : 0+2
IV. Practical

Investigative anesthetic problems in clinical or experimental models, Didactic and interpersonal learning-teaching, Problem solving self-learning strategies in problems related to anaesthesia.

I. Course Title : Special Problem in Surgery
II. Course Code : VSR 690
III. Credit Hours : 0+2
IV. Practical

Investigative surgical problems in clinical or experimental models, Didactic and interpersonal learning-teaching, Problem solving self-learning strategies in problems related to surgery.

VSR 591 MASTERS SEMINAR (1+0)
VSR 599 MASTERS RESEARCH (0+30)

Course Outline: Lecture wise

VSR 503: Principles of Surgery (2+1)

Suggested Reading

- Fossum TW. (Ed.). 2018. *Small Animal Surgery*. Mosby.
- Slatter DH. 2003. 3rd ed. *Textbook of Small Animal Surgery*. WB Saunders.
- Hendrickson DA and Baird AN. 2013. *Turner and McIlwraiths Techniques in Large Animal Surgery* 4th ed. Wiley Black Well.
- AK Gangwar, Naveen Kumar and Kh. Sangeeta Devi. 2010. *General Animal Surgery and Anesthesiology* (With Theory and Practicals) New India Publishing Agency, New Delhi (ISBN: 9789-38-0235-172).

VSR 504: Anaesthesia and Analgesia (2+1)

Suggested Reading

- AK Gangwar, Naveen Kumar and Kh. Sangeeta Devi. 2010. *General Animal Surgery and Anesthesiology (With Theory and Practicals)* New India Publishing Agency, New Delhi (ISBN: 9789-38-0235-172).
- Clarke KW, Trim CM and Hall LW. 2013. *Veterinary Anaesthesia*. 11th ed. WB Saunders.
- Grim KA, Lamont LA, Tranquilli WJ, Greene SA and Robertson SA. 2015. *Veterinary Anaesthesia and Analgesia*, The 5th ed. Lumb and Jones. Wiley Blackwell.
- Grim KA, Tranquilli WJ and Lamont LA. 2011. *Essentials of Small Animal Anesthesia and Analgesia*. 2nd ed. Wiley Blackwell.
- Paddleford RR. 1999. *Manual of Small Animal Anesthesia*. 2nd ed. WB Saunders.

VSR 505: Diagnostic Imaging Techniques (2+1)

Suggested Reading

- AK Gangwar, Kh. Sangeeta Devi and Naveen Kumar. 2015. *Radiography in Veterinary Practice at a glance (Including Diagnostic Imaging techniques*) Astral International Pvt. Limited, New Delhi (ISBN: 978-93-5124-335-9).
- Barr FJ and Gaschen L. 2011. *BSAVA Manual of Canine and Feline Ultrasonography*. British Small Animal Veterinary Association
- Boon JA. 2011. *Veterinary Echocardiography*. 2nd ed. Wiley-Blackwell.
- Bushong SC. 2017. *Radiologic Science for Technologists*. 11th ed. CV Mosby.
- Gillette EL, Thrall DE and Lebel JL. (Eds.). 1977. *Carlson's Veterinary Radiology*. Lea and Febiger.
- Goddard PJ. 1995. *Veterinary Ultrasonography*. CABI.
- Kealy JK, McAllister H and Graham JP. (Eds.). 2011. *Diagnostic Radiology and Ultrasonography of the Dog and Cat*. 5th ed. WB Saunders, Philadelphia.
- Mannion P. 2006. *Diagnostic Ultrasound in Small Animal practice*. Blackwell Science.
- Kirberger RM and McEvoy FJ 2016. *BASAVA Manual of Canine and Feline Musculoskeltal Imaging*. 2nd BASAVA Gloucester.
- Morgan JP. 1972. *Radiology in Veterinary Orthopaedics*. Lea and Febiger.
- Nyland TG and Mattoon JS. 2002. *Small Animal Diagnostic Ultrasound*. WB Saunders.
- Thrall DE. 2017. *Textbook of Veterinary Diagnostic Radiology*. 7th ed. Saunders, Philadelphia.
- Bargai U, Pharr, JW and Morgan JP. 1989. *Bovine Radiology*. Iowa State University Press, Ames.

VSR 506: Soft Tissue Surgery (2+1)

Suggested Reading

- Fossum TW. 2018. *Small Animal Surgery*. 5th ed. Mosby.
- Fubini SL and Ducharme NG. 2016. *Farm Animal Surgery*. 2nd ed. Saunders
- Slatter DH. 2003. *Textbook of Small Animal Surgery*. 3rd ed. WB Saunders.
- Yool DA. 2012. *Small Animal Soft Tissue Surgery*. CABI.
- Tobia KM. 2010. *Manual of Small Animal Soft Tissue Surgery*. Wiley Black Well.

VSR 507: Orthopaedic Surgery (2+1)

Suggested Reading

- AK Gangwar, Khangembam Sangeeta Devi, Ajit Kumar Singh and Naveen Kumar (2018) *Veterinary Orthopaedics and Lameness*, Kalyani Publishers, New Delhi (ISBN 978-93-272-8837-7).
- Auer JA. 2006. *Equine Surgery*. WB Saunders.
- Baxter GM. (Ed.). 2011. *Adams and Stashak's Lameness in Horses*. 6th ed. Wiley-Blackwell.
- Decamp CE, Johnston, SA, Dejardin LM and Schaefer SL. 2016. *Handbook of Small Animal*

Othopaedics and Fracture Repair, 5th ed., Elsevier.

- Fubini SL and Ducharme NG. 2016. *Farm Animal Surgery*. 2nd ed. Saunders.
- Greenough PR. 2007. *Bovine Laminitis and Lameness*. WB Saunders.
- Millis DL and Levine D 2014. *Canine Rehabilitation and Physical Therapy*, 2nd ed., Elsevier.
- Newton CD and Nunamaker DM. (Eds.). 1985. *Textbook of Small Animal Orthopaedics*. JB Lippincott.
- Oehme FW and Prier JE. (Eds.). 1974. *Textbook of Large Animal Surgery*. Williams and Wilkins.
- Tyagi RPS and Singh J. (Eds.). 1993. *Ruminant Surgery*. CBS.
- Weaver AD, Jean GS and Steiner A. 2007. *Bovine Surgery and Lameness*. 2nd ed. Wiley-Blackwell.

VSR 508: Anaesthesia of Zoo, Wild, Exotic and Laboratory Animals (1+1)

Suggested Reading

- Coles BH. 2007. *Essentials of Avian Medicine and Surgery*. 3rd ed. Blackwell Publishing
- Donely B. 2010. *Avian Medicine and Surgery in Practice*. Manson Publishing Ltd.
- Grim KA, Lamont LA, Tranquilli WJ, Greene SA and Robertson SA. 2015. *Veterinary Anaesthesia and Analgesia*. 5th ed. Lumb and Jones. Wiley Blackwell.
- Mader DR. 2005. *Reptile Medicine and Surgery*. 2nd ed. WB Saunders
- Miller RE and Fowler M. 2014. *Fowler's Zoo and Wild Animal Medicine*. 1st ed. Saunders
- Wobeser GA. 2007. *Disease in Wild Animals: Investigation and Management*. 2nd ed. Springer

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VSR 509: Urogenital Surgery (1+1)

Suggested Reading

- Fossum TW. 2018. *Small Animal Surgery*. 5th ed. Mosby.
- Fubini SL and Ducharme NG. 2016. *Farm Animal Surgery*. 2nd ed. Saunders
- Slatter DH. 2003. *Textbook of Small Animal Surgery*. 3rd ed. WB Saunders.
- Wolfe DF and Moll HD. *Large Animal Urogenital Surgery* 1999. 2nd ed., Williams and Wilkins, Tokyo.
- Yool DA. 2012. *Small Animal Soft Tissue Surgery*. CABI.

VSR 510: Ophthalmology (1+1)

Suggested Reading

- Fossum TW. 2018. *Small Animal Surgery*. 5th ed. Mosby.
- Fubini SL and Ducharme NG. 2016. *Farm Animal Surgery*. 2nd ed. Saunders
- Gelatt KN. 2014. *Essentials of Veterinary Ophthalmology*. 3rd ed. Wiley Blackwell. US.
- Gilger BC. 2017. *Equine Ophthalmology*, 3rd ed. Wiley Blackwell.
- Maggs DJ, Miller PE and Ofri R. 2017. *Slatter's Fundamentals of Veterinary Ophthalmology*. 6th ed. Saunders.
- Slatter DH 2003. *Textbook of Small Animal Surgery*. 3rd ed. WB Saunders.

VSR 511: Dentistry and Oral Surgery (1+1)

Suggested Reading

- Fossum TW. 2018. *Small Animal Surgery*. 5th ed. Mosby.
- Fubini SL and Ducharme NG. 2016. *Farm Animal Surgery*. 2nd ed. Saunders
- Holmstrom SE. 2013. *Veterinary Dentistry - A Team Approach*. 2nd ed. Elsevier.
- Slatter DH. 2003. *Textbook of Small Animal Surgery*. 3rd ed. WB Saunders.
- Soto JC. 2015. *Visual Atlas of Dental Pathologies in Dogs*. SERVET, Spain.

VSR 512: Camel Surgery (1+1)
Suggested Reading

- *Selected Topics on Camelids*, Ed-TK Gahlot, The Camelid Publishers, Bikaner and now marketed by Camel Publishing House, Edition 2000.
- *Medicine and Surgery of Camelids*. Ed-Murray E. Fowler, Wiley-Blackwell, Edition 2010.
- *Advances in Surgery and Diagnostic Imaging of the Dromedary Camel*, Ed- RO Ramadan, King Faisal University, Edition 2016.

VSR 513: Elephant Surgery (1+1)

Suggested Reading

- Fowler ME and Mikota SK. 2006. *Biology, Medicine, and Surgery of Elephants*. Blackwell Publishing

Minor Courses for M.V.Sc. Degree programme

Courses of any one department/ discipline from the list given below or as considered relevant by the Advisory Committee from the BSMA approved subjects:

- Veterinary Physiology
- Veterinary Biochemistry
- Veterinary Biotechnology
- Veterinary Anatomy
- Veterinary Medicine
- Veterinary Pathology
- Animal Reproduction, Gynaecology and Obstetrics

Course Title with Credit Load
Ph.D. in Veterinary Surgery and Radiology

Course Code	Course Title	Credit Hours
VSR 601	Clinical Practice-I*	0+2
VSR 602	Clinical Practice-II*	0+2
VSR 603	Clinical Practice-III*	0+2
VSR 604	Cardiovascular Surgery	2+1
VSR 605	Advances in Anaesthesiology	2+1
VSR 606	Advances in Radiology	2+1
VSR 607	Advances in Diagnostic Imaging Techniques	2+1
VSR 608	Advances in Orthopaedics	2+1
VSR 609	Neurosurgery	2+1
VSR 610	Reconstructive and Regenerative Surgery	1+1
VSR 611	Advances in Soft Tissue Surgery	2+1
VSR 612	Advances in Ophthalmology	1+1
VSR 613	Surgical Oncology	1+1
VSR 687	Clinical Case Conference*	0+1
VSR 688	Special Problem in Diagnostic Imaging	0+2
VSR 689	Special Problem in Anaesthesia	0+2
VSR 690	Special Problem in Surgery	0+2
VSR 691	Doctoral Seminar-I	2+0
VSR 692	Doctoral Seminar-II	2+0
VSR 699	Doctoral Research	0+75

*Core Courses

Course Contents
Ph.D. in Veterinary Surgery and Radiology

I. Course Title : Clinical Practice-I
II. Course Code : VSR 601
III. Credit Hours : 0+2

IV. Practical

Application of different equipment like inhalant anaesthesia machine, Computerized or digital radiography system, Ultrasonography, Endoscopy, Electro-surgery, Cryosurgery, Operating microscope, Phacoemulsification and physiotherapy, Client management and counseling, Treating surgical cases using advances techniques, managing surgical facilities, ICU equipment and personnel, Planning and formulating clinical research projects using the clinical data and facilities, Data analysis and writing of clinical case reports and success stories about the clinical achievements.

I. Course Title : Clinical Practice-II
II. Course Code : VSR 602
III. Credit Hours : 0+2

IV. Aim of the course

To learn clinical techniques and procedures in anaesthesia, Diagnostic imaging and surgery

V. Practical

Application of different equipment like inhalant anaesthesia machine, Computerized or digital Radiography system, Ultrasonography, Endoscopy, Electro-surgery, Cryosurgery, Operating microscope, Phacoemulsification and physiotherapy, Client management and counseling, Treating surgical cases using advances techniques, managing surgical facilities, ICU equipment and personnel, Planning and formulating clinical research projects using the clinical data and facilities, Data analysis and writing of clinical case reports and success stories about the clinical achievements.

I. Course Title : Clinical Practice-III
II. Course Code : VSR 603
III. Credit Hours : 0+2

IV. . Practical

Application of different equipment like inhalant anaesthesia machine, Computerized or digital radiography system, Ultrasonography, Endoscopy, Electro-surgery, Cryosurgery, Operating microscope, Phacoemulsification and physiotherapy, Client management and counseling, Treating surgical cases using advances techniques, Managing surgical facilities, ICU equipment and personnel, Planning and formulating clinical research projects using the clinical data and facilities, Data analysis and writing of clinical case reports and success stories about the clinical achievements.

I. Course Title : Cardiovascular Surgery

II. Course Code : VSR 604

III. Credit Hours : 2+1

IV. Theory

Unit I

Surgical anatomy, Pathophysiology, Systolic and diastolic functions, Heart failure.

Unit II

Physical examination, Electrocardiography, Cardiac catheterization.

Unit III

Special preoperative considerations for patients undergoing cardiovascular surgery, Surgical approaches to thorax, Different techniques of thoracotomy. Special instruments required in cardio-thoracic surgery, Defibrillator, Heart lung machine

Unit IV

Surgical management of congenital cardiac disorders: Malpositioning, Atrial septal defect, Endocardial cushion defect, Tricuspid valve disorder, Ventricular septal defect, Pulmonic stenosis, Teratology of fallot, Eisenmenger's complex, Anomalous pulmonary venous return, Mitral valve abnormalities, Aortic stenosis, Aortic regurgitation, transposition of the great vessels, Aortic pulmonary window, Persistent arteriosus, Patent ductus arteriosus, Coarctation of aorta, Persistent right aortic arch, Pericardial diaphragmatic hernia

Unit V

Acquired cardiac disorders: Mitral regurgitation, Tricuspid regurgitation, Dirofilariasis, Acquired aortic regurgitation, Endocarditis, Heart block, Cardiomyopathy, Pericarditis, Heart tumours, Hypothermia, Extracorporeal circulatory support, Cardiopulmonary bypass, Artificial heart transplant, Post operative management, Basic peripheral vascular procedures arteriotomy, Venotomy, anastomosis, Portocaval shunts and anomalies

V. Practical

Instrumentation and suture techniques for cardiovascular surgery, Vascular prostheses, Anticoagulants, Surgical approaches to thorax, Different techniques of thoracotomy, Hand-on-training of different techniques of centesis of thoracic cavity on cadavers, Thoracic drain placement, Demonstration of basic Cardiac procedures, Pericardiocentesis, Pericardiotomy, Cardiac catheterization, and various surgical conditions, Pericardiectomy, on cadaver and clinical cases of constructive pericarditis, Biopsy techniques, Use of IPPV in thoracic surgery.

I. Course Title : Advances in Anaesthesiology

II. Course Code : VSR 605

III. Credit Hours : 2+1

IV. Theory

Unit I

Cellular and molecular mechanisms of anaesthesia, Effects of anaesthesia on different systems.

Unit II

Drug interactions with anaesthetics, Pharmacokinetics and pharmacodynamics of anaesthetics, CRI and TCI, Computer assisted anaesthesia.

Unit III

Opioids, alpha-2 agonists and ketamine for epidural anaesthesia, Acupuncture and electroanaesthesia.

Unit IV

Critical acre in ICU, Pain transmission and processing, Methods for pain assessment in animals, Multimodal and preemptive analgesia, Techniques and drugs for pain managements.

Unit V

Anaesthesia for selected diseases (cardiovascular dysfunction, pulmonary dysfunction, Neurologic diseases, Renal diseases, Hepatic diseases, Gastrointestinal diseases, Endocrine diseases, Airway diseases).

Unit VI

Anaesthesia for special patients (ocular patients, heart patients, caesarian section patients, trauma patients, neonatal and geriatric patients).

V. Practical

Various procedures for catheterization of heart and great vessels, Central venous line, Haemodynamic changes and pulmonary function tests during trials of anaesthetics, Electrocardiographic, Encephalographic evaluation of central nervous system activity, Cybernetics, Data acquisition and retrieval, Administration and monitoring of newer anaesthetics combinations.

I. Course Title : Advances in Radiology

II. Course Code : VSR 606

III. Credit Hours : 2+1

IV. Aim of the course

To learn advance theoretical and practical knowledge in radiology.

V. Theory

Unit I

Biological effects of radiations (alpha, beta, X-ray and gamma rays) in vivo and *in-vitro* cellular response following radiation as an immunosuppressive agent.

Unit II

Different kind of projections and positioning, Contrast material, Different contrast techniques, PACS.

Unit III

Radiography of head and neck region, Radiography of thorax, Lung patterns, Radiography of abdominal and pelvic region

Unit IV

Radiography of limbs for lameness and fracture diagnosis, Application of image intensifiers in veterinary practice, Different types of screens.

Unit V

Computerized radiography (CR), Digital radiography (DR), Contrast CT and contrast MRI, PETCT, Advances in scintigraphy.

Unit VI

Radiation therapy in cancer patients, Biological effects of radiation physics, Physics of radiation, Electromagnetic radiations, Hazards of electromagnetic Radiations and protection and bio-safety.

VI. Practical

Radiographic positioning, Radiation safety measures, Handling radioactive material, Clinical radiological diagnosis at Radiology Unit, Demonstration of advanced radiological techniques.

I. Course Title : Advances in Diagnostic Imaging Techniques
II. Course Code : VSR 607
III. Credit Hours : 2+1

IV. Theory

Unit I

Techniques of ultrasonography for diagnosis of different affections of neck, thorax (echocardiography, Doppler techniques), Abdomen and pelvis (Urinary bladder and prostrate), Synovial joints, Muscle and tendons, Eye.

Unit II

Interpretation of ultrasonogram of different body organs/ vessels (normal and abnormal), Therapeutic applications of ultrasonography for physiotherapy.

Unit III

Imaging modalities like, MRI, CT scan, Nuclear medicine, Positron emission tomography technique, Single-photon emission computed tomography, etc.

Unit IV

Nuclear Scintigraphy-isotopes (natural and man-made); Cyclotron reactor, Half-life, decay pattern, Storage and handling of radioactive material,

Unit V

Methods in the detection of isotopes, Geiger-Mullar tubes, Photo-multiplier tube, medical use of isotope, Dosimetry, Nuclear medicine and its use in diagnosis of thyroid, Kidney, bone and liver function studies, Labelling of isotope and biological uses, Detonation and fission products, Image storage and transfer, DICOM, PACS and teleinterpretation.

V. Practical

Hands-on-practice on different visceral organs collected from slaughter house for ultrasonographic scanning in water tub, dry and wet lab training, Demonstration and practice on different clinical cases reported for ultrasonography, Visit to places with facility of other alternate imaging techniques.

I. Course Title : Advances in Orthopaedics

II. Course Code : VSR 608

III. Credit Hours : 2+1

IV. Theory

Unit I

Biomechanics of bone, Fracture etiology, Fracture reduction and different fracture fixation techniques like IM pinning, plating, nailing (inter locking nailing) and external skeletal fixation.

Unit II

Types, Properties, Biomechanics and use of different orthopaedic Implants, Bone grafts and their collection, Preservation, Indications and limitations, Bone graft substitutes like ceramics and composites, Their usage and limitations.

Unit III

Principles of osteogenesis, Osteoinduction and Osteoconduction.

Unit IV

Advances in internal fixation and external skeletal fixation techniques in veterinary orthopaedics.

Unit V

Metabolic bone diseases like rickets, osteomalacia, osteodystrophy and secondary hyperparathyroidism, etc. Classification, diagnosis and treatment of arthritis.

Unit VI

Advances in the management of congenital and acquired disorders of joints like traumatic dislocations, luxations and dysplasia. etiopathology and management of equine lameness including Laminitis, Navicular disease, Quitter, Canker and thrush, Sand cracks, Ring bone, Hygromas, Bursitis, Spavin and Splint.

Unit VII

Affections of muscles, tendons and ligaments, joint prosthesis and transplantation.

Unit VIII

Postoperative management of orthopaedic patients including the role of movement restriction, Weight bearing, Nutritional therapy, Physiotherapy and rehabilitation, Introduction to recovery assessment using lameness score, Gait analysis using computerized software.

V. Practical

Hands on practice for different internal fixation techniques on cadaver, Management

of different types of long bone fractures in different species of domestic animals, with special reference to practice of bone plating, Interlocking nailing and external skeletal fixation, Treatment of metabolic bone diseases in growing animals, Correction of antebrachial deformities including osteotomies and limb lengthening procedures, preservation of bone grafts, practice of bone grafting and use of osteoinducers in Clinical situation, Clinical and radiographic evaluation of various joint affections, Reduction and fixation of different joint luxations like coxo-femoral, Patellar, femoro-tibial, hock, scapulo-humeral, elbow and temporomandibular, Techniques of osteotomy, arthrodesis and joint replacement, Repair of tendon and ligament injuries, Diagnosis and treatment of various conditions causing lameness in equines and bovines.

I. Course Title : Neurosurgery

II. Course Code : VSR 609

III. Credit Hours : 2+1

IV. Theory

Unit I

Nervous system – anatomy, physiology and pathological manifestations.

Unit II

Clinical neurology, Therapeutic Neurectomy, Nerve anastomosis, Pathogenesis of disease of the central nervous system.

Unit III

Diagnostic methods – Electrodiagnostic methods, Neuro radiology.

Unit IV

Fundamentals of neurosurgery, Surgical approaches to brain, Surgical diseases of peripheral nerves, Surgical affections and approaches to the spine, Diseases of the spinal column, Intervertebral disc diseases.

Unit V

Surgical approaches to brain and intracranial surgery.

V. Practical

Methods for clinical and neurological examination including electro-encephalography, electromyography and electro-diagnostic testing, Collection of CSF and its evaluation, Techniques of myelography, Vertebral venography, Pneumoventriculography, Cerebral arteriography and cavernus sinus venography, Management of vertebral fractures and luxations with stabilization, Treatment of spinal cord compression, viz., Disc fenestration, Hemilaminectomy, Dorsal laminectomy and ventral slot, Techniques of peripheral nerve anastomosis and reconstruction of peripheral nerves.

I. Course Title : Reconstructive And Regenerative Surgery

II. Course Code : VSR 610

III. Credit Hours : 1+1

IV. Aim of the course

To learn principles and techniques of reconstructive and regenerative surgery.

V. Theory

Unit I

Principles of regenerative medicine, Tissue homeostasis, Tissue and organ transplantation, Histo-compatibility matching, Transplantation immunity and host graft reaction, Immunosuppression

Unit II

Classification, Isolation, Characterization, Storage and application of stem cells, Extracellular matrix, Microenvironment and growth factors for tissue repair and regeneration.

Unit III

Synthetic and biological scaffols, Preparation of biological scaffold and its role in Tissue regeneration, Whole organ decellularization and its application, Biomimetic scaffolds.

Unit IV

Designing for 3D printing, Bio-fabrication of organ and Tissue substitutes and its applications, Ethical concerns in regenerative medicine, GMP protocols and its applications in regenerative medicine

Unit V

Current techniques in designing and clinical application of biomaterials, Mechanical and functional testing of biomaterials, Biocompatibility testing

VI. Practical

Collection of bone marrow derived stem cells from different species of animals, Growth and differentiation of stem cells in different lineages, Decellularization of different tissues and organs, cell growth on different scaffolds, Clinical application of stem cells

I. Course Title : Advances in Soft Tissue Surgery

II. Course Code : VSR 611

III. Credit Hours : 2+1

IV. Theory

V. Unit I

Advances in surgeries of ENT affections of small and large animals, Rhinoscopy-rhinotomy, Tumors of turbinates, Cheiloplasty, Hare lip correction, Salivary duct ligation, Parotid gland abalation, Bullaosteotomy, Buccotomy procedures, Glossophagia, Self suck correction.

Unit II

Upper respiratory tract affection in small and large animals, Barchiochephalic air way syndrome, Laryngeal paralysis, Tracheal collapse, Tracheostomy (temporary/ permanent), Chest trauma, Chest tube placement, Thoracocentesis, Pneumectomy, (partial/ unilateral), Heart lung transplant, Thoracic duct ligation, Trans tracheal intubation, Thoracoscopic procedure.

Unit III

Esophageal affections in small and large animals, Dilatation, Diverticulum, PRAA-Mullers surgery, Gastroesophageal intussception, Short bowel syndrome, Colostomy, megacolon, Rectal tube placement, Rectal diverticulum, Gastroscopy techniques

Unit IV

Pyelolithotomy, Lithotripsy, Renal transplantation, Ectopic ureter, Prostatectomy, Urinary incontinence, Penile urethosotomy, Urethroscopic retrival of urolith, Endoscopic ureter stunt placement.

Unit V

Thyroidectomy in cats, Liver lobectomy, Cholelithiasis, Cholecystectomy, Cholecystoduo denostomy, Porto caval shunt, Adrenalectomy.

Unit VI

Skin grafting, Subdermal, Axial skeletal, Omocervical axial pattern flap, Thoracodorsal axial pattern flap, Superficial brachial axial pattern flap, Caudal superficial epigastric axial pattern flap, Cranial superficial epigastric axial pattern flap, Deep circumflex iliac dorsal axial pattern flap, Deep circumflex iliac ventral axial pattern flap, Genicular axial pattern flap, Reverse saphenous conduit flap, Caudal auricular axial pattern flap, Split thickness and full thickness grafts, Reconstructive surgical procedures.

VI. Practical

Endoscopic surgical procedures in small and large animals, Chest tube placement, Rhinoscopy, Thoracoscopy, Broncoscopy, Gastroscopy, Colonoscopy, Urethrocystoscopy, Laproscopic surgical techniques, Skin flap and grafting techniques, Tracheaostomy, Renal graft cystoplasty.

I. Course Title : Advances in Ophthalmology

II. Course Code : VSR 612

III. Credit Hours : 1+1

IV. Theory

V. Unit I

Embryology of the eye, study of ocular physiology and biochemistry, structure and function of eye and adenexa, Physiology of vision, Electrophysiology of visual system

Unit II

Advances in diagnosis and diseases of the eye and adnexia.

Unit III

Ocular neoplasia, advances in neuro ophthalmology, Advances in ophthalmic pharmacology, microbiology and nutrition

Unit IV

Advances in ocular imaging, Advances in ocular anaesthesia and analgesia

Unit V

Advances in ocular emergencies, Opthalmology of exotic species and lab animals, ocular toxicology

Unit VI

Corneal grafting, application of nanotechnology and stem cell therapy in veterinary ophthalmology.

VI. Practical

Exposure to latest ophthalmic instrumentation like phaco, ultrasound, cataract surgery and lens implantation, corneal transplantation.

I. Course Title : Surgical Oncology

II. Course Code : VSR-613

III. Credit Hours : 1+1

IV. Theory

Unit I

Biology of neoplastic disease: etiology, cellular mechanism, principles of surgical oncology.

Unit II

Diagnosis, classification and clinical staging of tumors and decision making for therapy, metastasis.

Unit III

Surgical management: Surgical excision of tumors, Cytoreductive surgery, Surgery for metastatic disease, Palliative surgery, Evaluation and interpretation of surgical margins.

Unit IV

Clinical signs, Diagnosis and treatment options of tumors of skin, Soft tissues, skeletal system, Head and neck, Gastro-intestinal tract, Respiratory tract, Urinary tract, Genital tract, Mammary gland, Nervous system, Endocrine system, haematopoietic system, the eye and orbit and miscellaneous tumours.

Unit V

Radiation therapy, Chemotherapy, Electrochemotherapy, Cryotherapy and targeted therapy. Side effects of radio and chemotherapy, Nutritional management of cancer patients, Basics of immunotherapy in cancer management.

V. Practical

General approaches to the diagnosis of neoplasia: Fine needle aspiration biopsy, needle core biopsy, excisional and incisional biopsy, bone marrow biopsy, lymph node biopsy, percutaneous lung biopsy, bone biopsy, ultrasound/ laparoscope guided biopsy.

I. Course Title : Clinical Case Conference
II. Course Code : VSR 687
III. Credit Hours : 0+1
IV. Practical

Present seminar on unusual/ interesting clinical cases done in the semester. Compile them from presentation to follow up and also submit the write up in soft or hard copy.

I. Course Title : Special Problem in Diagnostic Imaging
II. Course Code : VSR 688
III. Credit Hours : 0+2
IV. Practical

Investigative diagnosing imaging problems in clinical models, didactic and interpersonal learning-teaching, problem solving self-learning strategies in problems related to surgery

I. Course Title : Special Problem in Anaesthesia
II. Course Code : VSR 689
III. Credit Hours : 0+2
IV. Practical

Investigative anaesthetic problems in clinical models, didactic and interpersonal learning-teaching, problem solving self-learning strategies in problems related to anaesthesia

I. Course Title : Special Problem in Surgery
II. Course Code : VSR 690
III. Credit Hours : 0+2
IV. Practical

Investigative surgical problems in clinical models, didactic and interpersonal learning-teaching, problem solving self-learning strategies in problems related to surgery

VSR 691 Doctoral Seminar-I (2+0)
VSR 692 Doctoral Seminar-II (2+0)
VSR 699 Doctoral Research (0+75)

Course Outline: Lecture wise

VSR 604: Cardiovascular Surgery (2+1)

Suggested Reading

- Fossum TW. 2018. *Small Animal Surgery*. 5th ed. Mosby.
- Slatter DH. 2003. *Textbook of Small Animal Surgery*. 3rd ed. WB Saunders.

VSR 605: Advances in Anaesthesiology (2+1)

Suggested Reading

- Aronson LR. 2016. *Small Animal Surgical Emergencies*. Wiley Blackwell.
- Clarke KW, Trim CM and Hall LW. 2013. *Veterinary Anaesthesia*. 11th ed. WB Saunders.
- Grim KA, Lamont LA, Tranquilli WJ, Greene SA and Robertson SA. 2015. *Veterinary Anaesthesia and Analgesia*. 5th ed. Lumb and Jones. Wiley Blackwell.
- Grim KA, Tranquilli WJ and Lamont LA. 2011. *Essentials of Small Animal Anesthesia and Analgesia*. 2nd ed. Wiley Blackwell.
- Paddleford RR. 1999. *Manual of Small Animal Anesthesia*. 2nd ed. WB Saunders.

VSR 606: Advances in Radiology (2+1)

Suggested Reading

- Bargai U, Pharr, JW and Morgan JP. 1989. *Bovine Radiology*. Lowa State University Press, Ames.
- Bushong SC. 2017. *Radiologic Science for Technologists*. 11th ed. CV Mosby.
- Gillette EL, Thrall DE and Lebel JL. (Eds.). 1977. *Carlson's Veterinary Radiology*. Lea and Febiger.
- Kealy JK, McAllister H and Graham JP. (Eds.). 2011. *Diagnostic Radiology and Ultrasonography of the Dog and Cat*. 5th ed. WB Saunders, Philadelphia.
- Morgan JP. 1972. *Radiology in Veterinary Orthopaedics*. Lea and Febiger.
- Thrall DE. 2017. *Textbook of Veterinary Diagnostic Radiology*. 7th ed. Saunders, Philadelphia.

VSR 607: Advances in Diagnostic Imaging Techniques (2+1)

Suggested Reading

- Bargai U, Pharr, JW and Morgan JP. 1989. *Bovine Radiology*. Lowa State University Press, Ames.
- Barr FJ and Gaschen L. 2011. *BSAVA Manual of Canine and Feline Ultrasonography*. British Small Animal Veterinary Association.
- Boon JA. 2011. *Veterinary Echocardiography*. 2nd ed. Wiley-Blackwell.
- Bushong SC. 2017. *Radiologic Science for Technologists*. 11th ed. CV Mosby.
- Butler JA, Colles CM, Dyson SJ, Kold SE and Poulos PW. 2017. *Clinical Radiology of the Horse*. 4th ed. Wiley Blackwell.
- Gillette EL, Thrall DE and Lebel JL. (Eds.). 1977. *Carlson's Veterinary Radiology*. Lea and Febiger.
- Goddard PJ. 1995. *Veterinary Ultrasonography*. CABI.
- Kealy JK, McAllister H and Graham JP. (Eds.). 2011. *Diagnostic Radiology and Ultrasonography of the Dog and Cat*. 5th ed. WB Saunders, Philadelphia.
- Mannion P. 2006. *Diagnostic Ultrasound in Small Animal Practice*. Blackwell Science.
- Mantis P. 2016. *Practical Small Animal Ultrasonography Abdomen*. SERVET, Spain.
- Morgan JP@. 1972. *Radiology in Veterinary Orthopaedics*. Lea and Febiger.

- Nyland TG and Mattoon JS. 2002. *Small Animal Diagnostic Ultrasound*. WB Saunders.
- Thrall DE. 2017. *Text book of Veterinary Diagnostic Radiology*. 7th ed. Saunders, Philadelphia.
- Weisse C and Berent A (Eds.) 2015. *Veterinary Image Guided Interventions*. Wiley Blackwell.

VSR 608: Advances in Orthopaedics (2+1)

Suggested Reading

- Auer JA and Stick JA. 2017. *Equine Surgery*. 4th ed. Elesvier Saunders.
- Baxter GM. (Ed.). 2011. *Adams and Stashak's Lameness in Horses*. 6th ed. Wiley-Blackwell
- Fubini SL and Ducharme NG. 2016. *Farm Animal Surgery*. 2nd ed. Saunders.
- Greenough PR. 2007. *Bovine Laminitis and Lameness*. WB Saunders.
- Newton CD and Nunamaber DM. (Eds.). 1985. *Textbook of Small Animal Orthopaedics*. JB Lippincott.
- Oehme FW and Prier JE. (Eds.). 1974. *Textbook of Large Animal Surgery*. Williams and Wilkins.
- Ross MW and Dyson SJ. 2011. *Diagnosis and Management of Lameness in the Horse*. 2nd ed. Elsevier Saunders.
- Tyagi RPS and Singh J. (Eds.). 1993. *Ruminant Surgery*. CBS
- Weaver AD, Jean GS and Steiner A. 2007. *Bovine Surgery and Lameness*. 2nd ed. Wiley-Blackwell.

VSR 609: Neurosurgery (2+1)

Suggested Reading

- Dewey CW and C da Costa R. 2016. *Practical Guide to Canine and Feline Neurology*, 3rd ed. Wiley Blackwell.
- Lorenz MD, Coastes JR and Kent M. 2011. *Handbook of Veterinary Neurology*, 5th ed. Elsevier.

VSR 610: Reconstructive and Regenerative Surgery (1+1)

Suggested Reading

- Bojrab Joseph M, Monnet Eric. 2010. *Mechanisms of Disease in Small Animal Surgery*, 3rd Teton New Media, U.S.
- Griffers D and Hamaide A. (Eds.). 2016. *Complications in Small Animal Surgery*. Wiley Blackwell.
- Theoret C and Schumacher J. 2017. *Equine Wound Management*. Griffon, D and Hamaide A 2016. *Complications in Small Animal Surgery*, Wiley Blackwell.

VSR 611: Advances in Soft Tissue Surgery (2+1)

Suggested Reading

- Fossum TW. 2018. *Small Animal Surgery*. 5th ed. Mosby.
- Fubini SL and Ducharme NG. 2016. *Farm Animal Surgery*. 2nd ed. Saunders
- Slatter DH. 2003. *Textbook of Small Animal Surgery*. 3rd ed. WB Saunders.
- Yool DA. 2012. *Small Animal Soft Tissue Surgery*. CABI

VSR 612: Advances in Ophthalmology (1+1)

Suggested Reading

- Fossum TW. 2018. *Small Animal Surgery*. 5th ed. Mosby.
- Fubini SL and Ducharme NG. 2016. *Farm Animal Surgery*. 2nd ed. Saunders
- Gelatt KN. 2014. *Essentials of Veterinary Ophthalmology*. 3rd ed. Wiley Blackwell. US.

- Gilger BC. 2017. *Equine Ophthalmology*, 3rd ed. Wiley Blackwell.
- Maggs DJ, Miller PE and Ofri R. 2017. *Slatter's Fundamentals of Veterinary Ophthalmology*. 6th ed. Saunders.
- Slatter DH. 2003. *Textbook of Small Animal Surgery*. 3rd ed. WB Saunders.

VSR 613: Surgical Oncology (1+1)

Suggested Reading

- Kudnig ST and Sequin B. 2012. *Veterinary Surgical Oncology*, Wiley Blackwell.
- Fossum TW. 2018. *Small Animal Surgery*. 5th ed. Mosby.
- Fubini SL and Ducharme NG. 2016. *Farm Animal Surgery*. 2nd ed. Saunders.
- Maggs DJ, Miller PE and Ofri R. 2017. *Slatter's Fundamentals of Veterinary Ophthalmology*. 6th ed. Saunders.
- Slatter DH. 2003. *Textbook of Small Animal Surgery*. 3rd ed. WB Saunders.

Minor Courses for Ph.D. Degree programme

Courses of any one department/ discipline from the list given below:

- Veterinary Physiology
- Veterinary Biochemistry
- Veterinary Biotechnology
- Veterinary Anatomy
- Veterinary Medicine
- Veterinary Pathology
- Animal Reproduction, Gynaecology and Obstetrics
- Animal Biotechnology

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Veterinary Clinical Subjects
– Veterinary Medicine

Course Title with Credit Load
M.V.Sc. in Veterinary Medicine

Course Code	Course Title	Credit Hours
VMD 501*	Ruminant Medicine-internal	3+0
VMD 502*	Ruminant Medicine-infectious	3+0
VMD 503	Equine Medicine	2+0
VMD 504*	Canine and Feline Medicine-I	2+0
VMD 505*	Canine and Feline Medicine-II	2+0
VMD 506	Metabolic and Endocrine Diseases, Nutritional Deficiencies and Diseases of Mammary Gland	2+0
VMD 507	Paediatrics and Geriatrics	2+0
VMD 508	Avian and Swine Medicine	2+0
VMD 509	Zoo, Wild and Laboratory Animal Medicine	1+0
VMD 510	Toxicology and Forensic Medicine	1+0
VMD 511*	Clinical Diagnostic Techniques	0+2
VMD 512	Emergency Medicine	0+2
VMD 513*	Diagnosis of Veterinary Infectious Diseases	0+1
VMD 514	Oncology and Ethno-veterinary Medicine	1+0
VMD 515	Animal Disease Investigation and Biosecurity	1+1
VMD 516*	Clinical Practice-I	0+3
VMD 517*	Clinical Practice-II	0+3
VMD 591	Master's Seminar	1+0
VMD 599	Master's Research	0+30

Course Contents
M.V.Sc. in Veterinary Medicine

I. Course Title : Ruminant Medicine - Internal

II. Course Code : VMD 501

III. Credit Hours : 3+0

IV. Theory

V. Unit I

Examination of alimentary tract and abdomen; Diseases of the buccal cavity and related organs including pharynx, Oesophagus. Reticulo-ruminal fermentative disorders (simple indigestion, impaction, ruminal lactic acidosis), Primary and secondary bloat, Diaphragmatic hernia, Traumatic reticulo-peritonitis and Omasal impaction.

Unit II

Diseases of abomasum (impaction, displacements, ulcers, bloat), Acute and chronic diarrhoea, Intestinal obstructive disorders (intussusception, volvulus), Peritonitis, caecal dilatation and hemorrhagic bowel syndrome.

Unit III

Manifestations of liver and biliary diseases, Focal and diffuse diseases of liver. Disease of nasal cavity, sinuses, disease of larynx and trachea, pneumonias, pleuritis, manifestations Principles of treatment in uro-genital system; Rupture, Paralysis and infections of urinary bladder, Urolithiasis, Nephritis and renal failure, Nephrosis, renal ischemia, Hemolytic uremic like syndrome, Uremia and neoplasms of urinary tract.

Unit IV

Examination of cardiac system and Special examination of heart (ECG, echocardiography, Markers for diagnosis of cardiac disorders. Principal manifestations of cardiovascular diseases, congenital cardiac diseases, myocarditis), cardiomyopathy, endocarditis, pericarditis, phelebitis, thrombosis, anemia, lymphangitis, lymphadenopathies and thrombocytopenia.

Unit V

Principles of nervous dysfunction, Clinical manifestation and special examination, Localization of lesion in brain and spinal cord, Cortical diseases, Brain abscess, Meningitis, Diseases of brainstem, Cerebellar diseases, Spinal cord compression and peripheral nerve paralysis. Principal manifestations and special examination of musculoskeletal system, Myositis, Myopathies, Foot lameness, Arthritis, Osteodystrophies, Degenerative joint disease and nutritional deficiency diseases affecting musculoskeletal system; conjunctivitis, Keratitis, uveitis, Horner syndrome, neoplasms of eye, otits media, otitis externa; Skin diseases: folliculitis, furunculosis and skin neoplasms.

I. Course Title : Ruminant Medicine-infectious

II. Course Code : VMD 502

III. Credit Hours : 3+0

IV. Theory

V. Unit I

Clostridial diseases-black quarter, Botulism, Bacillary hemoglobinuria, Braxy, Enterotoxemia, Malignant edema, Pulpy kidney disease, Tetanus, Collibacilosis, Salmonellosis, Compylobacteriosis, Listeriosis, Actinobacillosis, Actinomycosis, Anthrax, Tuberculosis, Johne's disease, Leptospirosis, Pasteurellosis, Ulcerative lymphangitis, Infectious bovine keratoconjuctivitis, Chlamydiosis infections, Dermatophytosis, Cutaneous streptothricosis, Candidiasis and Rhinosporidiosis.

Unit II

Foot and mouth disease, Vesicular stomatitis, Vesicular exanthema, Rinderpest, PPR, Bovine viral diarrhea, Mucosal disease, Ephemeral fever, Bovine herpes viral diseases, Leucosis, Viral pneumonia, Pox diseases, Infectious gastroenteritis of viral etiology. Malignant catarrh fever, Rabies, Bluetongue, Louping ill, Papillomatosis, Contagious ecthyma (orf), Caprine arthritis and Encephalopathy(CAE), Contagious bovine pleuropneumonia and Contagious caprine pleuropneumonia.

Unit III

Bovine spongiform Encephalopathy, Scarpie, Bovine Anaplasmosis, Theileriasis, Babesiosis, Fascioliosis, Amphistomiosis, Gastrointestinal nematodiosis, Schistosomiosis, Lung worm infection, Echinococcosis, Coenurosis and Tapeworm infections, Coccidiosis, Thelaziasis, parasitic dermatitis (scabies, psoroptes).

I. Course Title : Equine Medicine

II. Course Code : VMD 503

III. Credit Hours : 2+0

IV. Theory

V. Unit I

Diseases of buccal cavity (dental diseases, stomatitis), Oesophagus, Gastric dilatation, gastro-duodenal ulceration, Acute and chronic diarrhea, Colic, Acute and chronic hepatitis.

Unit II

Diseases of cardio-vascular system and blood forming organs; Manifestations and principles of treatment in respiratory disorders, Epistaxis, Ethmoidal hematoma, pharyngitis, sinusitis, Guttural pouch diseases, Tracheal collapse, Adult pneumonia, foal pneumonia, Recurrent air way obstruction, Inflammatory airway disease, Pleura-pneumonia, Pulmonary congestion and edema; Manifestations and principles of treatment of urinary system diseases, Rupture of urinary bladder, Paralysis, urolithiasis, Urinary tract infections, Acute and chronic renal failure and Neoplasms of urinary tract.

Unit III

Principal manifestations of musculoskeletal diseases, Laminitis, Inflammatory Myopathy, Exertional Myopathies, Myotonia, Hyperkalemic periodic paralysis and Nutritional deficiency diseases affecting musculoskeletal system.
Nervous diseases, Viral encephalitis, Intracarotid drug injection, Trauma to brain and cranial nerves, Brain abscess, Peripheral vestibular disease, Temporo-hyoid osteoarthropathy, Ataxia (sorghum toxicity, spinal abscesses), Peripheral facial nerve paralysis, Peripheral nerve disorders; Skin diseases, bacterial, fungal, parasitic and allergic dermatitis (culicoides hypersensitivity), Cutaneous eczema, Cutaneous acne, Cutaneous pustular dermatitis, Candidasis, Histoplasmosis, Coccidiodomycosis and dermatophytosis.

Unit IV

Bacterial, fungal and viral keratitis, Equine recurrent uveitis, Uveitis, Ocular neoplasia. Trypanosomiasis/ dourine, Babesiosis, Parasitic pneumonia, Strangles, equine influenza, Equine herpes virus infection, Potomac horse fever, Equine infectious anaemia and setariasis.

I. Course Title : Canine and Feline Medicine-I

II. Course Code : VMD 504

III. Credit Hours : 2+0

IV. Theory

Unit I

Diagnostic approach to common manifestations of disease: Vomiting, acute diarrhea, Chronic diarrhea, Syncope, Anemia, Jaundice, Fever, Weight loss, Edema, Dyspnoea, coughing and nasal discharge.

Unit II

Etiology, pathogenesis, clinical signs, clinical pathology, diagnosis, Differential diagnosis and treatment of diseases of the oral cavity, oesophagus, acute gastritis, chronic gastritis, Gastric dilatation, Volvulus, Tumors of the stomach, Intussusception, Acute enteritis, Chronic enteritis, Inflammatory bowel disease, Colitis, Gastric and Intestinal foreign bodies, Diseases of rectum and anal sac, Peritonitis, Acute hepatitis, Chronic hepatitis, Diseases of gall bladder, Cholangitis, Vascular liver diseases, Extra hepatic biliary system, Acute pancreatitis and Exocrine pancreatic insufficiency.

Unit III

Anemia, Lymphangitis, Lymphadinopathies, Coagulopathies, Immune mediated diseases, Neoplastic diseases of hemo-lymphatic system; Examination of cardiac system and special examination of heart (ECG, Echocardiography, Holter and markers for diagnosis of cardiac disorders), Congenital heart diseases, Dilated cardiomyopathy, Endocardiosis, Cardiac arrhythmias, Pericardial disorders. Pet psychology, Pet behaviour, Adaptation needs and Behavioural medicine

Unit IV

Leptospirosis, Tetanus, Brucellosis, Lyme disease, Rocky mountain spotted fever, Kennel cough, Trypanosomiasis, Ehrlichiosis, Ancylostomiasis, Dirofilariasis, Giardiasis, Coccidiosis/ Isosporosis, Toxoplasmosis, Babesiosis, Neosporosis, Hepatozonoosis and Tape worm infections.

I. Course Title : Canine and Feline Medicine-II

II. Course Code : VMD 505

III. Credit Hours : 2+0

IV. Theory

Unit I

Principles of treatment in respiratory disorders, Diseases of nasal cavity, Tracheo-bronchitis, Chronic bronchitis, Pulmonary congestion and edema, Acute pneumonia, Chronic pneumonia, Feline asthma, Pleural effusions and Neoplasms of respiratory tract.

Diagnostic approach to common manifestations of disease: Seizures, Coma, Monoparesis, Pelvic limb paralysis, Pruritis, alopecia, Obesity, Urinary incontinence, Hematuria; Focal, diffuse and multifocal diseases of brain. Diseases of spinal cord and Peripheral nervous system, Vestibular diseases and toxins affecting nervous system.

Unit II

Diseases of muscles- congenital and inherited diseases of muscles, bone and joints, Myasthenia, Myopathy; Nutritional deficiency diseases- Rickets, Primary and Secondary Hyperparathyroidism, Osteodystrophy and Osteomyelitis.

Diseases of eyelids, Epiphora, Keratitis, Conjunctivitis, Uveitis, Glaucoma, Acute blindness and Neoplasms of eye.

Unit III

Skin diseases, Common pyodermas, Atopy, Dermatophytosis and Dermatomycosis, Demodicosis, Scabies, Myiasis, and Nutritional disorders related to skin and its therapeutic management, Flea allergy and its treatment and control measures, Alopecia. Cutaneous manifestations of hormonal imbalances and systemic disorders, Auto immune diseases of skin, Diseases of the pinna, Otitis and principles of treatment in otic infections.

Manifestations and principles of treatment of urinary system diseases, Urinary tract infections, Urolithiasis, Nephritis, Nephrosis, Pyelonephritis, Renal failure and neoplasms of urinary tract.

Viral diseases: Canine parvovirus, Canine distemper, Corona viral gastroenteritis, Infectious hepatitis, Infectious tracheobronchitis, Canine herpes virus, Rabies, Feline Panleukopenia, Infectious peritonitis (FIP), Feline leukemia virus infection, Feline immunodeficiency virus, Vaccination schedule for canine and feline diseases, Dermatophytosis, Blastomycosis, Histoplasmosis, Sporotrichosis, and coccidioidomycosis.

I. Course Title : **Metabolic and Endocrine Diseases, Nutritional Deficiencies and Diseases of Mammary Gland**

II. Course Code : **VMD 506**

III. Credit Hours : **2+0**

IV. Theory

Unit I

Metabolic profile test parturient paresis, Downer cow syndrome, Acute hypokalemia in cattle, Transit recumbency, Lactation tetany of mares, Hypomagnesemia, Tetany of calves, Ketosis, sub-clinical ketosis, Pregnancy toxemia, Fatty liver syndrome, Equine hyperlipidemia, Steatitis, Neonatal hypoglycemia, low milk fat syndrome, Peri-parturient hemoglobinuria and Eclampsia in bitches.

Unit II

Deficiency of energy and protein, Deficiency of fat and water soluble vitamins and deficiency of macro- micro minerals.

Unit III

Mastitis, Diseases of teats and udder in ruminants, "mastitis-metritis-agalactia" in sow and congenital abnormalities of udder and teats.

Unit IV

Diabetes mellitus, Diabetes insipidus, Hypothyroidism, Obesity, Hypo- and hyperadrenocorticism.

I. Course Title : Paediatrics and Geriatrics

II. Course Code : VMD 507

III. Credit Hours : 2+0

IV. Theory

Unit I

Perinatal management, Perinatal adaptation, Neonatal health, Asphyxia and Resuscitation; Physical examination of the neonate, perinatal and neonatal mortality, Colostrum and its substitutes, Manifestations of disease.

Unit II

Immunization of neonates, Fluid replacement therapy, Nutritional support, Blood and Serum transfusion, Antimicrobial therapy and neonatal diarrhoea.

Unit III

Non-infectious and infectious diseases of viral, bacterial, mycoplasma and parasitic origin of neonates, Young and aged farm and companion animals; Diseases acquired from dam, Congenital disorders, Metabolic disorders, Nutritional deficiencies, Miscellaneous conditions (hypothermia, hyperthermia, starvation, arthritis), Management of shock and other emergencies, Detection and correction of failure of passive transfer of immunity.

Unit IV

Geriatric diseases: Senility, Dental diseases, Glaucoma, Cataract, Keratitis sicca, Urinary incontinence, Renal insufficiency, Cardiac diseases, Pulmonary diseases, Neoplasia, Bone and joint diseases, Neurologic disorders, Otologic disorders, Endocrine diseases (diabetes mellitus, cushing's disease, hypothyroidism), Liver diseases, Psychological and behaviour disorders.

I. Course Title : Avian and Swine Medicine

II. Course Code : VMD 508

III. Credit Hours : 2+0

IV. Theory

Unit I

Specific needs of avian species; Diseases due to deficiency of vitamins (vitamins A, B complex, C, D, E, K); minerals (calcium, phosphorus, manganese, zinc, etc.) and sodium chloride.

Unit II

Miscellaneous diseases/ conditions/ vices (cage layer fatigue, beak necrosis, blue comb disease, round heart disease, kerato- conjunctivitis, ascites, urolithiasis, fatty liver, kidney hemorrhagic syndrome, heat stroke, cannabalism, vent picking), egg bound peritonitis, diseases of feather, skin, beak and foot, bumble foot, gout, infectious diseases of poultry (marek's disease, lymphoid leukosis, new castle disease, infectious coryza, fowl typhoid, CRD, pullorum disease, cocciodiosis, chlamydiasis, avian pox, infectious bursal disease, infectious bronchitis, infectious laryngo-tracheitis, etc.)

Unit III

Nutritional deficiency diseases of pigs, swine influenza, hog cholera, african swine fever, swine pox, vesicular exanthema, vesicular stomatitis, rabies. porcine enteroviruses, pseudorabies, listeriosis, leptospirosis, brucellosis, anthrax, salmonellosis, swine erysipelas, pasteurellosis, tuberculosis, mange, etc.

Unit IV

Handling, physical examination, sampling, diagnostic techniques and medication.

I. Course Title : Zoo, Wild and Laboratory Animal Medicine

II. Course Code : VMD 509

III. Credit Hours : 1+0

IV. Theory

Unit I

Study of diseases and health management of zoo, Wild and laboratory animals; Etiology, Clinical signs, Diagnosis and management of various diseases of zoo, wild and laboratory animals. Restraint, Feeding, Diseases and health management of exotic animals kept as pets.

Unit II

Specific diseases of laboratory animals caused by bacteria, viruses, fungi and parasites. Specific diseases of zoo (captive) animals caused by bacteria, viruses, fungi and parasites.

I. Course Title : Toxicology and Forensic Medicine

II. Course Code : VMD 510

III. Credit Hours : 1+0

IV. Aim of the course

Study of diseases caused by physical, chemical, other toxicants in domestic animals and animal welfare issues.

V. Theory

Unit I

Diseases caused by physical agents and poisoning of organic and inorganic compounds. Diseases caused by farm chemicals and phytotoxins. Diseases caused by mycotoxins and zootoxins.

Unit II

Collection, Dispatch and Examination of vetro-legal samples. Examination of wounds, blood, offenses and frauds in animal sales. Animal cruelty and welfare related issues. Study of common laws related to vetro-legal aspects.

I. Course Title : Clinical Diagnostic Techniques

II. Course Code : VMD 511

III. Credit Hours : 0+2

IV. Theory

V. Unit I

Peritoneal fluid analysis, Gastrointestinal endoscopy, Colonoscopy, Proctoscopy, Ultrasonography, Liver biopsy, Interventional imaging, Rhinoscopy, Brochoscopy, Transtracheal lavage, Endotracheal lavage, Broncho-alveolar lavage, Thoracocentesis, Pericardiocentesis, Interpretation of hemogram, Renal and Hepatic function tests. Neurological examination.

Unit II

Electrocardiography, Echocardiography, Pulse oximetry, Blood and blood component therapy, Bone marrow biopsy, Arterial blood gas analysis, Cerebrospinal fluid analysis, Cystocentesis, Urinary catheterization, Renal function tests, Specific gravity of urine by refractometer, Skin-biopsy, Cytology- scrapings, Otoscopy, Direct and indirect ophthalmoscopy, Shirmer tear test, Tonometry. Diagnosis tests in mastitis. Assay for T_3, T_4, lipase, Amylase, Radio immunoassay and indications of CT, MRI, nuclear medicine.

I. Course Title : Emergency Medicine

II. Course Code : VMD 512

III. Credit Hours : 0+2

IV. Practical

- Diagnosis and therapeutic management of various emergencies of cardiovascular, respiratory, gastrointestinal, urinary and nervous systems.
- Diagnosis and therapeutic management of various emergencies of toXicities, sting bites, snake bite and burns in farm and companion animals.
- Monitoring critical ill patient, application of emergency care procedures for resuscitation of critically ill patients.
- Placement of central venous catheters, introsseous fluid administration, endotracheal intubation, gastric lavage, decompression of guttural pouch, stomach, cecum, ventilation, nebulization, fluid therapy, CPR, oXygen therapy, enteral nutrition, nasogastric intubation, Blood transfusion

I. Course Title : Diagnosis of Veterinary Infectious Diseases

II. Course Code : VMD 513

III. Credit Hours : 0+1

IV. Practical

- Sampling techniques for collection of samples during research;
- Sensitivity and specificity of diagnostic tests including false positive and false negative tests. Mastitis diagnostic tests;
- Culture and staining techniques;
- Diagnosis of fungal diseases, protozoan and rickettsial diseases, fecal eXamination for endoparasites, skin scrapping eXamination for mites, fleas and lice;
- ELISA, PCR, culture sensitivity tests on milk and other body fluids, molecular techniques and types of PCR, Molecular epidemiology tools including RFLP, etc.

I. Course Title : Oncology and Ethno-veterinary Medicine

II. Course Code : VMD 514

III. Credit Hours : 1+0

IV. Theory

Unit I

Tumors related to different systems - biology and pathogenesis of cancer, diagnostic procedures, oncology medicine, chemotherapy, radiation therapy, immuno-therapy and miscellaneous therapeutic measures, including advancements of therapeutic approaches, supportive care for the cancer patient.

Unit II

Natural remedies and products for use towards therapy in animal ailments.

Unit III

Acupuncture, physiotherapy, laser therapy, nutraceuticals and dietary supplements.

I. Course Title : Animal Disease Investigation and Biosecurity

II. Course Code : VMD 515

III. Credit Hours : 1+1

IV. Theory

V. Unit I

Investigation and diagnosis on dead and live diseased animal (s) and poultry. Point source epidemics and propagating epidemics, Collection, Preservation and transport of material in the face of disease outbreak, and processing of material in the laboratory for diagnosis; Recording and analysis of epidemiological data. Establishing working hypothesis and formulating and advising and/ or implementing treatment, control and prevention measures.

Unit II

Biosecurity definition, Related concepts, Principles and basic components of biosecurity, Physical and operational elements of biosecurity. Routes of entry and transmission dynamics of pathogens. Shedding pattern of pathogens by infected animals and their survival in the environment. Protection of susceptible animals, interruption of pathways of transmission, role of disinfection to break cycle of infection. Sterilization, fumigation and disinfection methods, disinfectants and its classification, Microbial resistance to disinfectants, Risk assessment and its management. Principles of biosecurity in laboratory animal house, Biosecurity measures for collection of specimen from wild animals. Biosecurity in research laboratories. Vaccines-success stories of disease eradication through vaccination.

VI. Practical

- Isolation and identification of field isolates and vaccine strains by conventional, immunoassays and molecular techniques.
- To perform an outbreak investigation of infectious diseases and toxicological conditions in livestock and poultry in the field/ organised livestock farms.
- Practical use of disinfectants in destruction of microbes in laboratory and under field conditions. Determination of efficacy/ phenol coefficient of commonly used disinfectants.
- Approaches in animal disease control and eradication. Preliminary steps to control animal disease outbreaks.
- Types of vaccines, vaccination schedule in livestock, pets and poultry

I. Course Title : Clinical Practice-I

II. Course Code : VMD 516

III. Credit Hours : 0+3

IV. Practical

- Diagnostic and therapeutic protocol application, specimen collection, examination and management of sick farm and companion animals, use of diagnostic techniques for diagnosis of medicinal cases, acquaintance with different equipment, client management, public relations, code of conduct, hospital management, database management and maintenance of case records, disaster management
- Note: This course shall be conducted in Veterinary Clinical Complex (VCC), where students shall participate in diagnosis and treatment of diseased animals.

I. Course Title : Clinical Practice-II
II. Course Code : VMD 517
III. Credit Hours : 0+3

IV. Practical

- Diagnostic and therapeutic protocol application, specimen collection, examination and management of sick farm and companion animals, use of diagnostic techniques for diagnosis of medicinal cases, acquaintance with different equipment, client management, public relations, code of conduct, hospital management, database management and maintenance of case records, disaster management.
- **Note:** This course shall be conducted in Veterinary Clinical Complex (VCC), where students shall participate in diagnosis and treatment of diseased animals.

Course Outline: Lecture wise

VMD 501: Ruminant Medicine-internal 3+0

Suggested Books

- Bradford Smith, David Van Metre, Nicola Pusterla. 2019. *Large Animal Internal Medicine*. 6th Edition, Mosby.
- Neil V Anderson, 1992. *Veterinary Gastroenterology*. 2nd Revised edition, Lea and Febiger, USA.
- Simon F Peek, Thomas J Divers. 2018. *Rebhun's Diseases of Dairy Cattle*. 3rd Edition, Elseviers.
- Research and Review Papers in Current Journals.

VMD 502: Ruminant Medicine-infectious 3+0

Suggested Books

- *Dairy Herd Health*. 2012. MJ Green, Andrew J. Bradley. CABI Publishing.
- *Merck's Veterinary Manual* K. 2016. Susan E Aiello, Michael A Moses. (11th Edition). Merck Sharp and Dohme
- *Veterinary Medicine* 2016. Peter Constable, Kenneth W Hinchcliff, Stanley Done, Walter Gruenberg. 11th Edition. Saunders Ltd.
- Research and Review Papers in Current Journals.

VMD 503: Equine Medicine (2+0)

Suggested Books

- *Equine Internal Medicine*. 2017. Stephen Reed, Warwick Bayly, Debra Sellon, 4th Edition, Elsevier, Saunders.
- *Large Animal Internal Medicine*. 2019. Bradford Smith, David Van Metre, Nicola Pusterla, 6th Edition, Mosby
- Research and Review Papers in Current Journals.

VMD 504: Canine and Feline Medicine-I (2+0)
Suggested books

- *Small Animal Internal Medicine* 2013. Nelson and Couto, 5th edition, Elesvier Mosby, St. Louis, Missouri

- *Text book of Veterinary Internal Medicine* 2001. Part I and II, Ettinger and Feldman, 7th Edition, *Publisher*: Saunders
- *Small Animal Medical Diagnosis* 2009. MD Lorenz, TM Neer and PL Demars, 3rd Edition, Willey Blackwell, Iowa, USA.
- Research and Review Papers in Current Journals.

VMD 505: Canine and Feline Medicine-II (2+0)

Suggested books

- *Small Animal Internal Medicine* 2013. by Nelson RW and Couto, CG 5th edition, Elesvier Mosby, St. Louis Missouri
- *Text book of Veterinary Internal Medicine* 2010. by Ettinger and Feldman, 7th Edition, *Publisher*: Saunders
- Research and Review Papers in Current Journals.

VMD 506: Metabolic and Endocrine Diseases, Nutritional Deficiencies and Diseases of Mammary Gland (2+0)

Suggested books

- *Veterinary Medicine* 2007. *A Textbook of the Diseases of Cattle*, *Horses*, *Sheep*, *Pigs and Goats by Otto M Radostits*, Clive C Gay, Kenneth W Hinchcliff and Peter D Constable. 10th Edition. Saunders.
- *Clinical Endocrinology of Companion Animals* (2013). Ed. J Rand 1st Edition edt.by Jacquie Rand (Editor), Ellen Behrend (Editor), Danielle Gunn-Moore (Editor), Michelle Campbell-Ward (Editor). Wiley-Blackwell.
- Research and Review Papers in Current Journals.

VMD 507: Paediatrics and Geriatrics (2+0)

Suggested Readings

- *Equine Pediatric Medicine*. 2018. WV Bernard, BS Barr, 2nd edition, CRC Press.
- *Treatment and Care of the Geriatric Veterinary Patients* 2017. Mary Gardne and Dani McVety, Wiley-Blackwell.
- *Small Animal Pediatrics* 2011. Michael E. Peterson and Michelle Anne Kutzler, Elsevier.
- Research and Review Papers in Current Journals.

VMD 508: Avian and Swine Medicine (2+0)

Suggested Poultry Books

- *Diseases of Poultry*. 2013. DE Swayne, JR Glisson, LR McDougald, LK Nolan, DL Suarwz, and VL Nair. *13th Edition*, Wiley-Blackwell.
- *Diseases of poultry and their control*. 2001. R. Chandra, VDP Rao, JC Gomez-Villamandos, SK Shukla and PS Banerjee. 1st edition, International book distributing Co., Lucknow, India. 2001.
- Research and Review Papers in Current Journals.

Suggested Swine Books

- *Diseases of Swine*. 2012. JJ Zimmerman, LA Karriker, A Ramirez, KJ Schwartz and GW. Stevenson. 12th edition, Wiley-Blackwell.
- *Diseases of Swine* 2006. BE Straw, JJ Zimmerman, SD'Allaire and DJ Taylor. 9th edition, Blackwell Publishing.
- Research and Review Papers in Current Journals.

VMD 509: Zoo, Wild and Laboratory Animal Medicine (1+0)

Suggested Books

- *Wild Mammals in Captivity: Principles and Techniques for Zoo Management* (2010). 2nd ed. - Kleiman, DG, University of Chicago Press
- *Zoo and Wild Animal Medicine Current Therapy* (2007). 6th ed. -C Fowler, ME
- *Zoo Animal and Wildlife Immobilization and Anesthesia* (2014). 2nd Ed.-C West, D Heard. N Caulkett, Wiley Blackwell
- Research and Review Papers in Current Journals.

VMD 510: Toxicology and Forensic Medicine (1+0)Suggested Books

- *Veterinary Toxicology*. 2014. SK Garg, CBS Publishers.
- *Veterinary Medicine- A textbook of the diseases of cattle, horses, sheep, pigs and goats* by Constable *et al*. 11th Ed., Saunders Ltd.
- *Animal Welfare Ethics and Jurisprudence* 2014. Kirti Dua, 1st Ed., Kalyani Publishers.
- *Veterinary Jurisprudence*. 2015. SN Sharma AK Gahlot and RK Tanwar. 7th Ed., NBS Publisher and Distributor.
- Research and Review Papers in Current Journals.

VMD 511: Clinical Diagnostic Techniques (0+2)

Suggested Books

- *Large Animal Internal Medicine*. 2015. Bradford P. Smith, 5th Edition, Mosby Elsevier.
- *Small Animal Clinical Techniques*. 2010. Susan M. Taylor, Saunders Elsevier.
- *Handbook of Veterinary Neurology*. 2010. Michael D. Lorenz, Joan R. Coates and Marc Kent, 5th Edition, Saunders Elsevier.
- *Handbook of Equine Respiratory Endoscopy*. 2007. Safia Barakzai, First Edition, Saunders Elsevier.
- *Manual of Canine and Feline Cardiology*. 2008. Larry P. Tilley, Francis W.K. Smith Jr., M.A. Oyama and M.M. Sleeper, 4th Edition, Saunders Elsevier.
- *Diagnostic Techniques in Equine Medicine: A Textbook for Students and Practitioners Describing Diagnostic Techniques Applicable to the Adult Horse* (2009), Frank GR Taylor, Tim J Brazil and Mark H Hillyer, 2nd Edition, Saunders Elsevier.
- Research and Review Papers in Current Journals.

VMD 512: Emergency Medicine (0+2)

Suggested Books

- *Kirk and Bistner's Handbook of Veterinary Procedures and Emergency Treatment*. 2012. Richard B. Ford and Elisa Mazaferro, 9th Edition, Saunders Elsevier.
- *Blackwell's Five Minute Veterinary Consult Clinical Companion, Small Animal Emergency and Critical Care*. 2010. Mazzaferro, M. E. 1st Edition, (Wiley Blackwell)
- *Equine Emergencies Treatment and Procedures*. 2008. Orsini J.A. and Divers T.J., 3rd Edition, Saunders Elsevier.
- Research and Review Papers in Current Journals.

VMD 513: Diagnosis of Veterinary Infectious Diseases (0+1)

Suggested Books

- *Veterinary Epidemiology* (2018). Michael Thrusfield, Robert Christley. Wiley-Blackwell
- *Veterinary Epidemiologic Research*. (2003). Ian Dohoo, Wayne Martin and Henryk Stryhn, AVC Inc., Charlottetown.

- *Diseases of Animals: Diagnosis and Management* (2013). Singh, Bhoj and Somvanshi, R. Indian Veterinary Research Institute
- *Veterinarian's Guide to the Laboratory Diagnosis of Infectious Diseases* (1986). Gordon R. Carter. Veterinary Medicine Publishing Company
- Research and Review Papers in Current Journals.

VMD 514: Oncology and Ethno-veterinary Medicine (1+0)

Suggested Books

- *BSAVA Manual of Canine and Feline Oncology* by Dobson, Jane M. and Lascelles, B Duncan X. 3rd Ed., BSAVA.
- *Veterinary Herbal Medicine* by SG Wynn and BJ Fougere. 1st Ed., Mosby Elsevier.
- *Textbook of Veterinary Homeopathy*, by J Saxton and P Gregory. Beaconsfield Publishers, Beaconsfield
- *Complementary and Alternative Veterinary Medicine* by Narda G Robinson In: Merck Veterinary Manual. 11th Ed., Wiley.
- *Nutraceuticals in Veterinary Medicine* by, Ramesh C Gupta, Ajay Srivastava and Rajiv Lall. 1st Ed., 2019 Springer.
- Research and Review Papers in Current Journals.

VMD 515: Animal Disease Investigation and Biosecurity (1+1)

Suggested Books

- *History of the Surveillance and Control of Transmissible Animal Diseases.* (2003). Jean Blancou. Office International des Epizooties
- *Veterinary Epidemiology* (2018). Michael Thrusfield, Robert Christley. Wiley-Blackwell
- *Biosecurity in Animal Production and Veterinary Medicine* (2018). Jeroen Dewulf, Filip Van Immerseel. *From Principles to Practice*. AMSTERDAM University Press
- Research and Review Papers in Current Journals.

Minor Courses for M.V.Sc. Degree programme

Courses of any one department/ discipline from the list given below:

- Veterinary Physiology
- Veterinary Microbiology
- Veterinary Parasitology
- Veterinary Pharmacology and Toxicology
- Veterinary Surgery and Radiology
- Veterinary Public Health and Epidemiology

Course Contents
Ph.D. in Veterinary Medicine

Course Code	Course Title	Credit Hours
VMD 601	Farm Animal Gastroenterology	2+0
VMD 602	Farm Animal Cardiopulmonary and Urinary System Diseases	2+0
VMD 603	Farm Animal Neurological and Musculo-skeletal System Diseases	1+0
VMD 604	Farm Animal Neonatology	1+0
VMD 605	Herd Health Management	2+1
VMD 606	Canine and Feline Gastroenterology	2+0
VMD 607	Advances in Neurological and Musculoskeletal System Diseases of Canine and Feline	1+0
VMD 608	Canine and Feline Cardiopulmonary and Urinary System Diseases	1+0
VMD 609	Dermatology and Endocrinology	1+0
VMD 610	Canine and Feline Eye and Ear Diseases	1+0
VMD 611	Veterinary Diagnostics	0+2
VMD 612	Metabolic and Nutritional Deficiency Diseases	2+0
VMD 613	Emergency and Critical Care Medicine	1+1
VMD 614	Emerging and Re-emerging Animal Diseases	2+0
VMD 615	Prevention and Control of Infectious Diseases of Ruminants	2+0
VMD 616*	Clinical Practice-I	0+2
VMD 617*	Clinical Practice-II	0+2
VMD 618*	Clinical Practice-III	0+2
VMD 691	Doctoral Seminar-I	1+0
VMD 692	Doctoral Seminar-II	1+0

Course Contents
Ph.D. in Veterinary Medicine

I. Course Title : Farm Animal Gastroenterology
II. Course Code : VMD 601
III. Credit Hours : 2+0
IV. Theory
V. Unit I

Advances in diagnosis, Therapy and control of diseases of gastrointestinal system and associated organs of farm animals.

Unit II

Advances in diagnosis, Therapy, Control and prevention of infectious diseases of gastrointestinal system and associated organs of farm animals.

I. Course Title : Farm Animal Cardiopulmonary and Urinary System Diseases
II. Course Code : VMD 602
III. Credit Hours : 2+0
IV. Theo

ry

V. Unit I

Advances in diagnosis and therapeutic management of internal diseases of circulatory system and urinary systems.

Unit II

Advances in diagnosis and therapeutic management of internal diseases of respiratory system.

Unit III

Advances in diagnosis, control, prevention and therapeutic management of infectious diseases of cardiopulmonary and urinary systems.

I. Course Title : Farm Animal Neurological and Musculo-skeletal System Diseases
II. Course Code : VMD 603
III. Credit Hours : 1+0

IV. Theory

V. Unit I

Advances in diagnosis, Therapy and control of internal diseases of nervous and musculoskeletal system.

Unit II

Advances in diagnosis, Therapy, Control and prevention of infectious diseases of nervous and musculo-skeletal systems.

I. Course Title : Farm Animal Neonatology

II. Course Code : VMD 604

III. Credit Hours : 1+0

IV. Theory

Unit I

Advances in diagnosis, Therapy, Prevention and control of internal and infectious diseases of equine neonate.

Unit II

Advances in diagnosis, Therapy, Prevention and control of internal and infectious diseases of ruminant neonate.

I. Course Title : Herd Health Management

II. Course Code : VMD 605

III. Credit Hours : 2+1

IV. Theory

V. Unit I

General principles, Interactions between health and production, Herd medicine and population health.

Unit II

Herd health management programme for enzootic herds/ flocks.

Unit III

Recent concepts on herd management of chronic Bacterial, parasitic and fungal and rickettsial diseases.

Unit IV

Biosecurity and infection control, Herd and flock immunity, Quality management of herd health, Control of infectious diseases in the herd, Herd health economics.

VI. Practical

Visit to farms, Assessment of their problems, Estimating the presence and prevalence of a disease and new proposals for prevention and control strategies of a specific disease and its impact.

I. Course Title : Canine and Feline Gastroenterology

II. Course Code : VMD 606

III. Credit Hours : 2+0

IV. Theory

Unit I

Advances in diagnosis, Therapy and control of internal diseases of gastrointestinal system and associated organs of canine and feline.

Unit II

Advances in diagnosis, Therapy, Control and prevention of infectious diseases of gastrointestinal system and associated organs in canine and feline.

I. Course Title : Advances in Neurological and Musculoskeletal System Diseases of Canine and Feline

II. Course Code : VMD 607

III. Credit Hours : 1+0

IV. Aim of the course

Study of recent advances in the field of neurological and musculoskeletal diseases.

V. Theory

Unit I

Advances in diagnosis, Therapy and control of internal diseases of nervous and musculoskeletal systems.

Unit II

Advances in diagnosis, Therapy and control of infectious diseases of nervous and musculoskeletal systems.

I. Course Title : Canine and Feline Cardiopulmonary and Urinary System Diseases

II. Course Code : VMD 608

III. Credit Hours : 1+0

IV. Aim of the course

Advances in cardiopulmonary and urinary systems.

V. Theory

Unit I

Advances in diagnosis and therapeutic management of internal diseases of circulatory and urinary systems.

Unit II

Advances in diagnosis, therapeutic management of internal diseases of respiratory system.

Unit III

Advances in diagnosis, therapeutic management, prevention and control of infectious diseases of cardiopulmonary and urinary systems.

I. Course Title : Dermatology and Endocrinology

II. Course Code : VMD 609

III. Credit Hours : 1+0

IV. Theory

Unit I

Advances in diagnosis, therapy, prevention and control of infectious and non-infectious diseases of skin and integumentary systems.

Unit II

Advances in diagnosis, therapy and control of diseases of endocrine system.

I. Course Title : Canine and Feline Eye and Ear Diseases

II. Course Code : VMD 610

III. Credit Hours : 1+0

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IV. Theory

Unit I

Advances in examination, diagnosis and therapy of diseases of eye.

Unit II

Advances in diagnosis and therapy of diseases of ear.

I. Course Title : Veterinary Diagnostics

II. Course Code : VMD 611

III. Credit Hours : 0+2

IV. Practical

Unit I

Analysis and interpretation of hemogram, serum and blood biochemicals.

Unit II

Imaging techniques for the diagnosis of animal diseases (electrocardiography, echocardiography, etc.)

Unit III

Ophthalmoscopy, Ultrasonography, Pulse-oximetry. Assignments on advanced diagnostic techniques for various diseases of domestic animals. Use of above mentioned advanced diagnostic techniques where ever possible. Collection and examination of CSF, gastric/ rumen/ abomasal, peritoneal fluid, absorption and digestion tests, low and high dose dexamethasone test, ACTH stimulation test, hormone profile and enzyme profile.

I. Course Title : Metabolic and Nutritional Deficiency Diseases

II. Course Code : VMD 612

III. Credit Hours : 2+0

IV. Theory

Unit I

Metabolic profile tests, Parturient paresis, Downer's cow syndrome, Acute hypokalemia in cattle, Transit recumbency and lactation tetany of mares, Hypomagnesemic tetany of calves, Ketosis, Subclinical ketosis, Pregnancy toxemia, Fatty liver syndrome, Equine hyperlipidemia, Steatitis, Neonatal hypoglycemia, Low milk fat syndrome, Postparturient hemoglobinuria and eclampsia in bitches.

Unit II

Deficiency of energy and protein, Deficiency of fat. Deficiency of fat and water soluble vitamins, Deficiency of macro and micro minerals.

Unit III

Diabetes mellitus, diabetes insipidus, hypothyroidism, obesity, hypo- and hyperadrenocorticism, hormone deficiency syndromes.

I. Course Title : Emergency and Critical Care Medicine

II. Course Code : VMD 613

III. Credit Hours : 1+1

IV. Theo

ryUnit

Diagnosis and therapeutic management of various emergencies of cardiovascular, respiratory, gastrointestinal, urinary and nervous systems.

Unit

Diagnosis and therapeutic management of various emergencies of toxicities, sting bites and burns in farm and companion animals.

Unit

Monitoring critical ill patient, application of emergency care procedures for resuscitation of critically ill patients.

VI. Practical

- Placement of central venous catheters, Intra-osseous fluid administration, Endotracheal intubation, Gastric lavage, Decompression of guttural pouch, Stomach, Cecum, Ventilation, Nebulisation, Fluid therapy, CPR, oxygen therapy, Enteral nutrition, Nasogastric intubation.
- Continuous rate infusion, Defibrillation– Demonstration, Peritoneal dialysis, Peritoneal diagnostic lavage, Management of hypo/ hyper thermia, Trocarization.

I. Course Title : Emerging and Re-emerging Animal Diseases

II. Course Code : VMD 614

III. Credit Hours : 2+0

Unit I

General concepts for emergence of new diseases and re-emergence of old diseases. Factors and determinants of emerging diseases. The role of wildlife in emerging and re-emerging diseases.

Unit II

Microbial adaptation and change; Epidemiological processes involved in the emergence of vector-borne diseases. Epidemiology of globally and nationally important emerging/ re-emerging diseases and designing of strategies for their prevention and control.

I. Course Title : Prevention and Control of Infectious Diseases of Ruminants

II. Course Code : VMD 615

III. Credit Hours : 2+0

IV. Theory

Unit I

Bacterial and viral diseases of economic importance in bovines, sheep and goats.

Unit II

Fungal and parasitic diseases of economic importance in bovines, sheep and goats.

Unit III

Blood protozoan and rickettsial diseases of economic importance in bovines, sheep and goats.

I. Course Title : Clinical Practice-I

II. Course Code : VMD 616

III. Credit Hours : 0+2

IV. Practical

Diagnostic and therapeutic protocol application, Specimen collection, Examination and management of sick farm and companion animals, Use of diagnostic techniques for diagnosis of medicinal cases, Acquaintance with different equipment, Client management, public relations, Code of conduct, hospital management, Database management and maintenance of case records, Disaster management.

Note: This course shall be conducted in Veterinary Clinical Complex (VCC) where students shall participate in diagnosis and treatment of diseased animals.

I. Course Title : Clinical Practice-II

II. Course Code : VMD 617

III. Credit Hours : 0+2

IV. Practical

Diagnostic and therapeutic protocol application, Specimen collection, Examination and management of sick farm and companion animals**,** Use of diagnostic techniques for diagnosis of medicinal cases, Acquaintance with different equipment, Client management, Public relations, Code of conduct, Hospital management, Database management and maintenance of case records, Disaster management.

Note: This course shall be conducted in Veterinary Clinical Complex (VCC) where students shall participate in diagnosis and treatment of diseased animals.

I. Course Title : Clinical Practice-III

II. Course Code : VMD 618

III. Credit Hours : 0+2

IV. Practical

Diagnostic and therapeutic protocol application, Specimen collection, Examination and management of sick farm and companion animals, Use of diagnostic techniques for diagnosis of medicinal cases, Acquaintance with different equipment, Client management, Public relations, Code of conduct, Hospital management, Database management and maintenance of case records, Disaster management.

Course Outline: Lecture wise

VMD 601: Farm Animal Gastroenterology (2+0)

Suggested Books

- *Equine Internal Medicine*. 2017. Stephen Reed, Warwick Bayly and Debra Sellon, 4th Edition, Elsiever, Saunders.
- *Large Animal Internal Medicine*. 2019. Bradford Smith, David Van Metre and Nicola Pusterla, 6th Edition, Mosby
- *Rebhun's Diseases of Dairy Cattle*. 2018. Simon F Peek and Thomas J Divers, 3rd Edition, Elseviers
- *Veterinary Gastroenterology*. 1992. Neil V. Anderson, 2nd Revised edition, Lea and Febiger, USA.
- Research and Review Papers in Current Journals.

VMD 602: Farm Animal Cardiopulmonary and Urinary System Diseases (2+0)

Suggested Books

- *Large Animal Internal Medicine*. 2019. Bradford Smith, David Van Metre and Nicola Pusterla, 6th Edition, Mosby
- *Veterinary Medicine: A textbook of the diseases of cattle, horses, sheep, pigs and goats* by Otto M Radostits, Clive C Gay, Kenneth W Hinchcliff and Peter D Constable.10th Edition. Saunders
- *Rebhun's Diseases of Dairy Cattle*. 2018. Simon F Peek, Thomas and J Divers, 3rd Edition, Elseviers
- Research and Review Papers in Current Journals.

VMD 603: Farm Animal Neurological and Musculo-skeletal System Diseases (1+0)

Suggested Books

- *Bovine Laminitis and Lameness*. 2007. Paul R Greenough, First Edition, Saunders Elsevier.
- *Large Animal Internal Medicine*. 2019. Bradford Smith, David Van Metre, Nicola Pusterla, 6th Edition, Mosby
- *Handbook of Veterinary Neurology*. 2010. Michael D Lorenz, Joan R Coates and Marc Kent, 5th Edition, Saunders Elsevier.
- *Equine Internal Medicine*. 2004. Stephen M Reed, Warwick M Bayly and Debra C Sellon, 2nd Edition, Saunders Elsevier.
- Research and Review Papers in Current Journals.

VMD 604: Farm Animal Neonatology (1+0)

Suggested Books

- *Equine Pediatric Medicine*. 2018.W V Bernard, BS Barr, 2nd edition, CRC Press
- *Practical Lambing and Lamb Care*. 2018. N Sargison, JP Crilly and A Hopker, 4th edition, Wiley Blackwell
- *Equine Neonatal Medicine*. 2006. MR Paradis, 1st edition, Saunders
- *Bovine Neonatology*. 2009. *Veterinary Clinics of North America: Food Animal Practice*. 1st Edition, Saunders
- Research and Review Papers in Current Journals.

VMD 605: Herd Health Management (2+1)

Suggested Books

- *Dairy Herd Health*. 2012. MJ Green and Andrew J Bradley. CABI *Publishing*
- *Herd Health: Food*, *Animal*, *Production*, *Medicine*. 1994. OM Radostits, KE Leslie, J Fetrow and WB. Saunders,
- *Veterinary Epidemiology*. 2018. Michael Thrusfield, Robert Christley. Wiley-Blackwell
- *The Keys to Herd Health*. 2006. Jerry Brunetti. Acres U.S.A.
- *Herd Health and Production Management in Dairy Practice*. 2003. Arie Brand. International Book Distributing Company
- Research and Review Papers in Current Journals.

VMD 606: Canine and Feline Gastroenterology (2+0)

Suggested books

- *Canine and Feline Gastroenterology*. 2013. RJ Washabau and MJ Day, Elesvier Mosby, St. Louis Missouri
- *Text Book of Veterinary Internal Medicine*. 2001. Part I and II, Ettinger and Feldman, 7th Edition, Saunders
- *Small Animal Medical Diagnosis*. 2009. MD Lorenz, TM. Neer and PL Demars, 3rd Edition, Willey Blackwell, Iowa, USA.
- Research and Review Papers in Current Journals.

VMD-607 Advances in Neurological and Musculoskeletal System Diseases of Canine and Feline (1+0)

Suggested Books

- *Handbook of Veterinary Neurology*. 2011. MD Lorenz, JR Coates and Marc Kent 5th Edition. Elsevier Saunders
- *Textbook of Veterinary Internal Medicine: Diseases of the Dog and Cat*. 2010. Stephen J. Ettinger and Edward C. Feldman, Elsevier Saunders 7th Edition.
- *Veterinary Clinics of North America: Small Animal Practice*, Elsevier, Monthly
- Research and Review Papers in Current Journals.

VMD 608: Canine and Feline Cardiopulmonary and Urinary System Diseases (1+0)

Suggested Books

- *Small Animal Internal Medicine*. 2013. Nelson RW and Couto, CG 5th edition, Elesvier Mosby, St. Louis Missouri
- *Text book of Veterinary Internal Medicine*. 2010. Ettinger and Feldman, 7th Edition, Saunders
- Research and Review Papers in Current Journals.

VMD 609: Dermatology and Endocrinology (1+0)

Suggested Books

- *Clinical Endocrinology of companion animals*. 2013. Ed. J Rand 1st Edition edt. by Jacquie Rand (Editor), Ellen Behrend (Editor), Danielle Gunn-Moore (Editor) and Michelle Campbell-Ward (Editor). Wiley-Blackwell.
- *Muller and Kirk's Small Animal Dermatology*. 2013. 8th Edition. Edited by WH Miller, CE Griffin and KL Campbell. Elsevier, St Louis, MO, USA,
- *Equine dermatology*. 2011. 2nd Edition edited by Danny W Scott and William H. Miller, Jr 2nd edition. Elsevier, St Louis, MO, USA.
- Research and Review Papers in Current Journals.

VMD 610: Canine and Feline Eye and Ear Diseases (1+0)

Suggested Books

- *Veterinary Opthalmology*. 2013. Kirk N Gellat, Brian C Gilger and Thomas J Kern, 5th edition.Wiley Blackwell,
- *Saunders Manual of Small Animal Practice*. 2016. SJ Birchard and RG Sherding, WB Saunders Company
- Research and Review Papers in Current Journals.

VMD 611: Veterinary Diagnostics (0+2)

Suggested Books

- *Large Animal Internal Medicine*. 2019. Bradford Smith, David Van Metre and Nicola Pusterla, 6th Edition, Mosby
- *Small Animal Clinical Techniques*. 2010. Susan M Taylor, Saunders Elsevier
- Handbook of Veterinary Neurology. 2010. Michael D. Lorenz, Joan R. Coates and Marc Kent, 5th Edition, Saunders Elsevier.
- *Handbook of Equine Respiratory Endoscopy*. 2007. Safia Barakzai, 5th Edition, Saunders Elsevier.
- *Manual of Canine and Feline Cardiology*. 2008. Larry P Tilley, Francis WK Smith Jr., MA Oyama and MM Sleeper, 4th Edition, Saunders Elsevier.
- *Diagnostic Techniques in Equine Medicine: A Textbook for Students and Practitioners Describing Diagnostic Techniques Applicable to the Adult Horse*. 2009. Frank GR Taylor, Tim J Brazil and Mark H Hillyer, 2nd Edition, Saunders Elsevier.
- Research and Review Papers in Current Journals.

VMD 612: Metabolic and Nutritional Deficiency Diseases (2+0)

Suggested Books

- *Veterinary Medicine*. 2006. OM Radostits, CC Gay, KW Hinchcliff and PC Constable, 10th Edition, Saunders.
- *Large Animal Internal Medicine*. 2019. Bradford Smith, David Van Metre and Nicola Pusterla, 6th Edition, Mosby
- *Textbook of Preventive Veterinary Medicine and Epidemiology*. 2010. RD Sharma, M Kumar and MC Sharma, ICAR- New Delhi.
- *Textbook of Veterinary Internal Medicine Expert Consult*. 2016. SJ Ettinger, EC Feldman and E Cote, 8th Edition, Saunders-Elsevier
- Research and Review Papers in Current Journals.

VMD 613: Emergency and Critical Care Medicine (1+1)

Suggested Books

- *Kirk and Bistner's Handbook of Veterinary Procedures and Emergency Treatment*. 2012.

Richard B Ford and Elisa Mazaferro, 9th Edition, Saunders Elsevier.

- *Blackwell's Five Minute Veterinary Consult Clinical Companion, Small Animal Emergency and Critical Care*. 2010. Mazzaferro ME. 1st Edition, (Wiley Blackwell)
- *Equine Emergencies Treatment and Procedures*. 2008. Orsini JA and Divers TJ, 3rd Edition, Saunders Elsevier.
- Research and Review Papers in Current Journals.

VMD 614: Emerging and Re-emerging Animal Diseases (2+0)

Suggested Books

- *Veterinary Epidemiology*. 2018. Michael Thrusfield, Robert Christley. Wiley-Blackwell
- *Emerging Diseases of Animals*. 2000. Corrie Brown and Carole Bolin. ASM Press
- *Emerging and Re-emerging Infectious Diseases of Livestock*. 2017. Jagadeesh Bayry. Springer
- *Transboundary and Emerging Diseases of Animals*. 2016. Anna Rovid Spickler, James A Roth, Gayle Brown and Jane Galyon. Center for Food Security and Public Health
- Research and Review Papers in Current Journals.

VMD 615: Prevention and Control of Infectious Diseases of Ruminants (2+0)

Suggested Books

- *Merck's Veterinary Manual K*. 2016. Susan E Aiello and Michael A Moses, 11th Edition, Merck Sharp and Dohme
- *Veterinary Medicine*. 2016. Peter Constable, Kenneth W Hinchcliff, Stanley Done and Walter Gruenberg, 11th Edition. Saunders Ltd.
- *Dairy Herd Health*. 2012. MJ Green and Andrew J Bradley. CABI Publishing
- Research and Review Papers in Current Journals.

Minor Courses for Ph.D. Degree programme

Courses of any one department/ discipline from the list given below:

- Veterinary Physiology
- Veterinary Microbiology
- Veterinary Parasitology
- Veterinary Pharmacology and Toxicology
- Veterinary Surgery and Radiology
- Veterinary Public Health and Epidemiology

Restructured and Revised
Syllabi of Post-graduate Programmes
Vol. 3

Veterinary Para-Clinical Subjects

– Veterinary Microbiology
– Veterinary Pathology
– Veterinary Parasitology
– Veterinary Public Health and Epidemiology
– Veterinary Pharmacology and Toxicology

Contents

Acknowledgements

The Chairperson and Convener of BSMA for Veterinary Paraclinical disciplines, eXpress their sincere thanks and gratitude to all the committee members, eXperts and other stake holders for their direct and indirect contribution in formulation and revision of course curriculum and syllabi. The permission, logistic support and local hospitality provided by the administration of ICAR – Indian Veterinary Research Institute, Izatnagar, CoVAS, CSK HPKV, Palampur, Himachal Pradesh and SKUAST, JAMMU, J&K is duly acknowledged. The BSMA committee also eXpress their deepest sense of gratitude to the Education Division, Indian Council of Agricultural Research (ICAR), New Delhi for giving the opportunity to revise and update the syllabus.

Minimum Credit requirements:

Subject	Master's Programme	Doctoral Programme
i. Course work		
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	–
ii. **Seminar**	01	02
iii. **Thesis/ Research**	30	75
Total	**70**	**100**

Major courses

From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken is given *mark

Minor courses

From the subjects closely related to a student's major subject.

Supporting courses

The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of EXperiments, etc.) or necessary for building his/ her overall competence.

Common Courses

For Master's degree programme.

Course Code	Course Title	Credits
PGS 501	Library and Information Services	0+1
PGS 502	Technical writing and communication skills	0+1

Course Code	Course Title	Credit Hours
PGS 504	Basic concepts in laboratory techniques	0+1
PGS 505	Agricultural research, research ethics and rural development programmes	1+0

*A student shall be required to register for all the 5 credit hours core courses

*Mandatory Course for Doctoral Degree Programme.

CPE-RPE	Research and Publication Ethics	2+0

Veterinary Microbiology (VMC)

Masters Degree Programme

- VMC 501 : General Bacteriology (2+1), course name changed (Bacteriology – I) credit hour decreased and course contents updated.
- VMC 502 : Systematic Veterinary Bacteriology (2+1), course name changed (Bacteriology – II) with change in course contents.
- VMC 503 : General Virology (2+1), course number changed
- VMC 504 : Systematic Veterinary Virology (2+1), course number changed, 01 credit hour decreased with changes in course contents.
- VMC 505 : Principles of Veterinary Immunology (2+1), course number and name changed with changes in course contents.
- VMC 506 : Veterinary Mycology (1+1), course number and contents changed.
- VMC 507 : Vaccinology (2+0), course contents revised and updated.
- VMC 508 : Techniques In Microbiology (0+2), New course.
- VMC 509 : Techniques In Molecular Microbiology (1+2), New course.
- VMC 510 : Molecular Immunology (1+1), New course.
- VMC 511 : Mucosal Immunology (1+0), New course.
- VMC 512 : Introduction to Microbial Bioinformatics (1+0), New course

Doctoral Degree Programme

- VMC 601 : Advances in Veterinary Bacteriology (2+1), course contents revised and updated.
- VMC 602 : Advances in Veterinary Mycology (2+1), course contents revised and updated.
- VMC 603 : Bacterial Genetics (2+0), 01 credit hour (P) decreased with change in course contents.
- VMC 604 : Microbial Toxins (2+1), course contents revised and updated.
- VMC 605 : Bacterial Pathogenesis (2+0), course name changed (Molecular determinants of Bacterial Pathogenesis), 01 credit hour (P) decreased.
- VMC 606 : Advances in Veterinary Virology (2+1), course name changed (Advances in Virology), change in course contents.
- VMC 607 : Molecular Viral Pathogenesis (2+1), course name changed (Molecular and Genetic aspects of Viral Pathogenesis), change in course contents.
- VMC 608 : Structure Function Relationship of DNA and RNA Viruses (2+0), 01 credit hour (T) decreased.
- VMC 610 : Slow Viral Infections and Prions (1+0), 01 credit hour (T) decreased.
- VMC 611 : Advances in Veterinary Immunology (2+1), course name changed (Molecular Immunology), changes in course contents.
- VMC 612 : Cytokines and Chemokines (2+ 0), New course
- VMC 613 : Immunoregulation (1+0), New course
- VMC 614 : Advances in Vaccinology (2+0), Course contents revised and updated.

- VMC 615 : Current Topics in Infection and Immunity (2+0), 01 credit hour (T) decreased.

Veterinary Pathology (VPL)

Masters Degree Programme

- VPL 503 : Animal Oncology (1+1), course contents revised and updated.
- VPL 505 : Necropsy Procedures and Interpretations (1+1), 02 courses VPL (VPL – 605, 606) have been merged and course contents revised.
- VPL 506 : Necropsy Conference (0+1), New Course
- VPL 508 : Pathology of Infectious Diseases of Domestic Animals (2+1), course contents updated.
- VPL 509 : Toxicopathology (2+1), course contents revised.
- VPL 510 : Avian Pathology (2+1), course contents updated.
- VPL 511 : Pathology of Wild/ Zoo and Aquatic Animal Diseases (2+1), course reframed, Wild/ Zoo/ Fish diseases included.
- VPL 512 : Pathology of Laboratory Animal Diseases (2+1). New course

Doctoral Degree Programme

- VPL 601 : Molecular and Ultrastructural Basis of Cell Injury (2+1), New course with the merging of contents of molecular pathology of cell injury.
- VPL 602 : Molecular Basis of Inflammation (1+1), New course
- VPL 603 : Molecular Basis of Neoplasia (1+1), New course
- VPL 605 : Advances in Diagnostic Pathology (1+2), course contents revised and updated.
- VPL 607 : Pathology of Important Emerging and Re-emerging Diseases of Pets and Livestock (2+1). Course contents revised and updated.
- VPL 608 : Research Methodology in Pathology (1+0), New course

Veterinary Parasitology (VPA)

Masters Degree Programme

- VPA 501 : Platyhelminthes – I (1+1), Name and contents of old VPA-601 (2+1) changed.
- VPA 502 : Platyhelminthes – II (1+1), Name and contents of old VPA-601 (2+1) changed.
- VPA 503 : Nematyhelminthes and Acanthocephala (2+1), Name of old VPA 602 changed.
- VPA 504 : Arthropod Parasites (2+1), Name and contents of old VPA 603 revised and updated.
- VPA 505 : Parasitic Protozoa (2+1), old VPA 604, course contents revised and updated.
- VPA 506 : Diagnostic Parasitology (0+2), Name and contents of old VPA 605 changed and updated.
- VPA 507 : Clinical Parasitology (1+1), Name and contents of old VPA 606 changed.
- VPA 508 : Management of Parasitic Diseases (1+1), old VPA 607 with revised and updated contents.
- VPA 509 : Immunoparasitology (2+1), old VPA 608 with revised and updated course contents.
- VPA 510 : Parasitic Zoonoses (2+0), old VPA 609.
- VPA 511 : Parasites of Wildlife (1+1), old VPA 610 with change in course title.

Doctoral Degree Programme

- VPA 601 : Advances In Helminthology – I (2+1), old VPA 705 with revised and updated contents.
- VPA 602 : Advances In Helminthology – II (2+1), old VPA 706 with revised and updated contents.
- VPA 603 : Advances in Entomology and Acarology (2+1), old VPA 707 with revised and updated contents.
- VPA 604 : Advances in Protozoology (2+1), course contents revised and updated.
- VPA 605 : Immunology of Parasitic Diseases (1+2), New course.
- VPA 606 : Molecular Diagnostics and Vaccine Development in Parasitology (2+1), old VPA 702 with revised and updated course contents.
- VPA 607 : Host Parasite Interactions (2+0), old VPA 703 with revised and updated course contents.
- VPA 608 : *In-vitro* cultivation of parasites (1+2), New Course.
- VPA 609 : Emerging and Re-emerging Parasitic Diseases (2+0), No change.
- VPA 610 : Biology and Ecology of Parasites (3+0), New course including old VPA 701, 710 and 711 with revised and updated course contents.
- VPA 611 : Molecular Veterinary Parasitology (2+0), New course.
- VPA 612 : Parasite Epidemiology (2+0), New course.

Veterinary Public Health and Epidemiology (VPE)

Masters Degree Programme

- VPE 501 : Concepts in Veterinary Public Health and One Health (2+0), title modified with updated contents.
- VPE 502 : Zoonoses – I (2+1), title modified with updated contents.
- VPE 503 : Zoonoses – II (2+1), title modified with updated contents.
- VPE 504 : Principles of Epidemiology (2+1), New course.
- VPE 505 : Hygiene and Safety of Foods of Animal and Aquatic Origin (2+1), two courses merged (milk and meat hygiene, Fish/ Fish product).
- VPE 506 : Food-borne Infections and Intoxications (2+1), course contents revised and updated.
- VPE 507 : Food Safety Standards, and Regulations (2+1), New course.
- VPE 508 : Environmental Hygiene and Safety (2+1), title modified with updated contents. 01 credit hour reduced.
- VPE 509 : Applied Epidemiology (2+1). New course.
- VPE 510 : Bio-security, Bioterrorism and Disaster Management (2+0), title modified with updated contents.
- VPE 511 : Laboratory Techniques in Veterinary Public Health (0+3), New course.

Doctoral Degree Programme

- VPE 601 : Advances in Veterinary Public Health and Epidemiology (2+1), course contents revised and updated.
- VPE 602 : Emerging, Re-emerging Zoonoses and One Health (2+1), course contents revised and updated.
- VPE 603 : Advances in Food Safety and Quality Control of Foods of Animal Aquatic origin (2+1), course contents revised and updated.
- VPE 604 : Bio-security and Occupational Health Safety (2+1), course contents revised and updated.
- VPE 605 : Recent Concepts in Epidemiology and Disease Forecasting (2+1), New course.
- VPE 606 : Risk Analysis and Predictive Modelling (2+1), New course.
- VPE 607 : Advances in Environmental Hygiene (2+1), course contents revised

and updated.

- VPE 608 : Herd Health Management and Disease Economics (2+1), New course.
- VPE 609 : Epidemiology of Trans-boundary, Non-infectious and Chronic diseases (2+1), New course.
- VPE 610 : Ecology and Animal/ Human Health (2+0), New course.
- VPE 611 : Diagnostic Approaches in Epidemiology (2+1), New course.
- VPE 612 : Surveys, Surveillance and Data Management (2+1), New course.

Veterinary Pharmacology and Toxicology (VPT):

Masters Degree Programme

- VPT 501 : Concept of Pharmacology, Drug, Design and Development (2+0), course title changed with revised and updated course contents of General Pharmacology.
- VPT 504 : Digestive and Respiratory Pharmacology (2+1), one practical credit hour added.
- VPT 506 : Endocrine and Reproductive Pharmacology (2+1), one practical credit hour added.
- VPT 509 : Toxinology (2+1), course title changed and 01 practical credit hour added (Toxicology of plant and Toxins).
- VPT 510 : Pharmacological Technique (0+2), one theory credit hour converted to practical.
- VPT 511 : Techniques in Toxicology (0+2), one theory credit hour converted to practical.
- VPT 512 : Ethnopharmacology (1+1), one theory credit hour converted to practical.
- VPT 513 : Fundamental of Pharmacokinetics (1+1), New Course

Doctoral Degree Programme

- VPT 601 : Molecular Pharmacology (3+0), course contents of Advances in Neuropharmacology and Molecular Pharmacology merged.
- VPT 602 : Advances in Autacoid Pharmacology (1+0), course title changed.
- VPT 604 : Biotransformation of Xenobiotics (2+0), course title changed (Drug metabolism).
- VPT 605 : Clinical Pharmacology and Pharmacokinetics (2+1), clinical pharmacology and Pharmacokinetics have been merged.
- VPT 606 : Pharmacogenomics (2+0), course number changed with revised and updated course contents.
- VPT 607 : Immunopharmacology and Immunotoxicology (2+0), course number changed and 01 theory credit hour increased and course title changed to include immunotoxicology.
- VPT 608 : Molecular toxicology (3+0), course number changed and 01 theory credit hour increased.
- VPT 609 : Clinical Toxicology (2+1), course number and course title changed (Clinical Toxicology).
- VPT 610 : Ecotoxicology (3+0), course number changed and 01 theory credit hour increased.
- VPT 611 : Regulatory Toxicology (2+1), course number changed.

Suggested list of specified minor and supporting subjects

Veterinary Microbiology (VMC): Animal/ Veterinary Biotechnology, Veterinary Biochemistry, Veterinary Pathology, Veterinary Public Health and Epidemiology, Animal Genetics or any other discipline as per the requirement of the research problem of the

student.

Veterinary Pathology (VPL): Veterinary Microbiology, Animal/ Veterinary Biotechnology, Veterinary Biochemistry, Veterinary Medicine, Veterinary Parasitology, Veterinary Public Health and Epidemiology, Veterinary Pharmacology and Toxicology or any other discipline as per the requirement of the research problem of the student.

Veterinary Parasitology (VPA): Veterinary Microbiology, Animal/ Veterinary Biotechnology, Veterinary Biochemistry, Veterinary Medicine, Veterinary Pathology, Veterinary Public Health and Epidemiology, Veterinary Pharmacology and Toxicology or any other discipline as per the requirement of the research problem of the student.

Veterinary Public Health and Epidemiology (VPE): Veterinary Microbiology, Animal/ Veterinary Biotechnology, Veterinary Medicine, Veterinary Parasitology, Veterinary Pathology, Veterinary Pharmacology and Toxicology, Statistics or any other discipline as per the requirement of the research problem of the student.

Veterinary Pharmacology and Toxicology (VPT): Veterinary Biochemistry; Animal/ Veterinary Biotechnology; Veterinary Physiology; Veterinary Microbiology; Veterinary Pathology; Veterinary Medicine; Veterinary Public Health and Epidemiology or any other discipline as per the requirement of the research problem of the student.

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Vol. 3

Veterinary Para-Clinical Subjects

– Veterinary Microbiology

Course Title with Credit Load
M.V.Sc. in Veterinary Microbiology

Course Code	Course Title	Credit Hours
VMC 501	General Bacteriology*	2+1
VMC 502	Systematic Veterinary Bacteriology	2+1
VMC 503	General Virology*	2+1
VMC 504	Systematic Veterinary Virology	2+1
VMC 505	Principles of Veterinary Immunology*	2+1
VMC 506	Veterinary Mycology*	1+1
VMC 507	Vaccinology	2+0
VMC 508	Techniques in Microbiology	0+2
VMC 509	Techniques in Molecular Microbiology	1+2
VMC 510	Molecular Immunology	1+1
VMC 511	Mucosal Immunology	1+0
VMC 512	Introduction to Microbial Bio-informatics	1+0
VMC 591	Master's Seminar*	1+0
VMC 599	Master's Research	0+30

*Core Courses

Course Contents
M.V.Sc. in Veterinary Microbiology

I. Course Title : General Bacteriology
II. Course Code : VMC 501
III. Credit Hours : 2+1

IV. Theory

Unit I

Historical events of microbiology, Taxonomy and nomenclature of bacteria. Basic principles of microscopy and micrometry, Classical, Confocal, Nomaraski and electron microscopy. Staining of bacteria, Structure and function of bacterial cell. Growth, Nutrition, Metabolism, excretion systems of bacteria. General Secretion and principles of bacterial disease diagnosis.

Unit II

Bacterial genetics, Bacterial variation, Horizontal genetic transfer mechanisms (transformation, transduction and conjugation), Plasmids, Transposons and drug resistance.

Unit III

Determinants of pathogenicity and its molecular basis, Markers and PAMPs, exotoxin and endotoxin.
Bacteriophages: temperate and virulent phages; lysogeny and lysogenic conversion. Antimicrobial agents and disinfectants: Mechanism of action, Resistance and susceptibility testing. Bacterial immunity.

V. Practical

Orientation to a bacteriology laboratory, Sterilization and disinfection techniques, Laboratory biosafety and biosecurity. Cultivation of aerobic, Microaerophilic and anaerobic bacteria, Isolation of bacteria in pure culture, Microscopy, Morphological characterization of bacteria, Different staining methods and biochemical tests for identification of bacteria, Determination of bacterial number and biomass and standard protocols for antibiotic sensitivity test and detection of MIC.

I. Course Title : Systematic Veterinary Bacteriology

II. Course Code : VMC 502

III. Credit Hours : 2+1

IV. Theory

Unit I

Systematic study of following groups of bacteria:

Spirochetes: *Leptospira*, *Brachyspira* and *Borrelia*.

Gram-negative

- Aerobic/ Microaerophillic, motile helical/ vibrioid: *Campylobacter;*
- Aerobic/ Microaerophillic rods/ cocci: *Bordetella*, *Brucella*, *Morexella*, *Pseudomonas* and *Burkholderia;*
- Facultative anaerobic Gram-negative rods: members of *Enterobacteriaceae*, *Pasteurella*, *Mannheimia* and *Haemophilus;*
- Anaerobic, straight, curved and helical rods: *Dichelobacter* and*Fusobacterium*

Unit II

Rickettsia and Chlamydia: *Rickettsia*, *Chlamydia* (*Chlamydophila*) and *Coxiella*.

Gram-positive

- Gram-positive cocci: *Staphylococcus* and *Streptococcus* including *Enterococcus*.
- Endospore-forming rods: *Bacillus*and *Clostridium*.
- Regular non-spore forming rods: *Erysipelothrixa* and *Listeria*
- Irregular non-spore forming rods: *Actinomyces, Corynebacterium* and *Truepurella*.

Unit III

- Mycobacteria: Mycobacterium; *Actinomycetes*: *Nocardia* and *Rhodococcus*, *Dermatophilus*.
- Mollicutes: *Mycoplasma*.

Unit IV

- Emerging and transboundary bacterial pathogens.

V. Practical

Collection, transport and dispatch of clinical samples from various disease conditions. Isolation of bacteria in pure cultures from different clinical samples. Identification of the bacteria using staining, biochemical tests and other molecular techniques. Preservation and storage of bacterial cultures.

I. Course Title : General Virology

II. Course Code : VMC 503

III. Credit Hours : 2+1

IV. Theory

Unit I

History of virology, Origin and nature of viruses, Morphological structure and chemical composition of viruses, Nomenclature and classification of viruses, Cultivation and purification of viruses, Laboratory diagnosis of viral infections, Viroid and Prions.

Unit II

Replication of DNA and RNA viruses, genetic and non-genetic interactions between viruses.

Unit III

Virus-cell interactions, viral pathogenesis, viral persistence, oncogenic, oncolytic viruses and epidemiology of viral infections.

Unit IV

Immune response to viruses, viral vaccines, viral chemotherapy.

V. Practical

Orientation to a virology laboratory, Preparation of glassware, Plasticware, Media and reagents for cell culture and other items required for virus cultivation. Protocols for primary and secondary cell cultures, Maintenance of cell lines, Cryopreservation of cells and their revival. Staining of virus infected cultured cells and demonstration of inclusion bodies. Viable cell counting. Cultivation of viruses in embryonated chicken eggs and cell cultures.

I. Course Title : Systematic Veterinary Virology

II. Course Code : VMC 504

III. Credit Hours : 2+1

IV. Theory

Unit I: Double and Single stranded DNA virus families

Poxviridae, Asfarviridae, Herpesviridae, Adenoviridae, Papilomaviridae, Polyomaviridae, Parvoviride, Circoviridae and *Hepdnaviridae*.

Unit II: Single stranded Negative sense and Double stranded RNA viruses

Orthomyxoviridae, Paramyxoviridae, *Rhabdoviridae*, *Bornaviridae*, *Reoviridae* and *Birnaviridae*.

Unit III: Single stranded Positive sense RNA viruses

Picornaviridae, Caliciviridae, Togaviridae, Flaviviridae, Coronaviridae, Arteriviridae, Astroviridae and *Retroviridae*.

Unit IV: Prions

BSE, Scrapie and introduction to viriods.

Unit V

Emerging, re-emerging and transboundary viral pathogens

V. Practical

Collection, Preservation, Transportation of clinical samples and their processing for virus isolation and identification. Isolation and cultivation of viruses from clinical samples, using different methods and its plaque purification. Titration of viruses for 50% end points using different methods, Serum neutralization test. Electropherotyping. Concentration and purification of viruses by chemical agents, differential centrifugation, density gradient centrifugation and ultra-filtration. Methods for preservation of animal viruses.

I. Course Title : Principles of Veterinary Immunology

II. Course Code : VMC 505

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction to livestock and poultry immune system: ontogeny and phylogeny of vertebrate immune system, cells and organs of immune system. Types of immunity: Innate and adaptive immune system.

Unit II: Antigen and its characteristics

Characteristic of ideal antigen; Classification of antigens, Factors affecting immunogenicity, Concept of hapten and carrier. Antigenic determinant/ epitope and cross reactivity. B-cell epitope and T cell epitope. Immunoglobulins: Basic structure and function of immunoglobulins, Immunoglobulin diversity and immunoglobulin classes.

Antigen recognition by B cell and T cell: B cell receptor, T cell receptor, receptor diversity, B cell and T cell activation.

Unit III: Major Histocompatibility Complex

General feature, structure, function, gene organization, MHC and immune response. Immune-response development: Phases of humoral and cell mediated immune response. Immunoregulation with B and T cells: Antigen recognition, antigen presentation and processing, antigen recognition by TCR, MHC restriction, Cytokines and chemokines. Cell mediated immune response: General properties of effector T cells, cytotoxic T cells, NK-cells and ADCC. Role of integrin and selectin.

Unit IV: Complement System

Basic concept of complement, mechanism of complement activation, complement pathways and Complement deficiencies. Autoimmunity and autoimmune diseases, immunological tolerance and hypersensitivity: classification, mechanism of induction with examples.

Immunodeficiency: Types with examples. Immune response in foetus and new born.

Unit V: Antigen antibody interaction

Antibody affinity, avidity, cross reactivity, precipitation and agglutination test, radio-immunoprecipitation assay (RIPA), ELISA, Western blotting, Immunodiagnostics and Immunotherapy. Monoclonal antibodies and methods for production and characterization of monoclonal antibodies.

V. Practical

Preparation of antigens, raising of antisera against soluble and insoluble antigens. Detection of antibody by gel diffusion, radial immunodiffusion, immune-electrophoresis techniques. Haemagglutination and haemagglutination inhibition test, ELISA and its modifications. Immunoblotting. Agglutination tests. Separation and purification of Immunoglobulin from serum. Separation of mononuclear cells from blood by density gradient centrifugation, viable count of lymphocyte by dye exclusion method. Measurement of T cell response (DTH, lymphoproliferative assay).

I. Course Title : Veterinary Mycology

II. Course Code : VMC 506

III. Credit Hours : 1+1

IV. Theory

Unit I

History of mycology, Glossary of mycological terms; Morphology of fungi: structure and ultra-structure, differentiation, nutrition, physiology, reproduction, spores, cultural characters and classification of fungi of veterinary importance. Fungal immunity. Antifungal agents and important techniques in diagnosis of fungal infections.

Unit II: Systematic study of animal mycoses:

Aspergillosis, Candidiasis, Cryptococcosis, Epizootic lymphangitis, Rhinosporodiosis, Zygomycosis, Blastomycosis, Sporotrichosis, Histoplasmosis, Coccidioidomycosis, Mycetomas, Dermatophytoses, Dermatomycosis, Mycotoxicosis, Malassezia infections, Mycotic abortion, Mycotic mastitis, and Emerging mycoses.

V. Practical

Collection and processing of clinical material for isolation of fungi. Microscopy of fungi: Lactophenol cotton blue and India ink preparations. Preparation of basal and special fungal media of veterinary importance. Slide culture and cellophane tape technique for fungi. Diagnosis of dermatophytes. Biosafety precautions in handling yeast and dimorphic fungi. Study of gross and microscopic characters of pathogenic fungi, antifungal sensitivity testing, detection of mycotoxin. Serological and molecular diagnosis in fungi.

I. Course Title : Vaccinology

II. Course Code : VMC 507

III. Credit Hours : 2+0

Unit I

Types of vaccines andvaccine components, factors influencing choice of vaccines. **New generation vaccines:** subunit vaccines, peptide vaccines, recombinant vaccines, reverse genetics vaccines, Marker and DIVA enabled vaccines and transmission blocking vaccines.

Unit II: Preparation of vaccines

Identification of candidate strain, identification of epitopes, seed and challenge strain maintenance. Classical methods of eXaltation and attenuation of pathogens and their molecular basis. Technology of production of different types of vaccines.Multicomponent vaccines. Recent advances in vaccine delivery systems. Advances in vaccinesadjuvants with their classification and mode of action.

Unit III

Standardization of veterinary vaccines as per National and Global standards. Laws and regulatory requirements about veterinary biological and Indian pharmacopoeia.

Unit IV

Vaccine failure and post vaccinal reactions. Factors affecting response to vaccines: maintenance of vaccines and cold chain. Quality control. Principles of development of vaccination schedule, methods of conducting vaccine trials (lab to field use) and pharmaco-vigilance. Scaling up methods of vaccine production.

I. Course Title : Techniques in Microbiology

II. Course Code : VMC 508

III. Credit Hours : 0+2

(Course to be offered to the students not majoring in Veterinary Microbiology)

IV. Practic

alUnit I

Orientation to a microbiology laboratory. Different sterilization and disinfection techniques. Laboratory biosafety and biosecurity. Microscopy, media preparation, isolation, cultivation and purification of bacteria and fungi and their morphological and biochemical characterization. Antibacterial sensitivity test by Disc diffusion, broth dilution and MIC determination technique.

Unit II

Cultivation of viruses in embryonated eggs and cell culture. Virus Neutralization test.

Unit III

Different immunological techniques: Agglutination, precipitation, ELISA, Haemagglutination and HaemagglutinationInhibition and other immunological assays.

I. Course Title : **Techniques in Molecular Microbiology**

II. Course Code : **VMC 509**

III. Credit Hours : **1+2**

IV. Theory

Unit I

Basic requirements for establishing molecular diagnostics Laboratory. Principles of molecular diagnostic tests. Methods of nucleic acid extraction from pathogenic microorganisms.

Unit II

PCR, and variants of PCR. Principles of primer designing. Gel electrophoresis methods andblotting techniques: Southern blotting, northern blotting, western blotting, dot-blot. Microarrays, nucleic acid sequencing methods. Sequence analysis-sequence editing, sequence alignment, sequence comparison and phylogentic analysis. Gene cloning and expression. Molecular diagnosis as epidemiological tool.Development and validation of diagnostic tests.

V. Practical

Unit I

Orientation of molecular diagnosis laboratory: especially RNA and diagnostic PCR laboratory (handling RNA and DNA). Extraction of nucleic acid from different microbes: Gram positive bacteria, Gram negative bacteria, DNA viruses, RNA Viruses and fungi, DNA and RNA isolation from cell culture and blood and isolation of plasmids. Quality and quantity check of nucleic acids.

Unit II

Principles for Primer designing. Procedure for molecular diagnostic tests like PCR, RT-PCR and LAMP. Absolute and relative quantitation of DNA/ RNA using Q-PCR. SDS PAGE of proteins and RNA, study of nucleic acid and proteins by blotting techniques. Restriction Enzyme digestion Techniques and RFLP; PCR product concentration and purification for sequencing. Nucleic acid sequence analysis. Gene Cloning, expression and purification of expression products. An introduction to high throughput sequencing and MALDI-TOF.

I. Course Title : Molecular Immunology

II. Course Code : VMC 510

III. Credit Hours : 1+1

IV. Theory

Unit I

Molecular Structure and function of PRRs. Ligands of PRRs, signal transduction through PRRs andinflammosome. Cytokines, Lymphocyte markers and CD nomenclature.

Unit II

Molecular structure of Immunoglobulin and class, Isotypes, Synthesis and expression of immunoglobulin, Rearrangement and its organization, Immunoglobulin gene diversity and mechanism of recombination of B cell gene. Theory of antibody generation. Signature molecules of T cell and T regulatory cell. T cell receptor and T cell gene diversity.

Unit III

MHC structure, Genomic organization of the MHC gene haplotype. Concept of congenic and syngeneic, concept of polymorphism of MHC gene, pathway of signal transduction, role of co-stimulators in B cell and T cell activation and recruitment of adaptor proteins. Molecular mechanisms (events) of cell cytotoxicity.

V. Practical

Isolation and purification of mammalian and avian immunoglobulin by precipitation technique: Caprylic acid, PEG, Ammonium Sulphate, Sodium Sulphate. Separation of immunoglobulins by size, charge and ligand affinity: size exclusion chromatography (gel filteration on Sephadex G200), ion exchange chromatography, affinity chromatography (Protein-A-Sepharose). Immuno-electrophoresis Technique: polyacrylamide gel electrophoresis innative and reducing conditions, fixed andgradient gel, Western blot, Crossed immune-electrophoresis. Chemiluminscence assay and Cell cytotoxicity assays; Non-radioactive methods like LDH realease assay. Antigen detection by Immuno PCR. Haplotype matching between individuals, Flow cytometry for CD4 and CD8 ratio determination and other applications. ELISpot test for cytokine assay.

I. Course Title : Mucosal Immunology

II. Course Code : VMC 511

III. Credit Hours : 1+0

IV. Theory

Unit I: Innate Mechanisms

Mucosal barrier: Development and physiology of mucosal defense. Cells and lymphoid tissues of mucosal immune system: MALT, GALT, NALT and BALT. Innate immune response at mucosal surfaces: mucus, antimicrobial peptides, role of PPRs, intestinal Dendritic cell, intestinal macrophage, mucosal inductive and effector sites. Antigen uptake and presentation at mucosal sites, transepithelial transport of antigen.

Unit II: Acquired response

Mucosal Immunoglobulin, IgA synthesis and transport to intestinal lumen.Description and role of Paneth cell and crypto patches.M-cells and their functions.Mucosal immune effector mechanisms including secretory IgA response.
Extrathymic T cell development in mucosal tissues and their phenotypes and functions.

Unit III: Applications

Importance and limitations of mucosal immunization. Mucosal adjuvants and delivery systems. Oral tolerance mechanistic approach. Immunopathology at mucosal surfaces: Celiac disease, Inflammatory bowel disease, Jhone's disease; Assessment of mucosal immune response and potency testing.

I. Course Title : Introduction to Microbial Bioinformatics

II. Course Code : VMC 512

III. Credit Hours : 1+0

(Relevant practical demonstrations be given along with theory topic)

IV. Theory

Unit I

Introduction to Bioinformatics; History, Scope and Application, Internet and world wide web. Bioinformatics resources and information retrieval system. Nucleic acid sequence databases, Genome databases, Protein sequence databases, Metabolic pathways databases, NCBI, ExPASy and Ensembl Genome browser.

Unit II

Sequence comparison and alignment methods; Introduction to sequence alignment, principal methods of pairwise sequence alignment and Dot plot analysis. Significance of BLAST and FASTA programs in DNA and protein sequence analysis, variants of BLAST and FASTA programs. Introduction to multiple sequence alignment and Phylogenetic analysis to retrieve evolutionary information, Global multiple sequence alignment tool- CLUSTAL-W.

Unit III

Overview of protein structure and databases, Structure based protein classification, Protein structure database (CASP), Protein structure alignment tools (VAST, DALI), Protein 3-D structure visualization and modeling using SWISS PROT.

Course Title with Credit Load
Ph.D. in Veterinary Microbiology

Course Code	Course Title	Credit Hours
VMC 601	Advances in Veterinary Bacteriology*	2+1
VMC 602	Advances in Veterinary Mycology	2+1
VMC 603	Bacterial Genetics	2+0
VMC 604	Microbial Toxins	2+1
VMC 605	Bacterial Pathogenesis	2+0
VMC 606	Advances in Veterinary Virology*	2+1
VMC 607	Molecular Viral Pathogenesis	2+1
VMC 608	Structure Function Relationship of DNA and RNA Viruses	2+0
VMC 609	Oncogenic Viruses	2+0
VMC 610	Slow Viral Infections and Prions	1+0
VMC 611	Advances in Veterinary Immunology*	2+1
VMC 612	Cytokines and Chemokines	2+ 0
VMC 613	Immunoregulation	1+0
VMC 614	Advances in Vaccinology	2+0
VMC 615	Current topics in Infection and Immunity	2+0
VMC 616	Veterinary Microbial Biotechnology	2+1
VMC 690	Special Problem	0+1
VMC 691	Doctoral Seminar-I*	1+0
VMC 692	Doctoral Seminar-II*	1+0
VMC 699	Doctoral Research	0+75

* Core courses

Course Contents
Ph.D. in Veterinary Microbiology

I. Course Title : Advances in Veterinary Bacteriology
II. Course Code : VMC 601
III. Credit Hours : 2+1
IV. Theory

Unit I

Recent advances in bacterial taxonomy and phylogeny, advanced studies on cytology, molecular structure and function of bacterial cell surface, peptidoglycans, walls of Gram-positive and Gram-negative bacteria, Cell surface appendages: Flagella and Fimbriae. Role of bacteria cell envelope in pathogenicity and immunogenicity, Biochemical activities, Antigenic structure. Bacterial secretory and excretory system.

Unit II

Bacterial whole genome sequence analysis and its application.

V. Practical

Isolation of bacterial LPS, OMP, Peptidoglycans, Capsule, Flagellar antigen, genotyping, phage typing, serotyping of bacteria, studies on host pathogen interactions.

I. Course Title : Advances in Veterinary Mycology
II. Course Code : VMC 602
III. Credit Hours : 2+1
IV. Theory

Unit I

Advanced studies on taxonomy, Genetics, Physiology and Antigenic characterization of pathogenic fungi.

Unit II

Advanced studies on molecular approaches for identification of fungi; immunology and serology of mycoses, antifungal therapy, fungal vaccines, fungal viruses.

V. Practical

Morphological, Biochemical and Physiological studies of various fungi. *In vivo* pathogenicity study. Molecular detection and characterization of fungi.

I. Course Title : Bacterial Genetic

II. Course Code : VMC 603

III. Credit Hours : 2+0

IV. Theory

Unit I

Comparative studies of prokaryotic and eukaryotic genome and their replication; structure, classification and replication of plasmids.

Unit II

Bacterial variations: Phenotypic and genotypic variations, Mutations and mutagenesis, Types of bacterial mutants, Detection of mutants and genemapping. Mechanism of gene transfer: Transduction, Transformation and conjugation. Types and mechanism of recombination: Reciprocal, Non-reciprocal and illegitimate recombination's.

Unit III

Mobile genetic elements, molecular mechanism of antibiotic resistance, regulation of gene eXpression.

I. Course Title : Microbial Toxins

II. Course Code : VMC 604

III. Credit Hours : 2+1

IV. Theory

Unit I

Classification of bacterial and fungal toxin on the basis of their structure and functions. The role of microbial toxins in the pathogenesis of diseases; biochemical and biological characteristics of toxins. Toxin producing Grams-positive and Grams-negative bacteria. Properties and clinical conditions produced by different bacterial and fungal toxins. Analytical methods for detection of bacterial and fungal toxins: Biological assays, Immunological assays, Nucleic acid-based methods.

Unit II

Application of microbial toxins andimmunobiological studies of toxins.

V. Practical

Detection and identification of Mycotoxigenic fungi and mycotoxins. Method of detection of bacterial endotoxin, Production of toxins in suitable media, Purification and characterization of toxins, Biological characterization in animal and in tissue culture. Toxin neutralization test.

I. Course Title : Bacterial Pathogenesis

II. Course Code : VMC 605

III. Credit Hours : 2+0

IV. Theory

Unit I

Molecular structure, Production and mode of action of bacterial virulence factors, Bacterial biofilms and advance studies on pathogenesis of bacterial diseases of various systems.

Unit II

Host-pathogen interaction, Animal models for bacterial pathogens.

I. Course Title : Advances in Veterinary Virology

II. Course Code : VMC 606

III. Credit Hours : 2+1

IV. Theo

ryUnit

I

Biology of RNA and DNA virus replication. An introduction to bacteriophages and phage replication.

Unit II

Current concepts in animal virus research with respect to viral structure and architecture, viral virulence, viral pathogenesis, persistence and oncogenesis. Viruses as bio-terror agents and viruses for pest management (Bio-control).

Unit III

Antiviral drugs: Scope, Use and limitations, Existing antiviral drugs and their mechanism of action, Latest trends in antiviral drug development.

Unit IV

Preparation of plasmid backbone, Preparation of viral genes for cloning and cloning in viral genome backbone, Confirmation of cloned genes, Development of positive marker and negative markers, DIVA vaccine, Different types of viral vectors (vaccinia, adenoviral, retroviral vectors).

V. Practical

Characterization of viral proteins and genome. Problem oriented practical assignments aimed at development of bioreagents and relevant diagnostic tests.

I. Course Title : Molecular Viral Pathogenesis
II. Course Code : VMC 607
III. Credit Hours : 2+1

IV. Theory

Unit I

Study of virus host interactions: Host specificity, Tissue tropism, Mechanism of virus spread in the body.

Unit II

Host immune responses to viral infections; Viral strategies to evade host immune responses. Viral interference and interferons.

Unit III

Pathogenesis of viral diseases of various systems, animal models for studying viral pathogenesis, molecular and genetic determinants of viral virulence, mechanisms of viral virulence.

Unit IV

Molecular and genetic determinants of viral persistence, viral oncogenesis, viral immunosuppression, and immunopathology.

V. Practical

Pathotyping of animal viruses using Newcastle disease virus as model, Determination of immunosuppressive potential of animal viruses using infectious bursal disease virus/ Marek's disease virus/ chicken anaemia virus, Characterization of molecular determinants of viral virulence using variants, Recombinants and reassortants.

I. Course Title : Structure Function Relationship of DNA and RNA Viruses
II. Course Code : VMC 608
III. Credit Hours : 2+0

IV. Aim of the course

To understand the relationship between structure and function of DNA and RNA viruses of animals for the development of next generation viral vaccine and antivirals.

V. Theory

Unit I

Methods of studying virus structure and architecture, Methods of amplification of viral nucleicacids, Molecular characterization of viral protein and nucleic acids, Nucleotide sequencing and its analysis by software programmes.

Unit II

Detailed study of virus replication in various groups of animal viruses.

Unit III

Understanding the relationship between structure and function of animal DNA and RNA viruses, Development of modern vaccines and antivirals using the relationship between structure and function of animal DNA and RNA viruses.

I. Course Title : Oncogenic Viruses

II. Course Code : VMC 609

III. Credit Hours : 2+0

IV. Theory

Unit I

General features of cell transformation and characterization of transformed cells. Oncogenic RNA and DNA viruses. Oncolytic viruses, viral and cellular oncogenes.

Unit II

Mechanisms of viral oncogenesis and diagnosis of viral oncogenesis**.**

I. Course Title : Slow Viral Infections and Prions

II. Course Code : VMC 610

III. Credit Hours : 1+0

IV. Theory

Unit I

Epidemiology, Pathogenesis, Diagnosis and control of slow viral infections.

Unit II

Properties, Replication and epidemiology of prions. Pathogenesis, immunity, Diagnosis and control of Scrapies, Bovine spongiform encephalopathy, Chronic wasting disease of dear, Transmissible mink encephalopathy. Recent trends in prion research.

I. Course Title : Advances in Veterinary Immunology

II. Course Code : VMC 611

III. Credit Hours : 2+1

IV. Theory

Unit I

Cells and tissues of immune system: Significance of HSC l, Origin of myeloid cells; Lymphoid cells (T and B cells), NK cells, NKT cell, Apoptosis and its role in homeostatic mechanism. Ontogeny of the lymphoid tissue in mammals and birds. Cell adhesion molecules, Recirculation and trafficking, Cell homing receptor. Antigen presenting cells and their functions at cellular level.

Unit II

Cytokines, chemokines and cytokine receptors.

Unit III

Developmental biology of Immune cells**:** Early development of T and B cells and its differentiation, Maturation in primary lymphoid organ. B cell development and T cell development. Lineage commitment, Memory generation. Organization of eXpression of lymphocyte receptors gene, Multigenic organization of immunoglobulin gene andthymic selection of T cell repertoire. Concept of eXtrathymic origin of T cells. Effector and memory T and B cells.

Unit IV

Recombination events in T and B cell: Mechanism of recombination of immunoglobulin genes and T cell receptor genes.

Unit V

Activation of T and B cells: Clonal eXpansion. Role of T cell help in B cell response, affinity maturation of B cells and class switching and T cell activation.

Unit VI

MHC**:** MHC class-I and II structure and gene arrangement, polymorphism, antigen processing and presentation mechanism.

Unit VII

Antibody mediated and cell mediated effector functions. Cellular immune response: Effector mechanisms of CTL, NK cells and NK T cell activation. Regulation of immune response. Role of T reg-cells, immunological tolerance and graft rejection.

V. Practical

Purification of immunoglobulin classes, Subclasses, Fragmentation of antibody by enzyme digestion to F (ab)2 and Fc fragments, Affinity chromatography techniques. Separation of protein by SDS PAGE under reducing condition.Western blot eXperiment to detect the immunogenic protein, ELISPOT, cytotoXic T cell assay, morphological and functional assays of blood monocytes. FACS and MACS.

I. Course Title : Cytokines and Chemokines

II. Course Code : VMC 612

III. Credit Hours : 2+0

IV. Theory

Unit I

Properties of cytokines. General structure and function of classification of cytokines family's, Cytokine secretion by Th1 and Th2 subsets. Cytokines cross regulation. Cytokine receptors:general structure of cytokine receptors, Immunoglobulin superfamily receptors, class 1 and class 2 cytokine receptor families. TNF receptor families and cytokine antagonists.

Unit II

Cytokine related diseases. Therapeutic uses of cytokines and their receptors. Chemokines: subgroups of chemokines and their structures and functions, chemokine receptor families.

Unit III

Immunomodulators: Types of immunomodulators and their mechanism of action. Adjuvants: classification, Mode of action, Adjuvants combination and safety. Cytokine as adjuvant, PLG and microparticle as adjuvant, TLR agonist as adjuvant. Antigen delivery system and mode of action. Immunostimulants: Bacterial product and synthetic Compound, Complex carbohydrates, Immune enhancing drugs, Vitamins and cytokines.

Unit IV

Immunosuppression, Neuroendocrine control of immunoregulation, Immuno-suppressive agents and drugs, Corticosteroids, Cyclosporin's, Cyclophosphamide and other agents, Like irradiation and the mode of action**.**

I. Course Title : Immunoregulation

II. Course Code : VMC 613

III. Credit Hours : 1+0

IV. Theory

Unit I

Molecular mediators of immune response: Lymphokines and monokines. Idiotypic networks. Epitope specific regulation. Th, Tc and Treg cells. MHC in immuno-regulation, Immune response genes. Antigen specific suppressor molecules produced by T cells. Immunosuppressive agents and immune-stimulation. Immunoregulatory pathways.

I. Course Title : Advances in Vaccinology

II. Course Code : VMC 614

III. Credit Hours : 2+0

IV. Aim of the course

To learn about advances in vaccine research and modern approaches for the vaccine development.

V. Theory

Unit I

Different phases in vaccine development. Direct and indirect correlates of protection. Antigen identification and characterization employing emerging technologies such as microarrays, *in vivo* eXpression technology, Signature-tagged mutagenesis and phage display technology.

Unit II

Immuno-informatics applied to epitope mapping, T cell epitopes and identification of pathogenic epitopes. Novel vaccines: nucleic acids, Marker vaccines, Mucosal vaccines, Bacterial ghosts as vaccines and virus-like particles. Futuristic vaccines: anti-allergic, Anti-autoimmune diseases, De-addiction vaccines and transplant survival/ prolonging vaccines.

I. Course Title : Current Topics in Infection and Immunity

II. Course Code : VMC 615

III. Credit Hours : 2+0

IV. Theory

Unit I

Introduction and historical developments. Host-pathogen relationship.

Unit II

Effector mechanisms of specific and non-specific immunity to different groups of microbes.

Unit III

Immunobiology of major viral, Bacterial and fungal diseases of animals. Types of vaccines for infectious diseases; Current trends in vaccine development.

I. Course Title : Veterinary Microbial Biotechnology

II. Course Code : VMC 616

III. Credit Hours : 2+1

IV. Theory

Unit I

History of microbial biotechnology. Microbes in nature.Microbes as infectious agents of human and animals. Host-microbe relationships. Microbial metabolism and growth characteristics. Microbial genetics.

Unit II

Introduction to molecular biology of microorganisms: DNA, RNA and proteins structure and functions. DNA replication, RNA transcription, reverse transcription, protein translation and regulatory mechanisms. Bacterial extrachromosomal DNA elements.

Unit III

Genetic engineering: Restriction enzymes, DNA ligases, DNA polymerases, RNases and DNases and other enzymes. DNA sequencing. Plasmids and phage-derived vectors, Bacterial hosts for cloning and expression of transgenes. Genomic libraries and sequencing. Blotting of DNA, RNA and proteins. Polymerase chain reaction. An introduction to Microarrays and Metagenomics.

Unit IV

Expression of antigens and antibody fragments useful as diagnostic reagents and vaccines. PCR and blotting techniques in infectious disease diagnosis. Nucleic acid vaccines. Vectored viral and bacterial vaccines. Construction of defined mutants and marker vaccines using genetic manipulation techniques.Manipulation of microbial processes for production of industrially useful substances.

V. Practical

Extraction of nucleic acids from viruses and bacteria. Restriction endonuclease digestion of DNA and resolution in agarose gel electrophoresis. PCR amplification of DNA. RT-PCR of RNA. Insertion of DNA fragments into plasmid/ phagemid/ phage vectors. Construction of competent *E. coli* host cells. Transformation and transfection of competent *E. coli* cells. Screening of transformants and isolation of clones. Sequence analysis of clones/ PCR amplicons. Expression of genes of bacterial/ viral antigens. Use of PCR for infectious disease diagnosis.

I. Course Title : Special Problem

II. Course Code : VMC 690

III. Credit Hours : 1+0

IV. Practical

Short research problem(s) involving contemporary issues and research techniques.

Suggested Reading

- AM Lesk. 2002. *Introduction to Bioinformatics*. Oxford University press.
- Abbas AH. Lichtman and S. Pillai. 2017. *Cellular and Molecular Immunology: Functions and Disorders of the Immune System*, 7th Ed., Elsevier.
- B Detrick and RG Hamilton and JH Schimitz. 2016. *Manual of Molecular and Clinical Laboratory Immunology*. 8th Ed. American Society for Microbiology.
- B Markey, F Leonard, M Archambault, A Cullinane and D Maguire. 2013. *Clinical Veterinary Microbiology* 2nd Ed. MOSBY- Elsevier.
- BD Singh. 2012. *Biotechnology: Expanding Horizons*, 4thEd.Kalyani Pub.
- C Hirsh, NJ MacLachlan and RL Walker. 2004. *Veterinary Microbiology*, 2ndEdn., Wiley-Blackwell Pub.
- CC Kibbler, R Barton, Neil AR Gow, S Howell, DM MacCallum and RJ Manuel. 2018. *Oxford Textbook of Medical Mycology*, 1st Ed., Oxford University Press.
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- GM Callahan and RM Yates. 2014. *Basic Veterinary Immunology*. 1stEdn., University Press of Colorado.
- JB Carter and VA Saunders. 2013. *Virology: Principles and Applications*, 2nd Ed., John Wiley and Sons Pub.
- J Glenn Songer and KW Post. 2004. *Veterinary Microbiology: Bacterial and Fungal Agents of Animal Diseases*. 1st Ed., Saunders Pub.
- J Punt, S Stranford, P Jones and J Owen. 2019. *Kuby Immunology*, 8th Ed., W.H. Freeman Pub.
- J Willey, K Sandman and D Wood. 2019. *Prescott's Microbiology*, 11thEdn., McGraw-Hill Education Pub.
- J Mestecky, W Strober, MW Russell, H Cheroutre, BN Lambrecht and BL Kelsall. 2015. *Mucosal Immunology* 4th Edn., Academic Press.
- JE Coligan, AM Kruisbeek, DH Margulies, EM Shevach and W Strober. 2003. *Current Protocols in Immunology*. 3rd Edn. John Wiley and Sons.
- L Gyles, JF Prescott, J Glenn Songer and CO Thoen. 2010. *Pathogenesis of Bacterial Infections in Animals*, 4thEdn., Wiley-Blackwell Pub.
- MJ Dey and RM Schultz. 2014. *Veterinary Immunology: Principles and Practice*, 2nd Edn., CRC Press/ Taylor and Francis.
- MM Levine, JB Kaper, R Rappuoli, MA Liu and MF Good. 2004. *New Generation Vaccines*. 3rd Ed. Marcel-Dekker.
- NJ Maclachlan and EJ Dubovi. 2016. *Fenner's Veterinary Virology*. 5thEdn., Academic Press.
- PJ Quinn, BK Markey, FC Leonard, P Hartigan, S Fanning and ES Fitzpatrick. 2011. *Veterinary Microbiology and Microbial Disease*, 2nd Ed., Wiley-Blackwell Pub.
- PJ Delves, SJ Martin, DR Burton and IM Roitt. 2017. *Roitt's Essential Immunology* 13th Edition, Wiley Blackwell.
- R Tizard. 2017. *Veterinary Immunology*, 10thEdn., Saunders Publ.

- S Giguère, JF Prescott and PM Dowling. 2013. *Antimicrobial Therapy in Veterinary Medicine*, 5th Ed., John Wiley and Sons, Inc.
- SJ Flint, V Racaniello, G Rall and A Skalka. 2015. *Principles of Virology*, 4th Edition (2 volume set). ASM press
- S Jameel and L Villarreal. 2000. *Advances in Animal Virology*. Science Pub.
- Samanta. 2015. *Veterinary Mycology*. Springer, India, Private Ltd Pub.
- WJW Morrow, NA Sheikh, CS Schmidt and D Huw Davies. 2012. *Vaccinology: Principles and Practice*1 edition Wiley-Blackwell.
- TA Brown. 2016. *Gene Cloning and DNA Analysis*. 7th Edition., Wiley Blackwell
- WJ Dodds and R Schulz. 1999. *Veterinary Vaccines and Diagnostics*. Vol. 41 (Advances in Veterinary Medicine) 1st Ed. Academic Press.
- For Ph.D. Courses: Selected articles and reviews from journals

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Veterinary Para-Clinical Subjects

– Veterinary Pathology

Course Title with Credit Load
M.V.Sc. in Veterinary Pathology

Course Code	Course Title	Credit Hours
VPL 501	General Pathology*	2+1
VPL 502	Techniques in Pathology*	0+2
VPL 503	Animal Oncology	1+1
VPL 504	Clinical Pathology*	1+1
VPL 505	Necropsy Procedures and Interpretations*	1+1
VPL 506	Necropsy Conference*	0+1
VPL 507	Systemic Pathology*	2+1
VPL 508	Pathology of Infectious Diseases of Domestic Animals*	2+1
VPL 509	Toxicopathology	2+1
VPL 510	Avian Pathology*	2+1
VPL 511	Pathology of Wild/ Zoo and Aquatic Animal Diseases	2+1
VPL 512	Pathology of Laboratory Animal Diseases	2+1
VPL 591	Master's Seminar*	1+0
VPL 599	Master's Research	30

*****Core Courses

Course Contents
M.V.Sc. in Veterinary Pathology

I. Course Title : General Pathology
II. Course Code : VPL 501
III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction and principles of Pathology including genetic basis of disease; Cellular responses to injury: Causes and mechanisms of reversible and irreversible cell injury; Morphologic characteristics, Significance and fate of various intracellular (lipids, glycogen, proteins) and extracellular (hyaline material, amyloid, fibrinoid change, gout) accumulations/ degenerations, Endogenous and exogenous pigmentations, Cell death (necrosis, apoptosis and gangrene), Pathologic calcifications and cellular adaptive changes.

Unit II

Inflammation and repair: Introduction to inflammation, Acute inflammation-cellular and molecular events including mediators and heat shock proteins of acute inflammation; Cellular components, Morphologic classification and outcomes of acute inflammation, Chronic inflammation-causes, Morphologic features and cellular components of chronic inflammation, Healing and repair, Systemic effects of inflammation.

Unit III

Disturbances in circulation: Causes, mechanisms, Morphologic features, Significance and fate of hyperemia, Oedema, Haemorrhage, Thrombosis, Embolism, Ischaemia, infarction and shock.

Unit IV

Immune mediated reactions: Introduction to autoimmunity and immune mediated diseases, mechanisms of hypersensitivity reactions.

V. Practical

- To study the morphologic descriptions of lesions and nomenclature of a morphologic diagnosis based on gross and/ or microscopic lesions of variety of conditions (degenerations, infiltrations, pigmentations, necrosis, circulatory and growth disturbances and different types of inflammation) in the preserved specimens/ slides. Demonstration of post-mortem changes.
- Continuous assessment of students for their skills in the diagnosis of gross lesions during post-mortem examination of different tissues of domestic animals.
  Preparation of histopathology slides on the selected cases followed by interaction in the student seminars/ group discussions.

VI. Suggested Reading

- McGavin MD and Zachary JF. 2017. *Pathologic Basis of Veterinary Diseases*. 6th Ed. Elsevier.
- Vegad JL. 2007. *Text Book of Veterinary General Pathology*. 2nd Ed. International Book Distr.

I. Course Title : Techniques in Pathology

II. Course Code : VPL 502

III. Credit Hours : 0+2

IV. Practical

- Basic histopathological techniques-Collection of tissues, fixation, processing, section cutting and H and E staining of tissue sections. Collection and fixation of tissues for scanning electron microscopy, transmission electron microscopy, histochemical, toxicological, bacteriological and virological examinations. Application of micrometry and special staining techniques. Demonstration of different inclusions, bacteria and fungi in tissues.
- Principles of dark field, phase contrast and fluorescent microscopy; introduction to scanning electron microscopy and transmission electron microscopy.
- Histochemical techniques for demonstration of fat, glycogen, connective tissue, mucopolysaccharides and common enzymes, pigments and minerals Cryosectioning and application of immunohistochemical techniques–immunoperoxidase and immunofluorescence.
- Principles and applications of PCR and its variants.
- Museum specimen preparation and maintenance.

V. Suggested Reading

- Culling CFA. 1969. *Handbook of Histological Techniques*. Butterworths.
- Lillie RD. 1965. *Histopathologic Techniques and Practical Histo-chemistry*. 3rd Ed. McGraw-Hill.
- Culling CFA. 2013. *Handbook of Histopathological and Histochemical Techniques: Including Museum Techniques* PDF, eBook (http://mbooknom.men/go/best.php?id=B01DRY52U8)

I. Course Title : Animal Oncology

II. Course Code : VPL-503

III. Credit Hours : 1+1

IV. Theory

Unit I

Tumour-Etiology, Carcinogens and oncogenesis, Nomenclature and classification, characteristics of benign and malignant tumours, Molecular mechanisms, Pathways of spread of tumors and tumor immunology

Unit II

Effects of tumour, Grading, Staging and laboratory diagnosis of tumours. Animal tumour models–experimental induction of neoplasms

Unit III

Pathology of different types of epithelial and connective tissue tumours with their characteristic identification features and epidemiology. Commonly encountered tumours of respiratory, haemopoietic, integumentary, musculoskeletal, gastrointestinal, hepatobiliary, uro-genital, nervous, ocular, ear and endocrine system.

V. Practical

- Cytological diagnosis of tumours via impression smears and Fine Needle Aspiration Cytology.
- To study the gross and microscopic changes in different types of neoplasms.

VI. Suggested Reading

- Meuten DJ. 2016. *Tumors in Domestic Animals*. 5th Ed. Wiley-Blackwell

I. Course Title : Clinical Pathology

II. Course Code : VPL 504

III. Credit Hours : 1+1

IV. Theory

Unit I

Study of changes in blood/ plasma/ serum including biochemical profile for organ function tests, Cytological examination and examination of urine, Faeces, Cerebrospinal fluid and biopsy specimens and their interpretation.

V. Practical

Analysis of clinical samples (blood/ serum/ plasma, urine, faeces, Biopsy samples (exfoliative/ FNAC) including biochemical profile for organ function tests in different disease conditions in animals/ poultry and their interpretations.

VI. Suggested Reading

- Amy C. Valenciano, Rick L. Cowell. 2013. *Cowell and Tyler's Diagnostic Cytology and Hematology of the Dog and Cat*, 4th Ed, Elsevier
- Benzamin MM. 1985. *Outline of Veterinary Clinical Pathology*. 3rd Ed. Ludhiana, Kalyani Publishers.
- Coles EH. 1986. *Veterinary Clinical Pathology*. 4th Ed, WB Saunders.
- Douglas J., Weiss, K and Jane Wardrop. 2010. *Schalm's Veterinary Haematology*, Wiley.

I. Course Title : Necropsy Procedures and Interpretations

II. Course Code : VPL 505

III. Credit Hours : 1+1

IV. Theory

Unit I

General knowledge about the laws relating to veterinary practice, professional discipline and professional etiquettes.

Unit II

Regulations dealing with diseases of animals in India regarding epidemiology, quarantine certificate, issue of soundness certificate, etc.

Unit III

Different manners/ modes of death such as criminal assault, Cruelty to animals, malicious poisoning, Snake bite, Death due to drowning, Lightning strokes during thunderstorms; Veterolegal wounds like electrocution, Gunshot wounds, Automobile accidents, and violent death; Legal implications in animals in above conditions, doping in horses, etc.

V. Practical

- Detailed necropsy examination of various species of large and small animals including poultry, laboratory animals and wildlife**.** Systematic examination of brain, lungs, heart, endocrine glands, lymph nodes, liver, gastro-intestinal tract, urinary and genital systems for gross pathological and histopathological studies and correlation of the observations to diagnose the disease conditions.
- Necropsy case presentation and report writing/ protocol preparation. Collection, preservation and dispatch of morbid materials for diagnosis of viral, bacterial, protozoan, parasitic diseases, toxic/ poisoning and for histochemistry/ histopathology.

VI. Suggested Reading

- Albert C Strafuss.1988. *Necropsy: Procedures and Basic Diagnostic Methods for Practicing Veterinarians*, Charles C. Thomas Publisher Springfield
- Benjamin Lucio-Martinez and Jodi A Korich. 2010. *Illustrated guide to Poultry Necropsy and diagnosis*, Cornell University (https://www.slideshare.net/heshamkotb/illustrated-guide-to-poultry-necropsy-and-diagnosis)
- D Gopala Krishna Rao. 2005. *Textbook on necropsy and histopathological techniques*, 1st Ed. Academa
- Donald B Feldman and John Curtis Seely. 1988. *Necropsy Guide: Rodents and the Rabbit*, 1st Ed. CRC Press
- Gahlot AK, Sharma SN and Tanwar RA. 2003. *Veterinary Jurisprudence*. 5th Ed. NBS Publishers, Bikaner.
- John M King, David C Dodd and Lois Roth. 2006. *The Necropsy Book*, Fifth Edition, C L Davis Foundation
- Jones TC and Gleiser CA. 1954. *Veterinary Necropsy Procedures*. JB Lippincott
- Lincoln PJ and Thomson J. 1998. *Forensic DNA Profiling Protocols*. Humana Press.
- Majó Masferrer, Natàlia, Dolz Pascual, Roser and Shivaprasad HL. 2011. *Atlas of Avian Necropsy: Macroscopic Diagnosis Sampling*, SERVET Publishers
- Rudin N and Inman K. 2002. *An Introduction to Forensic DNA Analysis*. CRC Press

I. Course Title : Necropsy Conference

II. Course Code : VPL 506

III. Credit Hours : 0+1

IV. Practical

- Continuous assessment of students on detailed necropsy examination of various species of large and small animals including poultry; Necropsy associated cytological examinations; Systematic examination of different organs for morphologic description of gross lesions; gross photography; Collection of tissues for histopathology and based on nature of gross lesions, if possible further collection for investigation of viral/ bacterial/ protozoan/ fungal/ parasitic diseases/ toxic or poisoning, etc.
- Morphologic description of microscopic lesions; microscopic photography; correlation of gross and microscopic observations with the results of other parallel investigations to diagnose the disease conditions; presentation of select case(s) in the monthly seminars followed by report writing and final morphologic/ etiologic diagnosis, classification and preservation of microscopic slides.

V. Suggested Reading

- Albert C Strafuss. 1988. *Necropsy: Procedures and Basic Diagnostic Methods for Practicing Veterinarians*, Charles C. Thomas Publisher Springfield.
- Benjamin Lucio-Martinez and Jodi A Korich. 2010. *Illustrated guide to Poultry Necropsy and diagnosis*, Cornell University (https://www.slideshare.net/heshamkotb/illustrated-guide-to-poultry-necropsy-and-diagnosis)
- D Gopala Krishna Rao. 2005. *Textbook on necropsy and histopathological techniques*, 1st Ed. Academa.
- Donald B Feldman, John Curtis Seely. 1988. *Necropsy Guide: Rodents and the Rabbit*, 1st Ed. CRC Press.
- Jones TC and Gleiser CA. 1954. *Veterinary Necropsy Procedures*. JB Lippincott.
- John M King, David C Dodd and Lois Roth. 2006. *The Necropsy Book*, Fifth Edition, C L Davis Foundation.
- Majó Masferrer, Natàlia, Dolz Pascual, Roser and Shivaprasad HL. 2011. *Atlas of Avian Necropsy: Macroscopic Diagnosis Sampling*, SERVET Publishers.

I. Course Title : Systemic Pathology

II. Course Code : VPL 507

III. Credit Hours : 2+1

IV. Theory

Unit I

Advanced study of pathological conditions in relation to their etiology, Pathology and pathogenesis including examples of specific infectious or non-infectious diseases affecting cardiovascular (heart, blood vessels and lymph vessels), Respiratory (nasal cavity, Larynx, Trachea, Bronchi, Lungs and pleura) and haemopoietic (bone marrow, blood, spleen, lymph node) systems.

Unit II

Advanced study of pathological conditions in relation to their etiology, Pathology and pathogenesis including examples of specific infectious or non-infectious diseases affecting different organs of digestive (buccal cavity, pharynx, oesophagus, stomach and intestines), Urinary (kidneys, ureter, urinary bladder and urethra) and genital (male and female organs including mammary gland) systems.

Unit III

Advanced study of pathological conditions in relation to their etiology, Pathology and pathogenesis including examples of specific infectious or non-infectious diseases affecting different organs of nervous (brain and spinal cord), endocrine (pituitary, thyroid, parathyroid, pancreas) musculo-skeletal systems (muscles and bones) and organs of special senses (eye, ear), skin and its appendages (hoof, tail).

V. Practical

- To study the morphologic description of lesions and nomenclature of a morphologic diagnosis based on gross and/ or microscopic lesions in variety of organs in the preserved specimens/ slides.
- Continuous assessment of students for their skills in the morphologic description of lesions and nomenclature of a morphologic diagnosis based on gross and/ or microscopic lesions in variety of organs during post-mortem examination of domestic animals followed by interaction in the student seminars/ group discussions.

VI. Suggested Reading

- Grant Maxie. 2015. Jubb, Kennedy & Palmer's *Pathology of Domestic Animals*, 6th Ed. Saunders Ltd.
- Vegad JL and Madhu Swamy. 2010. *A text book of Veterinary Systemic Pathology*, 2nd Ed. Publisher IDBC, Lukhnow

I. Course Title : Pathology of Infectious Diseases of Domestic Animals

II. Course Code : VPL 508

III. Credit Hours : 2+1

IV. Theory

Unit I

Study of etiology, Pathology and pathogenesis of various viral diseases-Foot and mouth disease, Vesicular stomatitis, Vesicular eXanthema, Vesicular disease, Rinderpest, Bovine viral diarrhoea-Mucosal disease, Bovine malignant catarrhal fever, Infectious bovine rhinotracheitis, Parainfluenza-3, Bovine respiratory syncytial virus infection, PoX diseases, Blue tongue, Contagious ecthyma, PPR, Rabies, Canine distemper, Parvovirus infections, Infectious canine hepatitis, Pseudorabies, Classical swine fever, Swine and Equine influenza, Equine infectious anaemia, African horse sickness, Equine viral arteritis, Equine viral encephalomyelitis, Equine herpesvirus infections, Papillomatosis, Rift Valley fever, Japanese encephalitis, Ovine encephalomyelitis (Louping ill) and Prion diseases.

Unit II

Study of etiology, pathology and pathogenesis of various bacterial diseases-Tuberculosis, Johne's disease, Actinobacillosis, Actinomycosis, Brucellosis, Listeriosis, Pasteurellosis, Leptospirosis, AnthraX, Clostridial group of diseases, Streptococcal and Staphylococcal infections, Campylobacter infections, Swine erysipelas, Glasser's disease, Foot rot, Colibacillosis and Salmonellosis, Glanders, Melioidosis, Nocardiosis, Cutaneous strepthricosis, Corynebactrium infections, Chlamydial and Mycoplasma infections.

Unit III

Study of etiology, Pathology and pathogenesis of various fungal, Rickettsial and parasitic diseases-Aspergillosis, Blastomycosis, Coccidioidomycosis, Histoplasmosis, Epizootic lymphangitis, Rhinosporidiosis, Sporotrichosis, Candidiasis, Crytococcosis, Dermatomycoses;Diseases due to commonly occurring mycotoXins; Important rickettsial diseases-Q-fever, Heart water disease, Ehrlichiosis, Anaplasmosis, Haemobartonellosis; Important protozoan diseases-Coccidiosis, ToXoplasmosis, Babesiosis, Theilariosis, Cryptosporidiosis, Trypanosomiasis and Pathology of important diseases caused by helminths.

V. Practical

Morphologic description of lesions based on gross and/ or microscopic lesions and the study of their correlation with a specific disease in the preserved specimens/ slides.

VI. Suggested Reading

- Jones TC, Hunt RD & King NW. 1997. *Veterinary Pathology*. Blackwell Publishing.
- Grant MaXie. 2015. Jubb, Kennedy & Palmer's *Pathology of Domestic Animals*, 6th Ed. Saunders Ltd.
- Gary Procop and Bobbi Pritt. 2014. *Pathology of Infectious Diseases*, 1st Ed. Saunders

I. Course Title : Toxicopathology

II. Course Code : VPL 509

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction, classification and mode of action of different poisons.

Unit II

Study of pathogenesis, symptoms, gross and microscopic pathology of diseases caused by toxic plants, Organic and inorganic poisons commonly taken or administered maliciously to different species of domestic animals.

Unit III

Various regulatory bodies and regulatory processes, Protocols in conducting toxicopathological trials; Chronology for conducting preclinical toxicology. OECD-Good Laboratory Practices, Toxicopathological profile including battery of tests for pharmaceutical/ toxic agents.

Unit IV

In-vitro and *In vivo* models for toxicity studies and evaluation parameters.

V. Practical

- To study gross and histopathological alterations as a result of ingestion of toxic plants and extraneous poisons in domestic animals.
- Assignments on commonly occurring toxic plants of the region; Diagnosis of commonly taken or maliciously administered poisonous substances.

VI. Suggested Reading

- Jones TC, Hunt RD and King NW. 1997. *Veterinary Pathology*. Blackwell Publishing.

I. Course Title : Avian Pathology

II. Course Code : VPL 510

III. Credit Hours : 2+1

IV. Theory

Unit I

Avian inflammation and immunology, Study of etio-pathology, symptoms, transmission, and diagnosis of infectious diseases of chickens, turkeys, ducks and other birds caused by Bacteria: Salmonella, *Escherichia coli* and Clostridial infections, Infectious coryza, Fowl cholera, Tuberculosis and Spirochaetosis; Chlamydial and Mycoplasmal infections; Viruses: Ranikhet disease, Infectious bursal disease, Infectious bronchitis, Infectious laryngotracheitis, Marek's disease, Leukorsarcoma group of diseases, Reticuloendotheliosis, Fowl poX, Avian influenza, Avian encephalomyelitis, Inclusion body hepatitis, Hydropericardium syndrome, Egg drop syndrome-76, Chicken infectious anaemia, Avian nephritis, Reovirus infections- Viral arthritis and Infectious stunting syndrome, Duck plague, Duck viral hepatitis, Coronaviral enteritis and Haemorrhagic enteritis of turkeys: Fungi and mycotoXins; Parasites-Coccidiosis, Histomoniasis, Round worm and Tape worm infections; Ecto-parasites of birds.

Unit II

Study of etio-pathology, clinical symptoms, and diagnosis of nutritional deficiencies - Vitamin and Mineral deficiencies; Metabolic diseases-Ascites, Gout, Fatty liver and kidney syndrome, Fatty liver haemorrhagic syndrome, Cage layer fatigue, etc.; Miscellaneous conditions of poultry-Heat stress, Blue comb, Breast blister, Bumble foot, Cannibalism, False layer, Internal layer, Pendulous crop, Round heart disease etc.

Unit III

Emerging and re-emerging diseases of poultry: Introduction to an emerging and a re-emerging pathogen, mechanisms of poultry pathogen's emergence, co-evolution of poultry pathogens with their vaccines and medications, common diseases of poultry susceptible to point mutations and their pathology.

VI. Practical

- Necropsy eXamination of the different species of poultry; morphologic description of gross and/ or microscopic lesions in the preserved specimens/ slides.
- Continuous assessment of students for their skills in the diagnosis of gross lesions in different organs of various systems during post-mortem eXamination of poultry. Preparation of histopathology slides on the select cases followed by interaction in the student seminars/ group discussions.

VII. Suggested Reading

- Saif YM, Barnes FJ, Glisson JR, Fadly AM, Mc Dougald LR & Swayne D. 2008. *Diseases of Poultry*. 12th Ed. Blackwell Publishing.
- Randall CJ. 1984. *A Colour Atlas of Diseases of the Domestic Fowl and Turkey*, Mosby International.
- Majó Masferrer, Natàlia, Dolz Pascual, Roser and Shivaprasad HL. 2011. *Atlas of Avian Necropsy: Macroscopic Diagnosis Sampling*, SERVET Publishers.
- Benjamin Lucio-Martinez and Jodi A Korich. 2010. *Illustrated guide to Poultry Necropsy and diagnosis*, Cornell University (https://www.slideshare.net/heshamkotb/illustrated-guide-to-poultry-necropsy-and-diagnosis)

I. Course Title : Pathology of Wild/ Zoo and Aquatic Animal Diseases

II. Course Code : VPL 511

III. Credit Hours : 2+1

IV. Theory

Unit I: Wild/ Zoo Animal diseases

Etiology, transmission, gross and microscopic pathology of some commonly occurring infectious diseases of wild animals: West Nile fever, Rabies, Foot and mouth disease, Pox, Kyasanaur forest disease, Infectious hepatitis virus, Infectious feline peritonitis, Anthrax, Tuberculosis, Colibacillosis, Clostridial infections Trypanosomosis, Babesiosis, Theileriosis; Etiology, gross and microscopic pathology of commonly occurring non-infectious diseases of Wild/ Zoo animals.

Unit II: Infectious diseases of fish

Study of etiology, gross and microscopic pathology of Bacterial diseases- Bacterial cold water disease, Bacterial fin disease, Fill rot, Furunculosis, Aeromonas septicemia, Epizootic ulcerative syndrome, Yersiniosis, Pseudomoniasis, Alteromoniasis, Pasteurellosis, Enteric septicemia of catfish, Edwardsiellosis, Vibriosis, Streptococcosis, Bacterial kidney disease, Mycobacteriosis, Nocardiosis, Epitheliocystis: Salmonid rickettsialsepticaemia, Columnaris disease; Viral diseases-Spring viremia of carp, Infectious pancreatic necrosis, Viral hemorrhagic septicaemia, Koi herpes virus disease, Infectious spleen and kidney necrosis, Carp pox, Virus nervous necrosis, Lymphocystis disease, Infectious salmon anemia, Salmon alpha virus infections, Infectious hematopoietic necrosis, Herpes viral hematopoeitic necrosis, Chinese grass carp reovirusdisease, Viral hemorrhagic necrosis, Epizootic hemorrhagic necrosis; Fungal diseases- Saprolegniasis, Branchiomycosis (Gill rot), Ichthyosporidiosis, Exophiala infection, Aphanomyces and Fusarium infection; Parasitic and Protozoal diseases-Ich or White spot disease, Costiasis, Trichodiniasis, Velvet disease, Coral fish disease, Epistylis, Red sore disease, Glossatella, Myxosporidiosis, Whirling disease, Microsporidiosis (Glugea, Pleistophora, Loma), Coccidiosis, Proliferative kidney disease, Cryptosporidiosis.

Unit III: Other diseases of Fish

Nutritional diseases-Nutritional deficiency of protein, lipid, carbohydrate, vitamins and minerals; Neoplastic conditions- Melanoma in Platyfish/ Swordtail hybrids, Hepatoma and hepatocellular carcinoma in rainbow trout, Stomatopapilloma of eels (Cauliflower disease), Papilloma of the brown bullhead, Lip Fibroma (Fibropapilloma) of Angel fish, Dermal fibrosarcomas of walleye pike, Lymphosarcoma of pike, Schwannoma/ Neurofibromas of the bicoloured damselfish; Environmental stress-Gas bubble disease, Acidosis/ Alkalosis, Thermal shock, Sun burn disease, Anoxia, Increased in dissolved CO_2 or H_2S or Ammonia concentration in water, Increased in turbidity of pond water, Algal toxicosis disease.

V. Practical

Post-mortem examination of wild animals including wild birds. Study of gross and microscopic lesions of important infectious and non-infectious diseases of fish and wild animals

VI. Suggested Reading

- Arora BM. 1984. *Wildlife Diseases in India*. Periodical Expert Book Agency.
- Fowler ME. 1978. *Zoo and Wild Animal Medicine*. WB Saunders. Roberts RJ. 1979. *Fish Pathology*. Bailliere Tindall, London

I. Course Title : Pathology of Laboratory Animal Diseases

II. Course Code : VPL 512

III. Credit Hours : 2+1

IV. Theory

Unit I

Etiology, transmission, gross and microscopic pathology of some commonly occurring diseases of Rabbits: Pasteurellosis, Bordetellosis, Colibacillosis, Tyzzer's disease, Staphyloccal infections, Venereal spirochetosis, (rabbit syphilis, cuniculosis), Proliferative ileotyphilitis, Salmonellosis, Tularemia, Clostridium infections, Myxomatosis, Rabbit fibroma/ shope fibroma, Rabbit papillomatosis, Viral hemorrhagic disease, Coccidiosis, Enephalotozoonoses, Baylisascarisprocyonis, Cestode, Mites, Fleas and lice, miscellaneous and neoplastic diseases of rabbits.

Unit II

Etiology, transmission, gross and microscopic pathology of commonly occurring diseases of Rats: Bacterial diseases-Staphylococcal dermatitis, Pasteurellosis, Streptococcal diseases, Helicobacter infection, CAR bacillus, Mycoplasma pulmonis, Pseudotuberculosis (corynobacteriosis), Tyzzers disease, Salmonellosis, Rat bite fever; Viral diseases- Rat theilo virus (RTV-1), Parvovirus, coronavirus, pneumonia virus of mice, Hantaan virus, Sendai virus, Reovirus-3, Protozoan diseases (Trichomonads, Chilomastixbettencorti, Spironucleusmuris, Giardia muris, Rat sarcodines, Rat enteric coccidian), Arthropods (Mesostigmated mites, lice of rats), Helminths (rat pinworms, Hymenolepid tapeworm, Cestodes with a rat intermediate host, rat threadworms); fungal disease (*Pneumocystis carinii*), other miscellaneous and neoplastic diseases

Unit III

Etiology, transmission, gross and microscopic pathology of commonly occurring diseases of Mice: Bacterial diseases- Helicobacter infection, Pasteurellosis, Staphylococcal furunculosis, *Mycoplasma pulmonis*, Cilia associated respiratory bacillus, *Corynebacterium bovis*, *Pseudomonas aeruginosa*, *Citrobacter rodentium*, Tyzzer's disease, Salmonellosis; Viral diseases- Mouse norovirus, Mouse hepatitis virus, Mouse encephalomyelitis virus, Epizootic diarrhoea of infant mice, Parvovirus, Murine cytomegalovirus, Mouse adenovirus, Ectromelia virus, Lymphocytic choriomengitis virus, Pneumonia virus of mice, Lactate dehydrogenase elevating virus, Sendai virus, Mouse thymic virus, Mouse polyoma viruses, Reo-3 virus; Parasitic diseases-Pin worms, Fur mites of mice, Mange mites, Mesostigmatid mites, Lice of mice, Trichomonads, *Chilomastixbettencorti*, *Spironucleusmuris*, *Giardia muris*, Mouse sarcodines, Mouse enteric coccidian, Mouse parentral coccidian, Mouse sporozoans, Hymenolepid tapeworms, Encysted tape worm; Fungal disease (*Pneumocystis* pneumonia) and other miscellaneous and neoplastic diseases

Unit IV

Etiology, transmission, gross and microscopic pathology of commonly occurring diseases of Guinea pigs: Bacterial diseases- Antibiotic-induced enterotoxemia/ haemorrhagic typhlitis, *Bordetella* pneumonia, Streptococcal pneumonia, Cervical lymphadenitis, Pododermatitis, Mastitis, Tyzzer's disease, Salmonellosis; Viral diseases- Guinea pig cytomegalovirus, Adenovirus, Parainfluenza virus, Corona-like virus, Lymphocytic choriomeningitis virus; Parasitic diseases- Coccidia, Fur mites, Helminthes, Lice of guinea pigs, Mange mites, Cryptosporidiosis, Microsporidium parasites and other miscellaneous conditions

Unit V

Etiology, transmission, gross and microscopic pathology of commonly occurring diseases of Hamsters, Gerbills and primates

V. Practical

Post-mortem examination of laboratory animals. Study of gross and microscopic lesions of important infectious and non-infectious diseases of laboratory animals

VI. Suggested Reading

- Beninchka K, Garner FM and Jones TC. 1978. *Pathology of Laboratory Animals*. Vols. I, II. Springer Verlag.

Course Title with Credit Load
Ph.D. in Veterinary Pathology (VPL)

Course Code	Course Title	Credit Hours
VPL 601	Molecular and Ultrastructural Basis of Cell Injury*	2+1
VPL 602	Molecular Basis of Inflammation	1+1
VPL 603	Molecular Basis of Neoplasia	1+1
VPL 604	Immunopathology*	2+1
VPL 605	Advances in Diagnostic Pathology	1+2
VPL 606	Pathology of Nutritional and Metabolic Disturbances	2+1
VPL 607	Pathology of Important Emerging and Re-Emerging Diseases of Pets and Livestock	2+1
VPL 608	Research Methodology in Pathology*	1+0
VPL 609	Necropsy Conference I*	0+1
VPL 690	Special Problem	0+1
VPL 691	Doctoral Seminar-I*	1+0
VPL 692	Doctoral Seminar-II*	1+0
VPL 699	Doctoral Research	75

*Core courses

Course Contents
Ph.D. in Veterinary Pathology (VPL)

I. Course Title : Molecular and Ultrastructural Basis of Cell Injury

II. Course Code : VPL 601

III. Credit Hours : 2+1

IV. Theory

Unit I

Study of cells- cell morphology, interpretation of normal and abnormal cells.

Unit II

Overview of Cell injury, Targets of cell injury-Cell membranes, Aerobic respiration, structural proteins and enzymes and genetic apparatus of the cell; Mechanisms of cell injury-hypoxia, Injury by free radicals, Chemical injury, Infectious agents, other forms of cell injury-immune mediated reactions, Genetic derangements; Mechanisms of cell membrane damage; Mechanisms of DNA damage-base loss, Base modification, chemical modification, Replication errors, Inter-strand cross-links, DNA-protein cross-links, Strand breaks. Molecular and immunopathological changes associated with different types of cell injuries.

Unit III

Morphology of Reversible and irreversible cell injury with particular emphasis on ultra structural changes in the cells and organelles: Morphology of cell death-necrosis, Apoptosis and autolysis, Mechanism of apoptosis, Intracellular and extracellular accumulations, Pigment and tissue deposits, Consequences of cell injury Cellular adaptations-hyperplasia, Hypertrophy, Atrophy, Metaplasia and dysplasia.

Unit IV

Mechanism of other types of cell death, viz., Pyroptosis, Ferroptosis, Autophagy, ETOSIS, etc.

V. Practical

Collection and preparation of specimens for electron microscopic studies. Interpretation of ultra-structural changes and their correlation with gross and histopathological findings

VI. Suggested Reading

- Selected articles from journals.

I. Course Title : Molecular Basis of Inflammation

II. Course Code : VPL 602

III. Credit Hours : 1+1

IV. Theory

Unit I

Cellular, molecular and immunopathological changes associated with different types of inflammation. Acute inflammation, Vascular events of acute inflammation, Cellular events in acute inflammation, Leucocyte-endothelial interactions, Leucocyte adhesion molecules, Endothelial adhesion molecule receptors, Leucocyte chemotactic factors, Microbicidal activity of leucocytes, Leucocyte activation.

Unit II

Plasma derived mediators of inflammation-Complement system, Kinin system, Coagulation system and Fibrinolytic system; Cell derived mediators of inflammation-vasoactive amines, lipid mediators, cytokines, chemokines, oXygen radicals and nitric oXide, Cellular components of inflammation, types of eXudative inflammation.

Unit III

Chronic inflammation and its types, Elements of chronic inflammation, Healing and repair, Wound healing mediators and their functions, Repair of bone, Repair of nervous tissue and myocardium.

V. Practical

Molecular alterations and their correlation with gross and microscopic inflammatory changes

VI. Suggested Reading

- Selected articles from journals.

I. Course Title : Molecular Basis of Neoplasia

II. Course Code : VPL 603

III. Credit Hours : 1+1

IV. Theory

Unit I

Tumour characteristics, differentiation and proliferation, molecular basis of cancer, tumour stromal interaction, molecular mechanisms of invasion and metastasis of tumours, molecular changes underlying tumour progression and heterogeneity, tumour biology and growth.

Unit II

Tumour genetics, immunohistochemical/ including markers associated tumour diagnosis.

Unit III

Application of cytological, histopathological, immunohistochemical and molecular techniques in diagnosis and prognosis of various tumour conditions.

V. Suggested Reading

- Selected articles from journals.

I. Course Title : Immunopathology

II. Course Code : VPL 604

III. Credit Hours : 2+1

IV. Theory

Unit I

Principles of immunopathology, Etiopathology of hypersensitivity reactions and immune complex diseases; Autoimmunity, mechanisms of autoimmunity, Genetic, microbial and environmental factors in autoimmunity.

Unit II

Study of etiology, pathology and pathogenesis of commonly encountered Immunoproliferative disorders (Multiple myeloma, lymphoma, leukemia), Hypersensitivity diseases, Autoimmune diseases and immune deficiencies in domestic animals.

V. Practical

Immune complexes-quantification and determination by various techniques, Enumeration of various populations of lymphocytes by different techniques, Determination of C3 levels, Autoimmune reaction by demonstrating auto-antibodies, Gross and microscopic pathology of hypersensitivity reactions (class IV and others).

VI. Suggested Reading

- Selected articles from journals.

I. Course Title : Advances in Diagnostic Pathology

II. Course Code : VPL 605

III. Credit Hours : 1+2

IV. Theory

Unit I

Principles and applications of Scanning electron microscopy, Transmission electron microscopy, Laser scanning confocal microscopy, Telemicroscopy-Virtual slide microscopy.

Unit II

Current techniques for diagnosis of animal diseases namely ELISA, PCR and its variants, Flow cytometry (FCM), *In-situ* hybridization, Bio chip techniques (DNA chip, Protein microarray, Tissue microarray), Chromatography, Spectrophotometry and Immunodiffusion technique, Biopsy techniques, Use of laboratory animals, etc.

Unit III

In-vitro cell culture techniques (commonly used cell lines, chicken embryo), cytopathic effect of different viruses and their interpretations.

V. Practical

Principles and practice of advance techniques for the diagnosis of animal diseases.

VI. Suggested Reading

- Selected articles from journals.

I. Course Title : Pathology of Nutritional and Metabolic Disorders

II. Course Code : VPL 606

III. Credit Hours : 2+1

IV. Theory

Unit I

Pathogenesis, gross and microscopic pathology of nutritional imbalances, viz., carbohydrate, protein, fats, vitamins and macro and microelements.

Unit II

Pathogenesis, gross and microscopic pathology of different metabolic diseases namely Milk fever, Ketosis, Pregnancy toxaemia, Tetany, Azoturia, Equine hyperlipidemia, downer's cow and rheumatism like syndrome and post parturient hemoglobinuria in domestic animals and diabetes mellitus in dogs.

V. Practical

Estimation of certain minerals in sera of natural and experimentally induced deficiencies in domestic animals. To study the haematological, gross and microscopic pathological alterations caused by nutritional and metabolic disorders.

VI. Suggested Reading

- Selected articles from journals.

I. Course Title : Pathology of Important Emerging and Re-Emerging Diseases

II. Course Code : VPL-607

III. Credit Hours : 2+1

IV. Aim of the course

To teach the students about important emerging, re-emerging,transboundary diseases of pets and livestock.

V. Theory

Unit I

Advances in pathogenesis and pathology including molecular basis of important viral infections namely Foot and mouth disease, Vesicular stomatitis, Vesicular exanthema, Rinderpest, Bovine malignant catarrhal fever, Infectious bovine rhinotracheitis, Parainfluenza-3, Bovine respiratory syncytial virus infection, Blue tongue, Contagious ecthyma, Pox diseases, Peste des petits ruminants, Rabies, Canine distemper, parvovirus infections, Infectious canine hepatitis, Pseudorabies, Hog cholera/ swine fever, swine influenza, Rift valley fever, Scrapie, Bovine spongiform encephalopathy, Japanese encephalitis, Diseases caused by Nipah virus, Kyasanaur forest disease, West Nile fever, Hendravirus, Ebola virus, Crimean-Congo haemorrhagic fever, Chikungunya virus, Ganjam virus, Marburg virus, etc.

Unit II

Advances in pathogenesis and pathology including molecular basis of important bacterial infections namely Tuberculosis, Johne's disease, Actinobacillosis, Actinomycosis, Brucellosis, Listeriosis, Pasteurellosis, Leptospirosis, Anthrax, Clostridial group of diseases, Swine erysipelas, Glasser's disease, Colibacillosis and Salmonellosis, *Corynebactrium* infections, Chlamydial and Mycoplasmal infections.

Unit III

Advances in pathogenesis and pathology including molecular basis of important fungal infections namely Aspergillosis, Blastomycosis, Coccidioidomycosis, Histoplasmosis, Rhinosporidiosis, Sporotrichosis, Candidiasis, Crytococcosis, Dermatomycoses, diseases due to commonly occurring mycotoxins-Aflatoxins, Ochratoxin, Zearalenone, T-2 toxins, Rubratoxin, Fumonisin, Moniliformin, etc.

VI. Practical

Study of clinical and gross alterations and histopathology of some important emerging and enzootic diseases.

VII. Suggested Reading

- Selected articles from Journals.

I. Course Title : Research Methodology in Pathology

II. Course Code : VPL 608

III. Credit Hours : 1+0

IV. Theory

Unit I

Literature based study: Use of various eXperimentation techniques in pathology research, Animal eXperimentation techniques, Planning and design of various types of eXperiments through study of literature for selection of appropriate methodology and evaluation parameters including scoring system, Data evaluation methods, etc.

Unit II

Introduction to OECD-GLP guidelines, Reference studies through literature for safety evaluation of drug/ plant/ plant molecules using *In-vitro* and *In vivo* techniques, Determination and calculation of LD_{50}, ID_{50}, MIC, MTD, etc., use of modern molecular techniques in eXperimental pathology research.

VI. Suggested Reading

- Selected articles from journals.

I. Course Title : Necropsy Conference-I

II. Course Code : VPL-609

III. Credit Hours : 0+1

IV. Practical

- Continuous assessment of students on detailed necropsy examination of various species of large and small animals including poultry; necropsy associated cytological examinations; systematic examination of different organs for morphologic description of gross lesions; gross photography; collection of tissues for histopathology and based on nature of gross lesions, if possible further collection for investigation of viral/ bacterial/ protozoan/ fungal/ parasitic diseases/ toxic or poisoning, etc.
- Morphologic description of microscopic lesions; microscopic photography; correlation of gross and microscopic observations with the results of other parallel investigations to diagnose the disease conditions; presentation of select case(s) in the monthly seminars followed by report writing and final morphologic/ etiologic diagnosis, classification and preservation of microscopic slides.

V. Suggested Reading

- D Gopala Krishna Rao. 2005. *Textbook on necropsy and histopathological techniques*, 1st Ed. Academa.
- Donald B Feldman, John Curtis Seely. 1988. *Necropsy Guide: Rodents and the Rabbit*, 1st Ed. CRC Press.
- Albert C Strafuss. 1988. *Necropsy: Procedures and Basic Diagnostic Methods for Practicing Veterinarians*, Charles C. Thomas Publisher Springfield.
- Jones TC and Gleiser CA. 1954. *Veterinary Necropsy Procedures*. JB Lippincott.
- John M King, David C Dodd and Lois Roth. 2006. *The Necropsy Book*, Fifth Edition, C L Davis Foundation.
- Majó Masferrer, Natàlia, Dolz Pascual, Roser and Shivaprasad HL. 2011. *Atlas of Avian Necropsy: Macroscopic Diagnosis Sampling*, SERVET Publishers.
- Benjamin Lucio-Martinez and Jodi A Korich. 2010. *Illustrated guide to Poultry Necropsy and diagnosis*, Cornell University (https://www.slideshare.net/heshamkotb/illustrated-guide-to-poultry-necropsy-and-diagnosis).

I. Course Title : Special Problem

II. Course Code : VPL 690

III. Credit Hours : 0+1

IV. Practical

Short research problem(s) involving contemporary issues and research techniques.

VI. List of some selected Journals

- *American Journal of Veterinary Medical Association*
- *Annals of Nutrition and Metabolism*
- *Annual Review of Nutrition*
- *Avian Diseases*
- *Avian Pathology*
- *Cancer Research*
- *Cellular and Molecular Biology*
- *Current Contents*
- *European Journal of Nutrition*
- *Genomics, Proteomics and Bioinformatics*
- *Indian Journal of Animal Sciences*
- *Indian Journal of Poultry Science*
- *Indian Journal of Veterinary Pathology*
- *Indian Veterinary Journal*
- *Journal of Applied Toxicology*
- *Journal of Comparative Pathology*
- *Journal of Ethnopharmacology*
- *Journal of Immunology and Immunopathology*
- *Journal of Pathology*
- *Journal of Research in Veterinary Science*
- *Phytomedicine*
- *Toxicology Letters*
- *Toxicon*
- *Trends in Immunology*
- *Veterinary Bulletin*
- *Veterinary Immunology and Immunopathology*
- *Veterinary Pathology*

e-Resources

- www.iavp.org (Indian Journal of Veterinary Pathology)
- www.vetpathology.org (Veterinary Pathology)
- www.tandf.co.uk (Avian Pathology)
- www.avdi.allenpress.com (Avian Diseases)
- www.elsevier.com/locate/vetimm (Veterinary Immunology and Immuno- pathology).

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Veterinary Para-Clinical Subjects

– Veterinary Parasitology

Course Title with Credit Load
M.V.Sc. in Veterinary Parasitology

Course Code	Course Title	Credit Hours
VPA 501	Platyhelminthes-I*	1+1
VPA 502	Platyhelminthes-II*	1+1
VPA 503	Nemathelminthes and Acanthocephala*	2+1
VPA 504	Arthropod Parasites*	2+1
VPA 505	Parasitic Protozoa*	2+1
VPA 506	Diagnostic Parasitology	0+2
VPA 507	Clinical Parasitology	1+1
VPA 508	Management of Parasitic Diseases	1+1
VPA 509	Immunoparasitology	2+1
VPA 510	Parasitic Zoonoses	2+0
VPA 511	Parasites of Wildlife	1+1
VPA 591	Master's Seminar*	1+0
VPA 599	Master Research	30

*Core Courses

Course Contents
M.V.Sc. in Veterinary Parasitology

I. Course Title : Platyhelminthes-I

II. Course Code : VPA 501

III. Credit Hours : 1+1

IV. Theory

Unit I

Introduction, classification, general account and economic importance of trematodes.

Unit II

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, Treatment and control measures of trematodes belonging to families: Dicrocoeliidae, Opisthorchiidae and Fasciolidae.

Unit III

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment and control measures of trematodes belonging to families: Echinostomatidae, Heterophyidae, Plagiorchiidae, Troglotrematidae, Prosthogonimidae, Nanophyetidae and Paragonimidae.

Unit IV

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment and control measures of trematodes belonging to families: Notocotylidae, Brachylemidae, Cyclocoelidae, Paramphistomatidae and Schistosomatidae.

Unit V

Classification, characters of snails and control strategies of molluscs of veterinary importance.

V. Practical

- Collection, preservation/ processing and identification of trematode parasites; their eggs and intermediate hosts.
- Observation on parasitic stages in host tissues and associated pathological lesions.
- Identification of molluscs of veterinary importance and examination of molluscs for various developmental stages of trematode parasites.

I. Course Title : Platyhelminthes-II

II. Course Code : VPA 502

III. Credit Hours : 1+1

IV. Aim of the course

To study the morphology, biology, pathogenesis and control measures for cestode parasites of veterinary importance.

Unit I

Introduction, classification, general account and economic importance of cestodes

Unit II

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment and control measures of cestodes belonging to families: Diphyllobothriidae, Mesocestoididae and Taeniidae.

Unit III

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment and control measures of cestodes belonging to families: Davaineidae, Hymenolepididae, Dipylidiidae and Dilepididae.

Unit IV

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, Treatment and control measures of cestodes belonging to families: Anoplocephalidae and Thysanosomidae.

V. Practical

Collection, preservation/ processing and identification of cestode parasites; their eggs, larval stages and intermediate hosts. Parasitic stages in host tissues and associated pathological lesions.

I. Course Title : Nemathelminthes and Acanthocephala

II. Course Code : VPA 503

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction, classification, general account and economic importance of nematodes and thorny-headed worms.

Unit II

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment and control measures of nematodes belonging to families: Ascarididae, Anisakidae, Oxyuridae, Heterakidae and Subuluridae**.**

Unit III

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment, and control measures of nematodes belonging to families: Rhabditidae, Strongyloididae and Strongylidae.

Unit IV

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment, and control measures of nematodes belonging to families: Trichonematidae, Amidostomidae, Stephanuridae, Syngamidae and Ancylostomatidae.

Unit V

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment and control measures of nematodes belonging to families: Filaroididae, Trichostrongylidae, Ollulanidae, Dictyocaulidae and Metastrongylidae.

Unit VI

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment and control measures of nematodes belonging to families: Spiruridae, Thelaziidae, Acuariidae, Tetrameridae, Physalopteridae, Gnathostomatidae, Filariidae, Setariidae, Onchocercidae and Dracunculidae.

Unit VII

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment and control measures of nematodes belonging to families: Trichinellidae, Trichuridae, Capillariidae and Dioctophymatidae.

Unit VIII

Morphology, Epidemiology, Life cycle, Pathogenesis, Clinical signs, Diagnosis, treatment and control measures of thorny headed worms belonging to families: Polymorphidae, Oligacanthorhynchidae and Gnathobdellidae.

V. Practical

Collection, preservation/ processing and identification of nematode parasites and thorny headed worms; their eggs and larvae and associated pathological lesions.

I. Course Title : Arthropod Parasites

II. Course Code : VPA 504

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction, Classification, Harmful effects and Economic importance of arthropod parasites.

Unit II

Distribution, Morphology, Life cycle, Seasonal pattern, Pathogenesis, Vector potentiality, Economic significance and control of arthropods belonging to the families: Culicidae, Ceratopogonidae, Simuliidae and Psychodidae.

Unit III

Distribution, Morphology, Life cycle, Seasonal pattern, Pathogenesis, Vector potentiality, Economic significance and control of arthropods belonging to the families: Tabanidae, Gasterophilidae, Muscidae, Cuterebridae and Glossinidae.

Unit IV

Distribution, Morphology, Life cycle, Seasonal pattern, Pathogenesis, Vector potentiality, Economic significance and control of arthropods belonging to the families: Oestridae, Sarcophagidae, Calliphoridae and Hippoboscidae. Importance of blow flies in forensic entomology and treatment of wounds.

Unit V

Distribution, Morphology, Life cycle, Seasonal pattern, Pathogenesis, Economic significance and control of arthropods belonging to the families: Pediculidae, Haematopinidae, Linognathidae, Menoponidae, Philopteridae and Trichodectidae.

Unit VI

Distribution, Morphology, Life cycle, Seasonal pattern, Pathogenesis, Economic significance and control of arthropods belonging to the Orders- Siphonaptera and Hemiptera, Cimicidae and Reduviidae.

Unit VII

Distribution, Life cycle, Seasonal pattern, Vector potentiality, Pathogenesis economic significance and control of acarines belonging to the families: Argasidae and Ixodidae.

Unit VIII

Distribution, Morphology, Life cycle, Seasonal pattern, Pathogenesis, Economic significance and control of acarines belonging to the families: Sarcoptidae, Psoroptidae, Demodicidae, Trombiculidae, Dermanyssidae. Cytoditidae and Linguatulidae.

Unit IX

Chemical, Biological, Immunological control measures and integrated pest management. Detection and mechanisms of acaricidal resistance.

V. Practical

Collection, preservation/ processing, identification, differentiation of arthropod parasites and their developmental stages; associated lesions and skin scraping examination.

I. Course Title : Parasitic Protozoa

II. Course Code : VPA 505

III. Credit Hours : 2 + 1

IV. Theory

Unit I

Introduction, classification, general account and economic importance of protozoan parasites.

Unit II

Morphology, Epidemiology, Pathogenesis, Clinical signs, Diagnosis, and control measures of protozoan parasites belonging to the families: Trypanosomatidae, Monocercomonadidae, Trichomonadidae, Hexamitidae and Endamoebidae.

Unit III

Morphology, Epidemiology, Pathogenesis, Clinical signs, Diagnosis and control measures of protozoan parasites belonging to the families: Eimeriidae, Cryptosporidiidae and Sarcocystidae.

Unit IV

Morphology, Epidemiology, Pathogenesis, Clinical signs, Diagnosis, Treatment and control measures of protozoan parasites belonging to the families: Plasmodiidae, Babesiidae, Theileriidae, Haemogregarinidae and Balantidiidae.

Unit V

Morphology, Epidemiology, Pathogenesis, Clinical signs, Diagnosis and control measures of Rickettsiales in relation to haemoprotozoans.

V. Practical

Collection, Preservation/ Processing, Identification of parasitic protozoa in clinical material and host tissues. Special techniques for certain protozoans such as coccidia and Cryptosporidia.

I. Course Title : Diagnostic Parasitology

II. Course Code : VPA 506

III. Credit Hours : 0+2

IV. Practical

Microscopy and micrometry, Preparation of Romanowsky stains. Collection, preservation, Processing and examination of faecal and blood samples; Lymph node biopsy, Skin scrapings, Nasal washings, Sputum, genital discharges/ washings and urine samples from animals for parasitological examinations. Quantitative faecal examination, Maintenance of fly and tick colonies in laboratory for experimental purposes and testing of drugs; tick dissection for vector potential. Collection of aquatic snails from field and their examination for the presence of different parasitic stages. Collection, fixation, staining, whole mounts and identification of parasites. Culturing techniques for important parasites, pasture larval count, worm count and assessment of worm burden.

Remote Sensing (RS) and Geographic Information System (GIS) as tools for mapping parasitic diseases.

I. Course Title : Clinical Parasitology

II. Course Code : VPA 507

III. Credit Hours : 1+1

IV. Theory

Unit I

Collection, preservation and dispatch of clinical material to laboratory for diagnosis

Unit II

History, clinical signs, gross and microscopic examination of diagnostic material.

Unit III

Animal sub-inoculation technique; blood and lymph node biopsy smear examination; histopathology of affected organs.

V. Practical

Identification, observation of parasitic stages in host tissues, excretions, secretions and associated pathological lesions. Special techniques for haemoparasites and coccidians.

I. Course Title : Management of Parasitic Diseases

II. Course Code : VPA 508

III. Credit Hours : 1+1

Unit I

Conventional and novel methods for control of helminth infections in livestock – anthelmintics, their mode of action, characteristic of an ideal anthelmintic drug, Anthelmintic resistance, Spectrum of activity, Delivery devices and integrated control method. Immunological control, Deworming schedule, Snail and other intermediate host control. Ethno veterinary practices.

Unit II

Conventional and novel methods of control of protozoan parasites–antiprotozoal drugs, Their mode of action, Integrated control method including immunological control.

Unit III

Conventional and novel methods of control with insecticides/ acaricides. Methods of application, their mode of action, insecticide resistance, biological control, integrated control method, genetic control and immunological control.

IV. Practical

In vivo and *in-vitro* detection of efficacy of control agents and resistance to anthelmintics, anticoccidials, insecticides and acaricides.

I. Course Title : Immunoparasitology

II. Course Code : VPA 509

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction, types of parasite-specific antigens and their characterization.

Unit II

Types of immunity in parasitic infections.

Unit III

Invasive and evasive mechanisms, immunomodulators and their uses.

Unit IV

Immune responses in helminths, arthropods and protozoa of veterinary importance.

Unit V

Immunological control against parasitic diseases.

V. Practical

Preparation of various antigens (somatic, eXcretory-secretory) and their fractionation and characterization and demonstration of various immunodiagnostic methods for the diagnosis of parasitic infections.

I. Course Title : Parasitic Zoonoses

II. Course Code : VPA 510

III. Credit Hours : 2+0

Unit I

Introduction to the concept of Zoonotic infections, Definitions, Various classifications of zoonoses, Host-parasite relationships, Modes of infections and factors influencing prevalence of zoonoses.

Unit II

A detailed study of Transmission, Epidemiology, Diagnosis and Control of common protozoa of zoonotic importance.

Unit III

A detailed study of Transmission, Epidemiology, Diagnosis and Control of common helminths of zoonotic importance.

Unit IV

A detailed study of Transmission, Epidemiology, Diagnosis and Control of common arthropods of zoonotic importance.

I. Course Title : Parasites of Wildlife

II. Course Code : VPA 511

III. Credit Hours : 1+1

IV. Theory

Unit I

A detailed study of protozoa of zoo and wild animals with particular emphasis on morphological features, Geographical distribution Epidemiology, Diagnosis and management.

Unit II

A detailed study of arthropod parasites of zoo and wild animals with particular emphasis on morphological features, Geographical distribution, Epidemiology, diagnosis and management.

Unit III

A detailed study of helminth parasites of zoo and wild animals with particular emphasis on morphological features, Geographical distribution, Epidemiology, diagnosis and management.

V. Practical

Methods for investigating parasitic diseases of captive and wild animals. Collection and identification of parasites. Visits to zoos and biological parks/ sanctuaries for collection of samples.

Course Title with Credit Load
Ph.D. in Veterinary Parasitology

Course Code	Course Title	Credits Hours
VPA 601	Advances in Helminthology-I	2+1
VPA 602	Advances in Helminthology-II	2+1
VPA 603	Entomology and Acarology	2+1
VPA 604	Advances in Protozoology	2+1
VPA 605	Immunology of Parasitic Diseases*	1+2
VPA 606	Molecular Diagnostics and Vaccine Development in Parasitology*	2+1
VPA 607	Host Parasite Interactions	2+0
VPA 608	*In-vitro* Cultivation of Parasites	1+2
VPA 609	Emerging and Re-Emerging Parasitic Diseases	2+0
VPA 610	Biology and Ecology of Parasites	3+0
VPA 611	Molecular Veterinary Parasitology	2+0
VPA 612	Parasite Epidemiology *	2+0
VPA 690	Special Problem	0+1
VPA 691	Doctoral Seminar-I *	1+0
VPA 692	Doctoral Seminar-II*	1+0
VPA 699	Doctoral Research	75

*Core courses

Course Contents
Ph.D. in Veterinary Parasitology

I. Course Title : Advances in Helminthology-I
II. Course Code : VPA 601
III. Credit Hours : 2+1

IV. Theory

Unit I

Advanced studies on Taxonomy, Molecular biology, Pathogenesis and Immunology of trematodes and their larval stages.

Unit II

Advanced studies on Taxonomy, Molecular biology, Pathogenesis and Immunology of cestodes and larval stages.

V. Practical

Morphological, Pathological and Immunological studies of trematode and cestode parasites.

I. Course Title : Advances in Helminthology-II
II. Course Code : VPA 602
III. Credit Hours : 2+1

IV. Theory

Unit I

Advanced studies on Taxonomy, Molecular biology, Pathogenesis and Immunology of nematode parasites and their larval stages.

Unit II

Advanced studies on Taxonomy, Molecular biology, Pathogenesis and Immunology of thorny-headed worms.

V. Practical

Morphological, Pathological and Immunological studies of various nematodes and thorny-headed worms.

I. Course Title : Entomology and Acarology

II. Course Code : VPA 603

III. Credit Hours : 2+1

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IV. Theory

Unit I

Origin, Evolution, Regional/ Seasonal distribution and Forecasting of insect and acarine population.

Unit II

Population dynamics of insects and acarines in relation to biotic and abiotic factors

Unit III

Recent developments pertaining to insects of veterinary importance.

Unit IV

Recent developments pertaining to arachnids of veterinary importance**.**

Unit V

Chemical, Biological, Herbal and Immunological control measures and integrated pest management. Modulation of vector competence to transmit parasitic infections using molecular genetics by developing transgenic vectors.

V. Practical

Collection and identification of arthropods; Demonstration of the infective stages in vectors. Immuno pathological changes produced in the host tissues due to the infestation of arthropods.

I. Course Title : Advances in Protozoology

II. Course Code : VPA 604

III. Credit Hours : 2+1

IV. Theory

Unit I

Advanced studies on Taxonomy, Molecular biology, Pathogenesis and Immunology of intestinal protozoa.

Unit II

Advanced studies on Taxonomy, Molecular biology, Pathogenesis and Immunology of haemoprotozoans.

Unit III

Advanced studies on Taxonomy, Molecular biology, Pathogenesis and Immunology of tissue and other protozoa.

V. Practical

Morphological, pathological and immunodiagnosis of protozoan diseases

I. Course Title : Immunology of Parasitic Diseases

II. Course Code : VPA 605

III. Credit Hours : 1+2

Unit I

To study the salient features of immune responses in relation to trematode, cestode, nematode and protozoan infections in livestock. Immune responses to arthropod infestations.

Unit II

Principles and applications of immunodiagnostic methods for parasitic diseases.

Unit III

Standardization of immunodiagnostic methods for parasitic diseases.

Unit IV

Identification of candidate antigens for diagnosis and vaccine development.

IV. Practical

Methods for purification of antigens, fractionation and characterization of antigens, identification of candidate antigens as drug targets, raising of hyperimmune sera, development and standardization of immunodiagnostic methods for the diagnosis and control of parasitic infections.

I. Course Title : **Molecular Diagnostics and Vaccine Development for Parasitic Diseases**

II. Course Code : **VPA 606**

III. Credit Hours : **2+1**

IV. Theory

Unit I

Introduction to molecular taXonomy of parasites.

Unit II

Genome organisation in parasites of veterinary importance. Structure and function of nucleic acids.

Unit III

Basic plan of gene cloning, and eXpression in heterologous host. Production of recombinant protein and downstream processing for diagnostic/ prophylactic applications.

Unit IV

General concept of protein synthesis. Identification and molecular characterization of proteins of diagnostic/ prophylactic relevance of parasitic origin.

Unit V

Nucleic acid based techniques for genetic characterization and sensitive diagnosis of parasitic infections; PCR, LAMP, Nucleic acid hybridization technique, pyrosequencing, Real Time PCR, DNA Microarray, Microsatellite analysis, RNAi, Reverse Genetic Approaches and their applications.

Unit VI

Hybridoma technology. Principle of production of monoclonal antibody. The diagnostic application of monoclonal antibodies of parasitic infection.

Unit VII

DNA vaccine, Vector vaccine, Recombinant protein based vaccine, Subunit vaccine, Principle and Application.

V. Practical

Identification, Characterization, and Purification of Recombinant Protein Antigens; SDS-PAGE and Western Blotting, Extraction and quantification of nucleic acid and PCR and related techniques.

I. Course Title : Host Parasite Interactions

II. Course Code : VPA 607

III. Credit Hours : 2+0

IV. Theory

Unit I

Introduction, Distribution of parasites on/ in the host, Morphological adaptation for better survival in/ on the host.

Unit II

Behavioural defences, Host immune responses and Genetic resistance to parasites.

Unit III

Establishment of parasites in immune competent, Susceptible, Intermediate and Abnormal hosts, Chronicity of parasitic infections, Immuno evasive strategies of the parasites and host-parasite equilibrium.

Unit IV

Pathological consequences of host parasite interactions in relation to malnutrition and micronutrient metabolism.

I. Course Title : *In-vitro* Cultivation of Parasites

II. Course Code : VPA 608

III. Credit Hours : 1+2

IV. Theory

Unit I

Introduction, problems and goals of *in-vitro* cultivation of parasites.

Unit II

In-vitro cultivation of genital, Intestinal flagellates and Intestinal ciliates.

Unit III

In-vitro cultivation of intestinal protozoa.

Unit IV

In-vitro cultivation of haemoprotozoa.

Unit V

In-vitro techniques, media and tissue culture for cultivation of helminths and their larval stages.

Unit VI

In-vitro mass rearing and colonization of ticks, flies and other insects**.**

V. Practical

Preparation of media, sterilization methods and cultivation of different parasites.

I. Course Title : Emerging and Re-Emerging Parasitic Diseases
II. Course Code : VPA 609
III. Credit Hours : 2+0

IV. Theory

Unit I

Emerging and re-emerging helminthic diseases.

Unit II

Emerging and re-emerging protozoan diseases.

Unit III

Emerging and re-emerging vector- borne diseases.

I. Course Title : Biology and Ecology of Parasites
II. Course Code : VPA 610
III. Credit Hours : 3+0

IV. Theory

Unit I

Ultrastructure, Physiology, Biochemistry and Bionomics of trematodes and cestodes of veterinary importance.

Unit II

Ultrastructure, Physiology, Biochemistry and Bionomics of nematodes of veterinary importance.

Unit III

Ultrastructure, Physiology, Biochemistry and Bionomics of important arthropod parasites.

Unit IV

Ultrastructure, Physiology, Biochemistry and Bionomics of important protozoan parasites.

Unit V

Ecology related definitions, Environmental changes and ecological disturbances due to natural phenomenon and human interventions (demographic, societal and agricultural changes global warming, floods, hurricanes and pollution.

Unit VI

Principles of Remote Sensing, GIS and their role in Veterinary Parasitology.

I. Course Title : Molecular Veterinary Parasitology

II. Course Code : VPA 611

III. Credit Hours : 2+0

IV. Theo

ryUnit

I

Introduction to molecular biology of parasites-Biological molecules (carbohydrate, protein and nucleic acid)- Eukaryotic cell structure, cell membrane and organelles-kinetoplast, apicoplast, cilia, flagella biology-Eukaryotic cell metabolism and cell respiration-Oxidative phosphorylation-anaerobic metabolism in parasites-fatty acid metabolism of parasites-cellular reproduction mendelian genetics in parasites and vectors- Genome of parasites of veterinary importance, genome size- molecular taxonomy-DNA barcoding-phylogenetics.

Unit II

Genetic code- Gene expression-Transcription and Translation-post translational modifications- RNA interference in parasites-CRISPR/ Cas9 inparasites-metagenome-microbiome-transcriptome of parasites-transgenic and para transgenic approach in parasites-drug resistance mechanisms.

Unit III

Molecular biology of helminth parasites such as *Fasciola* spp, *Schistosoma* spp, *Taenia* spp, *Echinococcus* spp, *Toxocara* spp, *Haemonchus* spp., *Dictyocaulus* spp.

I. Course Title : Parasite Epidemiology

II. Course Code : VPA 612

III. Credit Hours : 2+0

IV. Theory

Unit I: Introduction to epidemiological concepts

Definitions, aims and uses of epidemiological studies, Approaches of epidemiology (descriptive, analytical and eXperimental), Types of epidemiological studies along with their advantages and disadvantages, Features of parasitic disease epidemiology. Measures of disease frequency: Morbidity and mortality (Rate, Ratio, Proportional rate), Measures of morbidity (Cumulative incidence, Incidence rate, Attack rate, Prevalence-Point and Period) and mortality (Cumulative Mortality, Mortality rate, Death rate, Age/ SeX/ Breed death rate, Case fatality proportion, Cause specific death rate, etc.). The epidemiological triangle, iceberg concept, endemic stability, herd immunity concept, etc.

Unit II: Methods in epidemiology

Cross-sectional, case control and cohort studies. Techniques of epidemiological surveys.

Types of sampling- Non-probability sampling (target sampling, choice sampling, etc.), Probability sampling (Random samples, systemic sampling, stratified sampling. cluster sampling, etc.). Sample size calculation for different epidemiological and eXperimental studies.

Unit III: Advances in Epidemiological techniques

Sero-epidemiological methods used in important parasitic disease-Uses and limitations, Properties and Evaluation. Molecular epidemiology- Principles, laboratory methods, Bioinformatics in molecular epidemiology. Serological and molecular epidemiology of important parasites. Remote sensing and geographic information system- Scope and applications in Veterinary Parasitology.

Unit IV: Epidemiology of Important Parasitic Diseases

Epidemiological factors affecting distribution and transmission of important parasitic diseases of animals and birds- Agent Factors/ Disease Patterns, Environment and Disease Patterns, Social Factors and Disease Patterns, etc. Parasitic disease monitoring and evaluation, outbreak investigations and surveillance. Forecasting of parasitic diseases

V. Suggested Reading

- Abubakar I, Stagg HR, Cohen T and Rodrigues LC. 2016. *Infectious Disease Epidemiology*, 1st Edn, Oxford University Press.
- Alan Gunn and Sarah Jane Pitt. 2012. *Parasitology: An integrated Approach*, 1st Edition, Wiley.
- Angela ER, Taylor and John R Baker. 1968. *In-vitro cultivation of parasites*, 1st Edition, Blackwell Scientific Pub.
- Atkinson CT, Thomas NJ and Hunter DB. 2009. *Parasitic diseases of wild birds*, 1st Edition, John Wiley and Sons, Inc

- Bhatia BB, Pathak KML and Juyal PD. 2014. *Textbook of Veterinary Parasitology*, 3rd Edition, Kalyani Publishers
- Boothroyd JC and Komuniecki R. 1995. *Molecular Approaches to Parasitology*. 1st Edition, Wiley-liss Publication, New York.
- Cohen S and Sadun EH. 1976. *Immunology of Parasitic Infections*, 1st Edition, Blackwell Scientific Publications
- David P Huges, Jacques Brodeur and Frederic Thomas. 2012. *Host manipulation by parasites*, Oxford University Press
- Elizabeth A Zeibeg. 2012. *Clinical Parasitology- A practical approach*. 2nd edition, Elsevier Health Sciences
- GW Krantz and DE Walter. 2009. *A manual of Acarology*, 3rdEdition, Texas Tech University Press
- Hendrix CM and Robinson E. 2017. *Diagnostic Parasitology for Veterinary Technicians*. 5th Edition. St. Louis, Missouri: Elsevier Inc
- Joanne P. 2009. *Advances in Parasitology Natural history of host- parasite interactions*- 1stedition, Vol 68 Academic Press
- Kennedy MW and Harnett W. 2001. *Parasitic nematodes: molecular biology*, *biochemistry*, *immunology*, 2nd Edition, CABI Publishing
- Kettle DS. 1995. *Medical and Veterinary Entomology*, 2nd Edition, CAB International
- Levine ND. 1999. *Veterinary Protozoology*, 1st edition, Wiley-Blackwell
- MA Taylor, RL Coop and RL Wall. 2015. *Veterinary Parasitology*, 3rd Edition, Wiley- Blackwell publishers.
- Marr JJ, Nilsen TW and Komuniecki RW. 2003. *Molecular Medical Parasitology*, 1st Edition, Elsevier
- Mehlhorn H. 2016. *Animal Parasites: Diagnosis*, *Treatment*, *Prevention*. 1st Edition, . Springer International Publishing
- Pittaway AR. 1991. *Arthropods of Medical and Veterinary Importance*, 1st Edition, CAB International
- Richard Wall and David Shearer. 1997. *Veterinary Entomology*, 1stEdition, Springer, Dordrecht
- Samuel W, Pybus M and Kocan A. 2001. *Parasitic Diseases of Wild Mammals*, 2nd Edition, Iowa State Univ. Press.
- Smyth JD. 1995. *Introduction to Animal Parasitology*, 3rdEdn., Cambridge University Press
- Soulsby EJL. 1982. *Helminths*, *Arthropods and Protozoa of Domesticated Animals* 7th Edition, Baillière Tindall, London
- Taylor MA, Coop RL and Wall RL. 2015. *Veterinary Parasitology*, 3rdEdn, Wiley- Blackwell Publishers
- Tibor Kassai. 1999. *Veterinary Helminthology*, 1stEdition, Butterworth-Heinemann publishers
- Urquhart GM, Armour J, Duncan JL, Dunn AM and Jennings FW. 1996. *Veterinary Parasitology*, 2nd Edition, Blackwell Science, London, UK
- Wakelin D. 1996. *Immunity to Parasites*. 2nd Edition, Cambridge University Press
- Walker A. 1994. *Arthropods of Humans and Domestic Animal: A Guide to Preliminary Identification*, 1st Edition, Springer Netherlands
- Zajac AM and Conboy GA. 2012. *Veterinary Clinical Parasitology*, 8th Edition, Wiley-Blackwell.
- Protozoological abstracts
- Advances in Parasitology
- Trends in Parasitology
- Experimental Parasitology
- Relevant Research/ Review articles

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Veterinary Para-Clinical Subjects

– Veterinary Public Health and Epidemiology

Course Title with Credit Load
M.V.Sc. in Veterinary Public Health and Epidemiology

Course Code	Course Title	Credit Hours
VPE 501	Concepts in Veterinary Public Health and One Health*	2+0
VPE 502	Zoonoses-I*	2+1
VPE 503	Zoonoses-II*	2+1
VPE 504	Principles of Epidemiology*	2+1
VPE 505	Hygiene and Safety of Foods of Animal and Aquatic Origin*	2+1
VPE 506	Food-borne Infections and Intoxications	2+1
VPE 507	Food Safety Standards, and Regulations	2+1
VPE 508	EnvironmentalHygiene and Safety	2+1
VPE 509	Applied Epidemiology	2+1
VPE 510	Biosecurity, Bioterrorism and Disaster Management	2+0
VPE 511	Laboratory Techniques in Veterinary Public Health*	0+3
VPE 591	Master's seminar*	0+1
VPE 599	Master's research	30

*Core courses

Course Contents
M.V.Sc. in Veterinary Public Health and Epidemiology

I. Course Title : Concepts in Veterinary Public Health and One Health

II. Course Code : VPE 501

III. Credit Hours : 2+0

IV. Theory

Unit I

VPH administration; organization, administration and implementation of VPH services/ programs; Structure and function of VPH agencies/ organizations of national and international importance. VPH team, administration and functions; responsibilities of veterinarians in public health team.

Unit II

Definition: One Health. Historical emergence of the concept. Scope, Objective and Area of activities of One Health. Strategic frame-work. Purpose for creation of Veterinary Public Health and Epidemiology –NET.

Unit III

Global burden of disease, Coordinated and systemic disease control response, Ecosystem, Urbanization intensive agriculture and animal husbandry practices, Host-pathogen interaction, Anti-microbial resistance and climate change.

V. Suggested reading

- Calvin W Schwabe. 1984. *Veterinary Medicine and Human health*. Williams and Wilkins
- Sherikar AT, Bachhil VN and Thapliyal DC. 2013. *Text book of Elements of Veterinary Public Health*, ICAR, Govt. of India.
- Zinsstag J, Schelling E, Waltner-Toews D, Whittaker M and Tanner M. 2015. *One Health: the theory and practice of integrated health approaches*. CABI.

I. Course Title : Zoonoses-I

II. Course Code : VPE 502

III. Credit Hours : 2+1

IV. Theory

Unit I

Definition and classification, Factors affecting the occurrence of zoonoses; Disease management strategies, Disease burden on population and socioeconomic impacts.

Unit II

History, Etiology, Epidemiology, Diagnosis and management of important Bacterial zoonoses, viz., Anthrax, Brucellosis, Tuberculosis, Leptospirosis, Salmonellosis, Borreliosis, Cat scratch disease, Glanders, Lyme disease, Malidiosis, Streptococcosis, Plague, Rat bite fever, Tetanus, Tularemia, Yersiniosis, Staphylococcosis, Vibriosis, Listeriosis, Campylobacteriosis and others.

Unit III

History, Etiology, Epidemiology, Diagnosis and Management of important Mycotic zoonoses, viz., Dermatophytosis, Blastomycosis, Coccidioidomycosis, Cryptococcosis, Histoplasmosis, Aspergillosis, Candidiasis, Rhinosporidiosis, Sporotrichosis and others.

Unit IV

History, Etiology, Epidemiology, Diagnosis and Management of Chlamydiosis (Psittacosis and Ornithosis) and Prions diseases, viz., Creutzfeldt-Jakob Disease (CJD); Variant Creutzfeldt-Jakob Disease (vCJD), Kuru. Bovine Spongiform Encephalopathy (BSE), Chronic Wasting Disease (CWD) and Scrapie.

V. Practical

Isolation and identification of important Bacterial, Mycotic and Chlamydial agents of public health significance from host, Vehicle and environment.

VI. Suggested reading

- Bauerfeind R, Graevenitz AV, Kimmig P, Schiefer HG, Schwarz T, Slenczka W and Zahner H. 2016. *Zoonoses: infectious diseases transmissible from animals and humans* (No. Ed. 4). American Society for Microbiology (ASM).
- Mahendra Pal.Zoonoses.
- Narayan KG *Epidemiology*, *Diagnosis and Management of Zoonoses*.
- Pedro N Acha and Boris Szyfres. *Zoonoses and Communicable Diseases Common to Man and Animals*.
- Seyedmousavi S, De Hoog GS, Guillot J and Verweij PE. 2018. *Emerging and Epizootic Fungal Infections in Animals*. Springereds.
- Thapliyal DC. 1999. *Diseases of animals transmissible to man*. 1st ed. International Book Distributing Company, Lucknow.
- *Zoonoses: Recognition Control and Prevention* (Martin E, Jones EH, Hubbart WT and Hagstard HV)

I. Course Title : Zoonoses-II

II. Course Code : VPE 503

III. Credit Hours : 2+1

IV. Theory

Unit I

Disease burden, History, Etiology, Epidemiology, Transmission pattern, Diagnosis and management of important viral zoonoses, viz., Japanese encephalitis, Tick-borne encephalitis, Encephalomyelitis, Rabies, Influenza, KFD, Rift valley fever, Chickungunya, FMD, and Enteroviruses.

Unit II

Disease burden, History, Etiology, Epidemiology, Transmission pattern, Diagnosis and management of important viral zoonoses, viz., Crimean-Congo haemorrhagic fever, Dengue, West-Nile fever, Yellow fever, Rift-valley fever, Equine encephalitis, Louping ill, Ebola, Marburg, Hantavirus, Zika, Hendra, Nipah and Corona viruses.

Unit III

Disease burden, History, Etiology, Epidemiology, Transmission pattern, Diagnosis and Management of important Rickettsial zoonoses, viz., Q fever, Typhus fever group.

Unit IV

Disease burden, Etiology, Host range, Epidemiology, Transmission pattern, Diagnosis and Management of important Parasitic zoonoses, viz., Hydatidosis, Taeniosis, Trichinosis, Fascioliosis, Fasciolopsiosis, Toxoplasmosis, Trypanosomosis, Cryptosporidiosis, Cysticercosis, Leishmaniosis, Sarcocystosis, Dracunculosis, Paragonimosis and Diphylobothriosis.

V. Practical

Isolation and identification methods for important viral and parasitic agents of public health significance from host, vehicle and environment.

VI. Suggested Reading

- Bauerfeind R, Graevenitz AV, Kimmig P, Schiefer HG, Schwarz T, Slenczka W and Zahner H. 2016. *Zoonoses: infectious diseases transmissible from animals and humans* (No. Ed. 4). American Society for Microbiology (ASM).
- Mackie and Mc. Cartney. *Practical Medical Microbiology*.
- Parija SC. *Text book of Medical Parasitology*.
- Pedro N Acha and Boris Szyfres. *Zoonoses and Communicable Diseases Common to Man and Animals.*
- Soulsby JL *Helminthes, Arthropods and Protozoa of Domesticated Animals.*
- Steele JL. *CRC Handbook series in Zoonoses.*
- Thapliyal DC. 1999. *Diseases of animals transmissible to man*. 1st ed. International Book Distributing Company, Lucknow.

I. Course Title : Principles of Epidemiology

II. Course Code : VPE 504

III. Credit Hours : 2+1

IV. Theory

Unit I

Historical perspective and scope of veterinary epidemiology. Theories of disease causation and advancement in the concepts of disease causation, Iceberg concept. Koch's postulates of disease causation. Epidemiological tringles, Disease causing wheels, webs and pies.

Unit II

Definitions: Epidemic, Endemic, Pandemic and Sporadic diseases. Qualitative and quantitative approaches to epidemiology. Measurement of disease. Endemic stability and herd immunity, Basic reproductive ratio, Trends and spatial distribution of disease, Epidemic curve and their utility.

Unit III

Transmission of disease and role of ecology in maintenance of disease agents. Type of epidemiological methods. Landscape and molecular methods used in the epidemiological investigation.

Unit IV

Epidemiological Studies-Observational (Case-control, cohort and cross-sectional studies) and eXperimental studies (field and clinical trials). Disease surveys, monitoring and surveillance. Epidemiological data bases.

Unit V

Definition, scope and limitation of serological epidemiology and interpretation of results. Characteristics of ideal serological test, multiple testing and evaluation of tests. Investigation of disease outbreaks. Strategies of disease control and eradication.

V. Practical

Data collection from various sources, analysis and interpretation. Serum collection method demonstration. Analytical diagnostic and relative sensitivity and specificity calculation. use of software for data analysis.

VI. Suggested Reading

- Elliot P, Wakefield JC, Best NG and Briggs DJ. 2000. *Spatial Epidemiology: methods and applications*; OXford University Press.
- Martin SW, Meek AH and Willeberg P. 1986. *Veterinary Epidemiology: Principles and methods*. IOWA State University Press/ Ames, Iowa. USA.
- Pfeiffer D. 1998. *Veterinary Epidemiology. An Introduction. Institute of Veterinary, Animal and Biomedical Sciences.* Massey University, Palmerston, New Zealand.
- Salman M. 2008. *Animal disease surveillance and survey systems: methods and applications*. John Wiley and Sonsed.
- Thrusfield M. 1995. *Veterinary Epidemiology*: Blackwell Science Ltd. OXford, UK.

I. Course Title : Hygiene and Safety of foods of Animal and Aquatic origin

II. Course Code : VPE 505

III. Credit Hours : 2+1

IV. Theory

Unit I

Principles of food hygiene in relation to foods of animal and aquatic origin. Importance of food hygiene in public health. Impact of environmental sanitation and other factors on food quality. General principles of prevention of food-borne illnesses, risk analysis.

Unit II

Importance and objectives of milk hygiene. Hygienic production, Handling, Transportation, Storage and marketing of milk. Mastitis. Milk spoilage and preservation. Milk-borne diseases of public health significance. Milk allergy-lactose intolerance. Residues of pesticide and antibiotics in milk and its impact on human health. Milk spoilage. Milk adulteration, synthetic milk. Milk plant hygiene and sanitation.

Unit III

Objectives and importance of meat hygiene. Hygienic practices at farm and during transportation of food animals including poultry. Hygienic meat production-an overview. Adulteration. Speciation, spoilage and preservation of meat. Meat-borne diseases of public health significance. Treatment and safe disposal of slaughter-house by-products. Hygienic practices in abattoirs.

Unit IV

Fish, fisheries and ichthyology: an introduction. Environmental factors affecting aquatic food hygiene. Hygienic production, Handling, Preservation, Transportation and marketing of aquatic foods. Microbiology and Spoilage of aquatic foods. Safe disposal of fish byproducts. Fish-borne diseases of public health significance.

V. Practical

Collection of meat/ milk/ egg/ fish samples for determination of physical as well as microbiological quality. Examination of meat/ milk samples for possible adulteration.

VI. Suggested reading

- FAO (Manual No. 79). *Manual on simple methods of Meat preservation.*
- Marriott NG, Schilling MW and Gravani RB. 2018. *Principles of Food sanitation*; Springer.
- Nollet LM and Toldrá F. 2016. *Safety Analysis of Foods of Animal origin*, CRC Press.ed.
- Norer R. 2016. *Genetic Technology and Food Safety*; Springer International Publishinged.
- Wro and Bruno. *Fish Disease and Disorders – Viral Bacterial and Fungal Infections.*

I. Course Title : Food-borne Infections and Intoxications

II. Course Code : VPE 506

III. Credit Hours : 2+1

IV. Theory

Unit I

Definition: Food borne infection, Food intoxication, Bacterial toxins, Toxi-infection, etc. Classification, Epidemiology, Disease burden and Economics of food-borne diseases. Reservoirs of food-borne pathogens and its mode of transmission. Vehicles of pathogens. Measures employed for prevention and control of food-borne diseases. Food- poisoning outbreak investigation and management.

Unit II

Epidemiology, Economic, Diagnosis and Management of bacterial food-borne infections and intoxications due to *Salmonella, Campylobacter, Clostridium, Staphylococcus, Listeria monocytogenes, Vibrio parahaemolyticus, E.coli, Bacillu cereus, Shigella, Yersinia enterocolitica* and others. Types of bacterial toxins and its manifestations.

Unit III

Epidemiology, Economics, Diagnosis and Management of food-borne Viral pathogens: Hepatitis viruses, Entero-viruses, Noroviruses, Rotaviruses and other. Food- borne parasitic and rickettsial infections.

Unit IV

Illness due to food additives, seafood toxins, mycotoxins, biocides, plant origin toxins, heavy metals, veterinary drugs, hormones, etc. in foods. Anti-microbial resistance (AMR) in food-borne pathogens-definition, current status, factors responsible, mechanism of resistance, mode of transmission and control.

V. Practical

Food-borne disease outbreak investigation. Detection, characterization and quantitation of food-borne pathogens, toxins, antibiotics, pesticides and additives in foods.

VI. Suggested reading

- Cliver DO, Potter M and Riemann HP. 2011. *Food borne Infections and Intoxications*; Elsevier.
- D'Mello JPF. *Food Safety-Contaminants and Toxins.*
- Jay JM, Loessner MJ and Golden DA. 2008. *Modern food microbiology*; Springer Science and Business Media.
- Hubbert WT. *Food Safety and Quality Assurance-Foods of Animal Origin.*
- Vernam AH. 1991. *Food-borne pathogens*; Wolfe Publishing Ltd, London.

I. Course Title : Food Safety Standards and Regulations

II. Course Code : VPE 507

III. Credit Hours : 2+1

IV. Theory

Unit I

Indicators of food quality and spoilage (biological and others). Food plant hygiene and sanitation. Hurdle technique and its relevance. Microbiological criteria for food quality.

Unit II

Food standards- National, International, Private standards. GSP, GMP, HACCP and ISO 22000, etc. Genesis of food safety standards, Mechanism of food safety standards formulation, Agencies associated in food standard formulation, Role of WTO, FSSAI, BIS and others in standard formulation. National and international regulations and legislation enacted for quality food production.

Unit III

Detection of Pesticides, Veterinary drug residues, Heavy metal in food samples. Visits to the various food processing units for examining the compliance of HACCP/ FSSAI regulations and other standards. Microbiological assessment of cleanliness of surface and equipment in abattoir/ meat/ milk plant

VII. Suggested Reading

- Fortin ND. 2016. *Food Regulation: law, science, policy, and practice*. John Wiley and Sons.
- Joint FAO. 2004. *Codex alimentarius: food hygiene basic texts* (No. Ed. 3). Food and Agriculture Organization of the United Nations.
- Josling TE, Roberts D and Orden D. 2004. *Food Regulation and Trade: toward a safe and open global system;* Peterson Institute Press.
- Van Der Meulen and Bernd. 2011. *Private Food Law: Governing food chains through contract law, self-regulation, private standards, audits and certification Schemes*. The Netherlands: Wageningen Academic Publishers.
- Vos E. 1999. *Institutional frameworks of community health and safety legislation: Committees, agencies, and private bodies*. Hart.

I. Course Title : Environmental Hygiene and Safety

II. Course Code : VPE 508

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction to environment, Environmental hygiene, Pollutants and its impact on animal/ human health. Green-house gasses and its effect. Microbial pollution. Environmental risk assessment and management.

Unit II

Nature and characteristics of various environmental pollutants. Pollutions of soil, air and water and its effects on health. Impact of noise pollution on health.

Unit III

Genetic risk from Environmental agents, Health problems due to nuclear energy, Microwave, Electro-magnetic and other radiation pollution, Environmental estrogens, Pesticides pollution. Industrial pollution as well as pollution due to plastic and petrochemical products.

Unit IV

Role of live-stock in environmental pollution, Dissemination of excreted pathogens, animal-waste and human risk, principles of safe disposal of bio-medical waste and recycling of wastes

Unit V

Contamination of environment with heavy metals, pesticides, veterinary drug residues and its impact on human health. National and international pollution control agencies and its role in management of environmental pollution. Regulations on control of environmental pollution.

V. Practical

Determination of portability of drinking water, Estimation and detection of pathogenic microbes in water, air, soil, animal products, sewage, and animal waste; Visit of sewage and waste disposal plants/ sites.

VII. Suggested reading

- Fairman R, Mead CD and Williams WP. 1998. *Environmental risk assessment: approaches, experiences and information sources.*
- Frumkin H. 2016. *Environmental health: from global to local.* John Wiley and Sons.ed.
- Levy BS. 2006. *Occupational and environmental health: recognizing and preventing disease and injury*. Lippincott Williams and Wilkins. ed.
- Linkov I and Ramadan AB. 2004. *Comparative risk assessment and environmental decision making* (Vol. 38). Springer Science and Business Media.Ed.
- Ray M. *Environmental Pollution: Impact of technology on quality of life.*
- Richard B Philp. *Environmental Hazards and Human Health*

I. Course Title : Applied Epidemiology

II. Course Code : VPE 509

III. Credit Hours : 2+1

IV. Theory

Unit I

Introduction to applied epidemiology. Models, modelling and types of models. Epidemiological and economic models. Principles and classification of models. Deterministic and stochastic models. Empirical and explanatory models. Application of models in disease forecasting. Modelling in disease prevention and control.

Unit II

Disease occurrence, Ecology of disease, Monitoring and surveillance. Outbreak investigation protocol. Path, regression and discriminate analyses. Time series analysis and analysis of variance.

Unit III

Animal disease economics (cost-benefit analysis, internal rate of return, payback period, partial budgeting), decision analysis. Bayesian analysis. Monte-Carlo and Markovian processes and system evaluation. Uses of multivariate analysis.

Unit IV

Disease outbreaks, Participatory epidemiology, Disease reporting system, Tracing and notification. Disease control strategies, Risk assessment, Exotic diseases, Trans-boundary diseases, Vaccination.

Unit V

Definition; Disease intelligence. Tele-epidemiology. Remote sensing, Geographic information system, Disease surveillance and Early warning system.

V. Practical

Survey, Sampling and Data presentation. Measurements of disease occurrence, Outbreak investigation and reporting. Use of epidemiological software.

VI. Suggested Reading

- Brownson RC and Petitti DB. 1998. *Applied Epidemiology: theory to practice*. Oxford University Press.
- Durr PA and Gatrell AC. 2004. *GIS and spatial analysis in veterinary science*. Cabi. Ed.
- Toma B, Dufour B, Sanaa M, Benet JJ, Moutou F, Louza A and Ellis P. 1999. *Applied Veterinary Epidemiology and the control of disease in populations*. 7 Avenue du Général de Gaulle.
- Twisk JW. 2013. *Applied longitudinal data analysis for epidemiology: a practical guide*. Cambridge university press.

I. Course Title : Bioterrorism and Disaster Management

II. Course Code : VPE 510

III. Credit Hours : 2+0

IV. Theory

Unit I

Definition: Bioterrorism. Major agents used as biological weapons, Hazard analysis and combating bioterrorism. Bio-ethics and social ethics, Advisory role of veterinarians during such events.

Unit II

Definitions, Natural and man- made disaster, Impact analysis and classification of disaster scale, Essential preparations to manage disaster, Role of central, State and Local government bodies in disaster management, Role of veterinarians/ veterinary public health personnel during emergency/ Disaster and sequence of emergency medical services.

Unit III

Effect of natural disasters like floods, Prolonged draughts, Forest fires, Earthquakes, Tsunami and Tidal damages, Storms, etc. on human as well as animal population, post-disaster disease susceptibility and remedial measures.

Unit IV

Biosecurity– definition, importance, methods used for pathogen inventory, Food processing/ quarantine units/ animals/ poultry farms, etc. Biomedical hazards and biosafety in the laboratories. Occupational health risk and its management.

V. Suggested Reading

- Antosia RE and Cahill JD. 2006. *Handbook of bioterrorism and disaster medicine*. Springer.ed.
- Hodgkinson PE and Stewart M. 1991. *Coping with catastrophe: A handbook of disaster management*. Taylor and Frances/ Routledge.
- Van De Walle B, Turoff M and Hiltz SR. 2014. *Information systems for emergency management*. Routledge.
- Van Oosterom P, Zlatanova S and Fendel E. 2006. *Geo-information for disaster management*. Springer Science and Business Media.Ed.

I. Course Title : Laboratory Techniques in Veterinary Public Health

II. Course Code : VPE 511

III. Credit Hours : 0+3

IV. Practical

Unit I

General practices: Use of PPE (Personal Protective Equipment) and biosafety cabinets, Preparation of glass-wares, cultural media, buffer solution, solutions of different molarity and other laboratory materials. Sampling methods for biological materials. Quality analysis of milk, meat, water and other food materials and others.

Unit II

Microbiological techniques: Plate counts, Enumeration and isolation of psychrophilic, Thermophilic and thermoduric organisms in food samples, Enumeration, isolation and identification of important food-borne pathogens, Detection of bacterial toxin involved in food-poisoning, Detection of viral pathogens in various samples. Isolation, identification and enumeration of yeast/ molds/ spores in food samples.

Unit III

Immunological/ Serological and electrophoretic techniques: AGPT, Precipitation tests, Agglutination test, Haem-agglutination test, Polyacrylamide gel electrophoresis, Counter immuno- gel electrophoresis, ELISA, FAT, Intra-dermal inoculation tests and others.

Unit IV

Detection and quantification of residues of pesticides and drugs using immunological and chromatographic methods.

Unit V

Methods for isolation and quantitation of genomic DNA/ RNA from bacterial and other biological specimens using Latest molecular techniques and others. Laboratory records and log books of equipment.

V. Suggested Reading

- Bremner A and Jhonston M. *Poultry Meat Hygiene and Inspection.*
- Duncan JR and Prasse KW. 1986. *Veterinary Laboratory Medicine* (No. Ed. 2). Iowa State University Press.
- Garvin ML *Infectious Waste Management-A practical guide.*
- Gradwohls' *Clinical Lab Methods and Diagnosis.*
- Jerome KR. 2016. *Lennette's laboratory diagnosis of viral infections.* CRC (Sonnenwirth and Jarett) Press. ed.
- Prasad J and Neeraj. *Principles and Practice of Animal Health and Hygiene.*
- Rupprecht C and Nagarajan T. 2015. *Current laboratory techniques in rabies diagnosis, research and prevention* (Vol. 2). Academic Press.ed.

Course Title with Credit Load
Ph.D. in Veterinary Public Health and Epidemiology

Course Code	Course Title	Credit Hours
VPE 601	Advances in Veterinary Public Health and Epidemiology*	2+1
VPE 602	Emerging, Re-emerging Zoonoses and One Health*	2+1
VPE 603	Advances in Food Safetyand Quality Control of Foods of Animal/ Aquatic origin*	2+1
VPE 604	Biosecurity and Occupational Health Safety	2+1
VPE 605	Recent Concepts in Epidemiology and Disease Forecasting	2+1
VPE 606	Risk Analysis and Predictive Modelling	2+1
VPE 607	Advances in Environmental Hygiene	2+1
VPE 608	Herd Health Management and Disease Economics	2+1
VPE 609	Epidemiology of Trans-boundary, Non-infectious and Chronic diseased	2+1
VPE 610	Ecology and Animal/ Human Health	2+0
VPE 611	Diagnostic Approaches in Epidemiology	2+1
VPE 612	Surveys, Surveillance and Data Management	2+1
VPE 613	Research Methodology and Publication Ethics in VPE*	2+0
VPE 690	Special Problem	0+1
VPE 691	Doctoral Seminar-I*	0+1
VPE 692	Doctoral Seminar-II*	0+1
VPE 699	Doctoral Research	75

*Core Courses

Course Contents
Ph.D. in Veterinary Public Health and Epidemiology

I. Course Title : **Advances in Veterinary Public Health and Epidemiology**

II. Course Code : **VPE 601**

III. Credit Hours : **2+1**

IV. Theory

Unit I

Contemporary status of Veterinary Public Health in India and abroad. Public Health in the 21stCentury.Veterinary public health and its role in the society. Role of veterinary public health professionals in prevention and control of zoonoses. Organization and administration of veterinary public health agencies structure and functions. Data analysis framework in healthcare and social sectors. Evidence-based information updates on current VPH topics. Global animal disease surveillance.

Unit II

Recent diagnostic tools used for emerging public health problems including zoonoses. Molecular surveillance of recent pandemics of zoonoses. Modes of evolutionary emergence of disease agents pertinent to VPE.

Unit III

Application of bioinformatics, biotechnological and computational tools in food hygiene, safety, quality assurance and environmental health protection. Global pandemic threat preparedness. Emerging Disease Surveillance and Control. Biomedical models in veterinary public health.

V. Practical

Estimation of burden of food-borne zoonotic diseases. Special problems related to field investigations of outbreaks of food poisoning and zoonotic diseases in a community. Application of recent analytical methods and *in-silico* techniques for public health research. Visits to hospitals to acquaint the students with public health related problems.

VI. Assignments

Each student will select at least two recent articles from journals related to the course and discuss the same in the class through presentation.

VII. Suggested reading

- Eldridge BF and Edman JD. eds., 2012. *Medical entomology: A textbook on public health and veterinary problems caused by arthropods*. Springer Science and Business Media
- Noordhuizen, Josephus Pieter Thérèse Maria K Frankena, Michael V Thrusfield and EA M
- Graat. *Application of quantitative methods in veterinary epidemiology*. Wageningen Pers, 2001.
- Schwabe CW, Riemann HP and Franti CE. 1977. *Epidemiology in veterinary practice*. Lea and Febiger.
- Thrusfield M. 2018. *Veterinary epidemiology*. John Wiley and Sons.

I. Course Title : Emerging, Re-emerging Zoonoses and One Health

II. Course Code : VPE 602

III. Credit Hours : 2+1

IV. Theory

Unit I

Status of emerging and re-emerging zoonotic infections, National and international interests in zoonoses, Measurement and economics of zoonoses, Latest diagnostic and Management planning for zoonoses. Factors responsible for emergence and re-emergence of zoonotic diseases. Health threats at the human- animal-ecosystems/ environment interface (HAEI), a tripartite concept of OIE, WHO and FAO.

Unit II

Current challenges and strategies, euzoonoses, xenozoonoses, nosocomial zoonoses, newer zoonotic agents, viz., cat-scratch disease, rat bite fever, Creutzfeld-Jacob disease, Ebola, Marburg, Lassa, Nipah, Menangle, Herpes B, SARS, AI, ZIKA, MERS, etc.

Unit III

Simian and human immunodeficiency, bovine spongiform encephalopathy, hepatitis A and E, Toro, influenza viruses; re-emerging zoonoses with new pathology, viz., neuro-cysticercosis, campylobacteriosis, rabies, Guillain-Barre Syndrome, tuberculosis.

Unit IV

Safety regulations in laboratories, hospitals and biological plants. Use of bio safety cabinets. Bio security.

V. Practical

Special problems related to emerging/ re-emerging/ prevalent zoonotic diseases in India. Status of Brucellosis and Tuberculosis in the India, OIE recommended diagnostic tests, vaccines/ strategies for prevention and control. Visits to rural health centres to acquire status of zoonotic diseases.

VI. Assignments

Each student will select at least two recent articles from journals related to course and discuss the same in the class through presentation.

VII. Suggested reading

- Calvin W Schwabe. 1984. *Veterinary Medicine and Human health*. Williams and Wilkins
- Rezza G and Ippolito G. eds. 2017. *Emerging and Re-emerging Viral Infections*. Springer.
- Singh SK. ed. 2015. *Human Emerging and Re-emerging Infections*. John Wiley and Sons.

I. Course Title : **Advances in Food Safety and Quality Control of Foods of Animal/ Aquatic**

II. Course Code : **VPE 603**

III. Credit Hours : **2+1**

IV. Theory

Unit I

Food supply chain. Food handling practices. New age voluntary and mandatory food standards. Types and evolution of food standards. Characteristics of food safety hazards. Quality control, assurance and food safety specifications for animal origin foods such as meat, milk, egg and fish. Trends in green technologies in food production and processing.Impacts and performance of organic farming *vis-a-vis* conventional farming.

Unit II

Recent innovations in shelf-life extension, preservation and packaging. Requirements for food testing and calibration Laboratory Mechanism of food spoilage (microbial and non-microbial). Nature of major food-borne infections and intoxications. Traceability system. Waste reduction along the food supply chain.

Unit III

Rapid detection of food safety hazards. Food safety risk assessment. Quality assurance schemes applicable to foods of animal origin. Elements of national food control system. National food control systems. Global considerations and role of committees and agencies associated with food safety, quality control and quality assurance.

Unit IV

Genesis of food quality/ safety standard. Food quarantine and export guidelines, specifications and standards. National and international food safety compliances. Traceability of foods of animal origin.

V. Practical

Special problems on quality and safety of foods of animal origin foods. Detection, enumeration and identification of major food-borne pathogens. Visits to food processing establishments. Environmental impact assessment of production of foods of animal origin.

VI. Assignments

Each student will select at least two recent articles from journals related to course and discuss the same in the class through presentation.

VII. Suggested reading

- Marriott NG, Schilling MW and Gravani RB. 2018. *Principles of food sanitation*. Springer.
- Nollet LM and Toldrá F. eds., 2016. *Safety analysis of foods of animal origin*. CRC Press
- Paustenbach DJ. ed., 2015. *Human and Ecological Risk Assessment: Theory and Practice* (Wiley Classics Library). John Wiley and Sons.
- Toldrá F and Nollet LM. eds., 2017. *Advances in food diagnostics*. John Wiley and Sons.

I. Course Title : Biosecurity and Occupational Health Safety

II. Course Code : VPE 604

III. Credit Hours : 2+1

IV. Theory

Unit I

Definitions. Physical, Chemical and Biological hazards. Bio-safety and bio-security. Elements of bio-security and bio-containment. Biosecurity requirements. Containment Barriers. Equipment safety. Risk assessment. Bio-safety levels. Laboratory safety. Bio-safety in microbiological and biomedical laboratories.

Unit II

Risk groups, Classification of organisms by risk groups. Classification of occupational groups. Laboratory designs. Transmission, spread, Maintenance and control of diseases affecting various occupational groups in contact with animals and their public health significance. Diseases associated with various occupations.

Unit III

Occupational safety and health. Occupational Health and Safety (OHS) management system standard ISO 45001. regulations pertaining to the Occupational safety and health. Occupational Safety and Health Administration. International Labour Organization.

V. Practical

Diagnosis of occupational diseases of public health significance. Handling of Bio-safety cabinets. Relation of risk group to bio-safety levels, practices and equipment. Visit to BSL-3 and BSL-4 laboratories.

VI. Suggested reading

- Fleming DO and Hunt DL. 2006. *Biological safety: principles and practices* (No. Ed. 4). ASM Press.
- Guillén J. ed. 2017. *Laboratory Animals: Regulations and Recommendations for the Care and Use of Animals in Research*. Academic Press.
- Rabinowitz PM, Lefkowitz RY, Conti LA, Redlich CA and Weigler BJ. 2015. *Occupational health of laboratory animal workers. In Laboratory Animal Medicine* (pp. 1381-1402). Academic Press.
- World Health Organization. 2016. *Assessment Tool for Key Processes associated with the Design, Construction, Operation, Maintenance and Regulation of BSL-3 Facilities in the WHO African Region*.

I. Course Title : **Recent Concepts in Epidemiology and Disease Forecasting**

II. Course Code : **VPE 605**

III. Credit Hours : **2+1**

IV. Theory

Unit I

Review of epidemiological concepts and applications, recent concepts.

Unit II

Epidemiology of economically important diseases in the region (haemorrhagic septicaemia, foot and mouth disease, surra, brucellosis, PPR, swine fever, IBD, NCD, avian Influenza, sheep pox, contagious ecthyma, etc).

Unit III

Geographical Information System and its applications in epidemiology, various expert systems and their role in epidemiology.

Unit IV

Modelling and application of various models in disease forecasting. Epidemiological software and its applications, global and national early warning system.

V. Practical

Epidemiological exercises of economically important diseases in the region, use of Geographical Information System in epidemiology, various expert systems, modelling and various models used in disease forecasting, development of suitable epidemiological software for the prevailing problems to attend disease outbreaks including laboratory investigations and reporting of routs.

VI. Suggested reading

1. Beaglehole R, Bonita R and Kjellstrom T. 1993. *Basic Epidemiology*, World Health Organization, Geneva.
2. Lilienfeld DE and Stolley P. 1994. *Fundamentals of Epidemiology*, 3rd ed., Oxford University Press, New York
3. Noordhuizen JPTM, Frankena K, van der Hoofd CM and Graat EAM: *Application of quantitative methods in Veterinary Epidemiology*. Wageningen Pers, Wageningen, The Netherlands. 1997.
4. Raj S Bhopal. 2016. *Concepts of Epidemiology: Integrating the ideas, theories, principles and methods of epidemiology*. 3rd Ed., Oxford University Press. Oxford.

I. Course Title : Risk Analysis and Predictive Modelling

II. Course Code : VPE 606

III. Credit Hours : 2+1

Unit 1

Definitions. History of risk analysis. Relevance of risk analysis (RA) to food sector. Principles of risk analysis. Risk analysis components (risk assessment, management and communication). Microbial Risk Assessment (MRA) involving hazard identification, exposure assessment, hazard characterization, and risk characterization. Methodologies used in RA/ MRA. Qualitative and quantitative risk analysis. Quantitative Microbial Risk Assessment (QMRA) for foods of animal origin including water. Application of mathematical models to study propagation of microbial hazards from farm-to-fork. Risk-based decision-making.

Unit II

Variability and uncertainty inherent to biological data. Measurement and modelling of uncertainty and variability during risk assessment. Risk assessment, risk analysis and HACCP. Linking microbial food safety with risk assessment. Relevance of assumptions and observed data for predictive models. Study of software packages used for risk analysis.

Unit III

Mathematical modelling of microbial growth rate. Predictive modelling tools for food safety management. Microbial modelling for the prediction of product shelf life and safety. Applications of predictive modelling of microbial behaviour in foods.

IV. Practical

Modelling of infectious diseases using computational and mathematical methods. Building and analysing models of infectious diseases. Study of population-level processes for infectious diseases of animals and humans. Performing risk analysis for selected food safety hazards using microbial risk analysis tools. Risk assessment using through simulation modelling.

V. Suggested reading

1. Haas CN, Rose JB and Gerba CP. 1999. *Quantitative microbial risk assessment*. John Wiley and Sons.
2. Lelieveld HL, Holah J and Gabric D. eds., 2016. *Handbook of hygiene control in the food industry*. Woodhead Publishing.
3. Pastorok RA, Bartell SM, Ferson S and Ginzburg LR. eds., 2016. *Ecological modeling in risk assessment: chemical effects on populations, ecosystems, and landscapes*. CRC Press.
4. Subramaniam P and Wareing P. eds., 2016. *The stability and shelf life of food*. Woodhead Publishing.

I. Course Title : Advances in Environmental Hygiene

II. Course Code : VPE 607

III. Credit Hours : 2+1

IV. Theory

Unit I

Current status of problems pertaining to environmental hygiene, air, soil and water pollution, Disinfection procedures, Impact of global warming and other environmental problems leading to change in ecology of diseases and impact on human/ animal health; Carbon footprint, Eco-philosophy, Environmental ethics and Environmental economics, Environmental conflicts and cooperation.

Unit II

Environmental risks their assessment and management and reporting, modern global information, surveillance and monitoring systems, decision making and public awareness. Role of VPH in National Sanitation Programmes such as Swachh Bharat Abhiyan.

Unit III

International environmental management efforts, participatory international organizations and their selected programmes and selected legislations.

Practical

Detection and monitoring/ estimation of air, soil and water pollution; detection of pathogens from environmental sources. Visits to water/ sewage treatment plants.

Assignments

Each student will select at least two recent articles from journals related to course and discuss the same in the class through presentation.

VII. Suggested reading

1. Curtis SE. 1983. *Environmental management in animal agriculture*. Iowa State University Press.
2. Frumkin H. ed., 2016. *Environmental health: from global to local*. John Wiley and Sons.
3. Paustenbach DJ. ed., 2015. *Human and Ecological Risk Assessment: Theory and Practice* (Wiley Classics Library). John Wiley and Sons.
4. Sparling DW. 2016. *Ecotoxicology essentials: environmental contaminants and their biological effects on animals and plants*. Academic Press.

I. Course Title : Herd Health Management and Disease Economics

II. Course Code : VPE 608

III. Credit Hours : 2+1

IV. Theory

Unit I

General principles, interactions between health and production and herd immunity.

Unit II

Dairy cattle: mastitis, brucellosis and haemo-protozoan control and health management of dairy cows and calves.

Unit III

Health and production in swine, sheep, goats and poultry, vaccination, biosecurity practices for prevention and control of diseases.

V. Practical

Visit to various bovine, equine, sheep, goat and poultry farms, assessment of their problems, systematic programmes for prevention and control of specific diseases and its impact, calculation of disease economics. Animal-house hygienic practices.

Assignments

Each student shall select at least two recent articles from journals related to course and discuss the same in the class through presentation.

VI. Suggested Reading

- Dijkhuizen AA and Morris RS. 1997. *Animal health economics. Postgraduate Foundation in Veterinary Science,* University of Sydney, Sydney, Australia.
- FAO. 2016. *Economic analysis of animal diseases*. FAO Animal Production and Health Guidelines. No. 18. Rome.
- Schwabe CW. 1984. *Veterinary Medicine and Human Health*, *Baltimore*: Williams and Wilkins
- Rushton, Jonathan. 2009. *The economics of animal health and production*. CABI.

I. Course Title : Epidemiology of Trans-boundary, Non-infectious and Chronic Diseases

II. Course Code : VPE 609

III. Credit Hours : 2+1

IV. Theory

Unit I

Establishment of causality and associations in non-infectious and chronic diseases. Characteristics of Koch's/ Henle-Koch postulates and Evans' rules of disease causation. Unified principles of establishing causality for both infectious and non-infectious diseases. Infectious disease and chronic disease connections. Causal role of infectious agents in cancer (relating criteria). Establishment of trends in disease occurrence. Epidemiology of non-infectious and chronic diseases affecting different systems in various animal species.

Unit II

Emerging infectious determinants of chronic diseases- reasons for emergence, range of pathways and epidemiology of chronic non-infectious disease. Study of characteristics of risk factors (genetic, physiological, environmental, behavioral, etc) associated with non-infectious and chronic diseases. Demographic, epidemiological and nutrition transition. Social determinants of non-communicable diseases. Spatial and temporal epidemiology of non-infectious diseases, viz., nutritional, reproductive, chemical poisoning, toxicity (pesticides, poisonous plants), metabolic diseases, toxicities, neoplastic and other miscellaneous diseases.

Unit III

Global status of non-communicable diseases. Modelling of non-infectious non - communicable diseases or chronic diseases. Economic Impact of chronic diseases. Prevention and control: current status and future perspectives.

V. Practical

Measurement of burden of non-infectious and chronic diseases (mortality, morbidity, survival, risk factors, etc.). Controlled trials and short research problem(s) involving contemporary issues and research techniques. Animal models for the study of non-infectious and chronic diseases. Survey of non-infectious and chronic diseases using animal disease model systems.

VI. Suggested Reading

- Baldock C, Forman T, Geering B and Taylor B. 1999. *New Technologies in the fight against transboundary animal diseases*. In: FAO-Japan Cooperative Project: Collection of Information on Animal Production and Health. Rome, Italy: The Food and Agricultural Organization of the United Nations.
- Fernández PJ and White WR. 2016. *Atlas of transboundary animal diseases*. OIE (World Organisation for Animal Health).
- Martin SW, Meek AH and Willeberg P: *Veterinary epidemiology. Principles and methods*. 1986, IOWA State University Press/ Ames, Iowa, USA

  Noordhuizen JPTM, Frankena K, van der Hoofd CM and Graat EAM: *Application of quantitative methods in veterinary epidemiology*. Wageningen Pers, Wageningen, The Netherlands. 1997.
- Thrusfield M: *Veterinary epidemiology*. 1995.Blackwell Science Ltd. Oxford, UK.

I. Course Title : Ecology and Animal/ Human Health

II. Course Code : VPE 610

III. Credit Hours : 2+0

IV. Theory

Unit I

Establishment of links between animal/ human health with the ecosystems. Assessment of changing trends in the environments and its on the animal/ human health. Study of emerging public health threats linked to the changes in the environment. Study of landscape epidemiology of diseases. Study of contemporary issues centered on ecological and evolutionary perspectives of infectious diseases.

Unit II

Animal–human-ecosystem interface. Study of ecological/ environmental factors influencing spatio-temporal occurrence of disease such as temperature, rainfall and other environmental factors. Ecological conditions and evolutionary dynamics. Disease ecology based explanatory and predictive models. Elucidation of natural history and host-parasite interactions linked to the ecological factors.

Unit III

Ecology of vector borne diseases. Vector dynamics and ecology. Study extrinsic incubation period. Understanding of critical risk factors of spread such as timing, distribution, abundance of competent vectors.

Unit IV

Study of cyclical patterns of disease. Mapping environmental conditions with disease. Establishing functional links between environmental modifications and disease. Linking climate change with disease occurrence. Study of dynamics of ENSO with climate change and disease. Evolution of disease alert and forecasting systems. Use of global positioning and remote sensing tools for disease management. Early warning and GIS based disease predictions.

V. Suggested reading

- Norrgren L and Levengood JM. eds., 2012. *Ecology and Animal Health* (No. 2). Baltic University Press.
- Waltner-Toews, David. 2007. *The Chickens Fight Back: Pandemic Panics and Deadly Diseases that Jump from Animals to Humans*. Vancouver: Greystone Books
- World Health Organization. 2013. "*Zoonoses and Veterinary Public Health*." WHO

I. Course Title : Diagnostic Approaches in Epidemiology

II. Course Code : VPE 611

III. Credit Hours : 2+1

IV. Theory

Unit I

The concept of molecular basis of a disease, molecular determinants of pathogenicity of infectious agents and their transmissibility to susceptible populations of livestock and poultry.

Unit II

Laboratory biosafety, Antigenic, Genetic and Biological characterization of field isolates of pathogens incriminated in field outbreaks, Differentiation of field and Vaccine strains, the concept of Marker vaccines, and Correlation of pathotypes and genotypes of a pathogen.

Unit III

Immunological tests, immunoblotting techniques and use of monoclonal antibodies in different ELISAs for antigenic analysis. Application of nucleic acid-based assays, viz., polymerase chain reaction (PCR) assays, nucleotide sequencing, restriction endonucleaseanalysis and RFLP analysis for genomic characterization using the field material directly or after extraction of nucleic acid from small scale cultures, use of radio-actively labelled or non-radioactive oligo-nucleotide probes in dot-blot and Southern hybridizations.

V. Practical

Finger printing of the nucleic acid obtained from field isolates and their comparative analysis. PCR and ELISA for screening of field samples.

VI. Assignment

Each student shall select at least two recent articles from journals related to the course and discuss the same in the class through presentation.

VII. Suggested reading

- Boniolo G and Nathan MJ. eds., 2016. *Philosophy of molecular medicine: Foundational issues in research and practice*. Taylor and Francis.
- Pfeiffer D. 1998. *Veterinary Epidemiology. An Introduction. Institute of Veterinary, Animal and Biomedical Sciences*. Massey University, Palmerston, New Zealand.
- Stites DP, Stobo JD, Fundenberg HH and Wells JV. 1982. *Basic and Clinical Immunology*, 4th Edition. Lange Medical Publications, Los Altos, USA.
- Thrusfield M. 2018. *Veterinary Epidemiology*, John Wiley and Sons.

I. Course Title : Surveys, Surveillance and Data Management

II. Course Code : VPE-612

III. Credit Hours : 2+1

IV. Theory

Unit I

Robust survey: Planning, Statistical models for the same and Surveillance, Purpose and method of sampling, Size of sample, Questionnaires. State, National and International agencies (OIE, CDC, etc.), their data bases and their management systems.

Unit II

Goals and types of surveillance, monitoring, mechanism of surveillance and surveillance network.

Unit III

Disease/ data recording and reporting, vet. recording schemes, vet. information system and data bases.

Unit IV

Emergence of new diseases and re-emergence of old diseases. Epidemiology of globally and nationally important emerging/ re-emerging diseases and designing of strategies for their prevention and control.

V. Practical

Prepare questionnaires on selective topics, survey for livestock and poultry farmers to find out usefulness/ effectiveness of vaccination/ artificial insemination/ other practices, surveillance of important diseases in different parts of state, data analysis and presentation of data, development of suitable software.

VI. Assignment

Each student will select at least two recent articles from journals related to course and discuss the same in the class through presentation.

VII. Suggested reading

- Hawker J, Begg N, Reintjes R, Ekdahl K, Edeghere O and Van Steenbergen JE. 2018. *Communicable disease control and health protection handbook*. John Wiley and Sons.
- Salman M. ed., 2008. *Animal disease surveillance and survey systems: methods and applications*. John Wiley and Sons.
- Thrusfield M. *Veterinary epidemiology*. John Wiley and Sons; 2018 Apr 30.

I. Course Title : Special Problem

II. Course Code : VPE 690

III. Credit Hours : 0+1

IV. Practical

Short research problem(s) involving contemporary issues and research techniques. Presentation and discussion of novel research papers on the disease or intervention strategies such disease pathogenesis, pathobiology, epidemiology, host-agent-environmental relationships, molecular mechanisms/ diagnostics, spatio-temporal trends, etc. Planning a short research problem or working on a published research paper or new developments.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Veterinary Para-Clinical Subjects

– Veterinary Pharmacology and Toxicology

Course Title with Credit Load
M.V.Sc. in Veterinary Pharmacology and Toxicology

Course Code	Course Title	Credit Hours
VPT 501	Concepts of Pharmacology, Drug Design and Development*	2+0
VPT 502	Autonomic and Autacoid Pharmacology*	2+1
VPT 503	CNS Pharmacology	2+1
VPT 504	Digestive and Respiratory Pharmacology	2+1
VPT 505	Cardiovascular and Urinary System Pharmacology	2+0
VPT 506	Endocrine and Reproductive Pharmacology	2+1
VPT 507	Chemotherapy*	2+1
VPT 508	Toxicology of Xenobiotics*	2+1
VPT 509	Toxinology	2+1
VPT 510	Pharmacological Techniques*	0+2
VPT 511	Techniques in Toxicology*	0+2
VPT 512	Ethnopharmacology	1+1
VPT 513	Fundamentals of Pharmacokinetics	1+1
VPT 591	Master's Seminar*	1+0
VPT 599	Master's Research	30

*Core courses

Course Contents
M.V.Sc. in Veterinary Pharmacology and Toxicology

I. Course Title : Concepts of Pharmacology, Drug Design and Development

II. Course Code : VPT 501

III. Credit Hours : 2+0

IV. Theo

ryUnit

I

Scope of pharmacology, Drugs and other therapeutic agents, Principles of biopharmaceutics and veterinary dosage forms, Dynamics of ADME; Principles of therapeutics; Rationale and Empirical, Various other types of therapeutics.

Unit II

Pharmacodynamics targets for drug actions (enzymes, ion channels, structural and transporter proteins) evidence of drug action through receptor, Signal transduction mechanisms (GPCR, enzyme linked receptor), Regulation and malfunctioning of diseases.

Unit III

Quantitation of drug-receptor interactions and elicited effects, Drug-drug interactions and adverse drug reactions.

Unit IV

Drug invention: Screening, Assaying, Designing and Development of drugs, Clinical trials, Drug safety, Regulations and standards; Gene based therapy and drug delivery system.

I. Course Title : Autonomic and Autacoid Pharmacology

II. Course Code : VPT 502

III. Credit Hours : 2+1

IV. Theory

Unit I

Anatomical and physiological considerations of autonomic and somatic motor nervous system and Neurohumoral transmission.

Unit II

Agents modulating peripheral nervous system, Non-adrenergic-non cholinergic (NANC) transmission.

Unit III

Pharmacology of adrenergic agonists, Antagonists and Adrenergic neuron blockers.

Unit IV

Pharmacology of cholinergic agonists, Antagonists and cholinergic neuron blockers.

Unit V

Drugs acting at the Neuromuscular Junction and Autonomic Ganglia.

Unit VI

Autacoids: Introduction to immunity and inflammation, Immunostimulants, Immunosuppressants and Tolerogens, Pharmacological aspects of histamine, serotonin, kinins, eicosanoids and platelet activating factor, Angiotensins and other putative autacoids.

V. Practicals

Pharmacological experiments on intact and isolated preparations for studying the effects of various prototype autonomic and autacoids drugs on vascular, intestinal, respiratory, urinary and reproductive smooth muscles, autonomic ganglia, skeletal muscles; blood pressure, ECG, heart, etc.

I. Course Title : CNS Pharmacology
II. Course Code : VPT 503
III. Credit Hours : 2+1

IV. Theory

Unit I

Anatomical and physiological considerations and neurohumoral transmission in CNS.

Unit II

Historical development, theories, principles and stages of general anaesthesia.

Unit III

Recent advances in pharmacology of general anaesthetics and therapeutic gases, local anaesthetics, sedatives, hypnotics, neuroleptics, antiepileptics.

Unit IV

Pharmacology of CNS stimulants, analeptics, opioid agonists and antagonists; non-steroidal anti-inflammatory agents, central muscle relaxants, Pharmacology and regulations of euthanizing agents.

V. Practicals

Study of pharmacodynamics of prototype drugs of each class of drugs in experimental animals.

I. Course Title : Digestive and Respiratory Pharmacology

II. Course Code : VPT 504

III. Credit Hours : 2+1

IV. Theory

Unit I

Physiological considerations of GIT functions in ruminants and non-ruminants. Pharmacology of drugs acting on gastrointestinal tract. Appetite stimulants, emetics and anti-emetics.

Unit II

Pharmacology of anti-ulcer drugs, modulators of gastric and intestinal motility and secretions.

Unit III

Agents promoting digestive functions; bile acids and pancreatic enzymes, drugs affecting liver; rumen pharmacology.

Unit IV

Gastrointestinal protectant and adsorbents, laxatives and cathartics.

Unit V

Physiological considerations of respiratory functions in animals. Pharmacology of drugs acting on respiratory system: Bronchodilators, Antitussives, Mucolytics, Expectorants, Decongestants. Drugs used in treatment of asthma.

V. Practicals

Study of effects of drugs on digestive and respiratory functions using different *in-vitro* and *in vivo* animal models.

I. Course Title : Cardiovascular and Urinary System Pharmacology

II. Course Code : VPT 505

III. Credit Hours : 2+0

IV. Theory

Unit I

Cardiac electrophysiology consideration, Pharmacology of antiarrhythmic drugs, Cardiac glycosides, Myocardial stimulants.

Unit II

Antihypertensive, Antihypotensive and Antihyperlipidaemic drugs.

Unit III

Coagulants and anticoagulants,Thrombolytic

agents, Plasmaaffecting haemopoietic system and antiplatelet drugs.

Unit IV

Pharmacology of drugs affecting renal functions and fluid-electrolyte balance: Diuretics, Antidiuretics, Urinary acidifiers, Urinary alkalizers, Urinary antiseptics and Uricosuric and other anti-gout drugs. Principles of acid-base balance, fluid and electrolyte therapy and blood substitutes.

I. Course Title : Endocrine and Reproductive Pharmacology

II. Course Code : VPT 506

III. Credit Hours : 2+1

IV. Theory

Unit I

Drugs affecting endocrine functions of hypothalamus, pituitary, thyroid, adrenals and pancreas.

Unit II

Drugs affecting calcium and phosphorus homeostasis.

Unit III

Drugs affecting male reproductive organs, spermatogenesis and erectile dysfunctions.

Unit IV

Drugs affecting female reproductive organs: ovulation, oestrus, conception, gestation and lactation.

Unit V

Oxytocic and other drugs affecting uterus.

V. Practicals

To study the effects of various endocrine agonists and antagonists in animal models and isolated tissues.

I. Course Code : VPT 507

II. Course Title : Chemotherapy

III. Credit Hours : 2+1

IV. Theory

Unit I

General consideration and principles of Chemotherapy, Classification of chemotherapeutic agents; Molecular mechanism of Antimicrobial resistance-development and Prevention strategies; Combination therapy, Therapeutic failure.

Unit II

Systemic and gut acting sulphonamides, diaminopyrimidines, sulfones, quinolones, nitrofurans, nitroimidazoles.

Unit III

Penicillins, Cephalosporins, Carbapenems, Carbacephems, monobactam, beta lactamase inhibitors.

Unit IV

Aminoglycosides, Tetracyclines, Chloramphenicol and its congeners, macrolides, lincosamides.

Unit V

Antitubercular drugs, Glycopeptides, and Polypeptide antibiotics, Methenamine, Carbadox, Novobiocin, Virginiamycin, Spectinomycin, Oxazolidinones and newer agents.

Unit VI

Antiprotozoans, Anthelmintics, Ectoparasiticides

Unit VII

Antifungal agents, Antiviral and Anti-neoplastic drugs.

V. Practicals

Assay of chemotherapeutic agents, Antibiotic sensitivity tests. Determination of minimum inhibitory concentration (MIC), Mutant Prevention Concentration (MPC), Minimum Bactericidal Concentration (MBC) and time kill kinetics. Molecular techniques for intervention of antimicrobial resistance. Determination of anthelmintic properties of drugs using *in-vitro* models.

I. Course Title : Toxicology of Xenobiotics

II. Course Code : VPT 508

III. Credit Hours : 2+1

IV. Theo

ryUnit

I

Principles and scope of toXicology.

Unit II

Molecular mechanism of action of poisons and their detoXification, rational approach for diagnosis and treatment of poisonings.

Unit III

ToXicology of metals, non-metals, agrochemicals, solvents and vapors, common salt, urea and other feed additives. ToXicity of drugs.

Unit IV

GenotoXic and other effects of radiations and radioactive chemicals; toXicogenomics and developmental toXicology; forensic and regulatory aspects of toXicology.

V. Practicals

EXtraction, separation and detection of common poisons in toXicological specimens, study of toXicity and antidotal treatment in animals, designing of animal toXicity eXperiments and general toXicity spot tests.

I. Course Title : Toxinology

II. Course Code : VPT 509

III. Credit Hours : 2+1

IV. Theory

Unit I

Classification and identification of different types of toxins.

Unit II

Toxicity induced by abrin, strychnine, dhurin, amygdaline, sanguine, solamine, gossypol, beta-amino propionitryl, beta-oxolyl amino L-alanine, other Phytotoxins

Unit III

Toxin induced Teratogenicity, Thiamine deficiency and Phototoxicity.

Unit IV

Toxicology of mycotoxins: aflatoxins, rubratoxins, ochratoxins, sporidesmin, citrinin, F-2 toxin, trichothecenes, tremorgens and ergot alkaloids.

Unit V

Zootoxins: snake venom, scorpion, spider and insect stings and bufotoxins, Puffer fish and Shell fish toxins. Bacterial toxins (botulinum and tetanus toxins)

V. Practicals

Detection of alkaloids, glycosides, cyanides, nitrate/ nitrite, tannins, saponins, resins and oxalates. Detection of mycotoxins in the samples of feed/ fodder and animal tissue. Identification of toxic weeds and plants of the state/ local area.

I. Course Title : Pharmacological Techniques

II. Course Code : VPT 510

III. Credit Hours : 0+2

IV. Practicals

Unit I

Principles of drug action and bioassay. Construction of dose-response plots and their significance. Determination of EC_{50}, median effective (ED_{50}), toxic (TD_{50}) or lethal doses (LD_{50}) from dose-response plots. Calculation of dissociation rate constants, therapeutic ratio, margin of safety, potency ratio, pAx, pDx and pD'x values.

Unit II

Techniques for setting up isolated and intact preparations, recording of BP in hen/ rat, recording of ECG in rat/ other small animals.

Unit III

Organization of screening programme of drugs; multidimensional screening procedures and gross observational methods. Specific tests for evaluation of tranquillizing, hypnotic, analgesic, anticonvulsant, general and local anaesthetic, muscle relaxant, anti-inflammatory, antipyretic, antiarrhythmic, antihypertensive and antihyperglycemic activities.

Unit IV

Guidelines for safety studies on drugs.

I. Course Title : Techniques in Toxicology

II. Course Code : VPT 511

III. Credit Hours : 0+2

IV. Practicals

Unit I

Designing of animal models in toxicological studies. Introduction to different toxicological guidelines for *in-vitro* and *in vivo* studies (OECD, WHO, EPA, etc.). In silico toxicity prediction.

Unit II

Animal toxicity tests for acute, sub-acute and chronic toxicity.

Unit III

Specific toxicity tests for Neurotoxicity, Immunotoxicity, Behavioural, Reproductive and Developmental, Inhalation Toxicity, Mutagenicity, Carcinogenicity.

Unit IV

Toxicological tests for the study of metabolism, synergism and antagonism. Assay for marker enzymes, analysis of toxicant residues in biological materials.

I. Course Title : Ethnopharmacology

II. Course Code : VPT 512

III. Credit Hours : 1+1

IV. Theory

Unit I

Historical aspects of traditional Indian remedies. Alternate systems of medicine in animals. Scope of Ethnopharmacology.

Unit II

Classification and identification of medicinal plants. Classification, Metabolism and interactions of Phytoconstituents.

Unit III

Standardization and clinical validation of bioactive molecules from plant sources. Therapeutic and adverse effects of potential herbal drugs. Indigenous drugs used as glactagogues, carminatives, antiseptics, antidiarrhoeals, anthelmintics, Immuno-stimulants, antimicrobials, bioenhancers, analgesics, anti-inflammatory agents, etc.

V. Practicals

Identification of medicinal plants. Preparation of plant extracts in various solvents using different techniques. Phytochemical screening of plant extracts. Evaluation of pharmacological activities of extracts using *in-vitro* and *in-vivo* methods.

I. Course Title : Fundamentals of Pharmacokinetics

II. Course Code : VPT 513

III. Credit Hours : 1+1

.

IV. Theory

Unit I

Routes of drug administration, ADME, plasma protein binding, factors modifying ADME

Unit II

Basic concept of pharmacokinetics, Order of pharmacokinetics processes (zero order, first order and mixed order), Models of pharmacokinetics analysis of drugs (compartmental, non-compartmental model)

Unit III

Compartmental models of drug distribution, determinants of absorption, distribution and elimination, rate constants (CmaX, TmaX)

Unit IV

Calculation of pharmacokinetic parameters, dosage regimen and bioavailability based on compartmental analysis, Non-compartmental pharmacokinetic modelling.

V. Practicals

Analysis of pharmacokinetic data and determination of different pharmacokinetic parameters and bioavailability of drugs in normal and diseased animal models.

Course Title with Credit Load
Ph.D. in Veterinary Pharmacology and Toxicology

Course Code	Course Title	Credit Hours
VPT 601	Molecular Pharmacology*	3+0
VPT 602	Advances in Autacoid Pharmacology	1+0
VPT 603	Pharmacology of Herbal Drugs	2+1
VPT 604	Biotransformation of Xenobiotics	2+0
VPT 605	Clinical Pharmacology and Pharmacokinetics*	2+1
VPT 606	Pharmacogenomics	2+0
VPT 607	Immunopharmacology and Immunotoxicology	2+0
VPT 608	Molecular Toxicology	3+0
VPT 609	Clinical Toxicology*	2+1
VPT 610	Ecotoxicology	3+0
VPT 611	Regulatory Toxicology	2+1
VPT 690	Special Problem	0+1
VPT 691	Doctoral Seminar I*	1+0
VPT 692	Doctoral Seminar II*	1+0
VPT 699	Doctoral Research	**75**

*Core courses

Course Contents
Ph.D. in Veterinary Pharmacology and Toxicology

I. Course Title : Molecular Pharmacology
II. Course Code : VPT 601
III. Credit Hours : 3+0
IV. Theory

Unit I

Physicochemical properties of drugs, Forces involved in binding of drugs to receptors, Classification of receptors, Molecular structure of receptors, Properties and regulation of receptors, Receptors for physiological regulatory molecules.

Unit II

Receptor conformation and configuration. Structure activity relationship. Ligand binding study of receptors. Cellular mechanism of signal transduction and second messenger systems; Structures, Types and Functions of membrane ion channels.

Unit III

Theories of drug receptor interactions; Analysis of dose response Relationship and molecular mechanisms of drug actions, Quantitation of drug-receptor interactions and effects, receptors as pharmaceutical targets.

Unit IV

Calcium homeostasis within the cells, pharmacology of mitogen-activated protein (MAP) kinases/ extracellular signal-regulated kinases (ERK) and small G proteins. Methods of identification, isolation and characterization of receptors.

I. Course Title : Advances in Autacoid Pharmacology
II. Course Code : VPT 602
III. Credit Hours : 1+0
IV. Theory

Unit I

Histamine and antihistamines, serotonin and its antagonists.

Unit II

Kinins (Bradykinin, kallikrein, Neurokinin, Substance P, Atrial natriuretic peptides and others).

Unit III

Angiotensins, agonists and antagonists.

Unit IV

Eicosanoids, platelet-activating factors, slow reacting substances of anaphylaxis, Putative neurotransmitters (purine nucleotides, peptides, amino acids and nitric oxide).

Unit V

Pharmacotherapy of inflammation, fever, pain and gout; clinical manifestation of autacoid imbalance.

I. Course Title : Pharmacology of Herbal Drugs

II. Course Code : VPT 603

III. Credit Hours : 2+1

IV. Theory

Unit I

Historical aspect, Chemical constituents of medicinal plants and their classification.

Unit II

Identification, Collection, Preservation, Purification, Isolation, Standardization and Clinical validation of bioactive molecules from vegetable sources.

Unit III

Characterization of pharmacological, therapeutic and toxic effects of potential herbal drugs.

Unit IV

Strategies for development of herbal drugs.

V. Practical

Extraction, detection, phytochemical analysis and fractionation of medicinal plant extracts. Screening of plant extracts for potential pharmacological activity; Pharmacological effects of herbal drugs on intact and isolated preparations.

I. Course Title : Biotransformation of Xenobiotics

II. Course Code : VPT 604

III. Credit Hours : 2+0

IV. Theory

Unit I

Process of drug biotransformation phase I, phase II, and III, Microsomal and non-microsomal metabolizing enzyme systems.

Unit II

Mechanisms and processes of synthetic biotransformation

Unit III

Chemical, biological, genetic and environmental factors affecting drug biotransformation mechanisms.

Unit IV

Metabolic interactions, Enzyme induction and inhibition. Scope of biotransformation in drug development.

I. Course Title : Clinical Pharmacology and Pharmacokinetics

II. Course Code : VPT 605

III. Credit Hours : 2+1

IV. Theory

Unit I

Scope of clinical pharmacology. Drug discovery and clinical trials. Pharmacovigilance, pharmacoepidemiology and pharmacoeconomics.

Unit II

Various drug delivery systems-ruminal, intravaginal, intramammary, etc. Targeted

drug delivery systems-liposomes, microparticles, nanoparticles, etc. Factors modifying drug delivery.

Unit III

Application of pharmacokinetic principles in therapeutics. PK-PD relationship and its applications.

Unit IV

Alterations in pharmacological behaviour of drugs in clinical conditions, neonates and pregnancy. Drug interactions and adverse drug reactions. Therapeutic drug monitoring. Rationale of drug use. Medication control programs in performance animals.

V. Practicals

Analysis of pharmacokinetic data and determination of different pharmacokinetic parameters and drugs interactions in normal and diseased animal/ models.

I. Course Title : Pharmacogenomics

II. Course Code : VPT 606

III. Credit Hours : 2+0

IV. Aim of the course

To study the concepts of genomicsin drug development.

V. Theory

Unit I

History, concepts and definitions of pharmacogenomics transcriptomics, proteomics and metabolomics. Genomic basis of species variations in drug response.

Unit II

Genetic polymorphism and its impact on pharmacokinetics, drug target receptors and disease-drug response.

Unit III

Pharmacogenomics and drug development, Pharmacogenomics in clinical practice, role of bioinformatics in pharmacogenomics.

Unit IV

Concept of gene therapy, gene therapy of inherited diseases, DNA repair and inactivation strategies. Synthesis of therapeutic proteins.

I. Course Title : Immunopharmacology and Immunotoxicology

II. Course Code : VPT 607

III. Credit Hours : 2+0

IV. Theory

Unit I

General aspect of immune system and its interaction with nervous and endocrine systems. Chemical mediators of immune system.

Unit II

Immunomodulators; Immunostimulants, Immunosuppressant and Tolerogens; Immunological basis of drug allergy and drug tolerance.

Unit III

Immunotoxic effects of xenobiotics and environmental pollutants.

Unit IV

Immune deficiencies and autoimmune reactions. Immunotherapeutic applications in asthma, arthritis, cancer, dermatology, and organ transplant, etc.

I. Course Title : Molecular Toxicology

II. Course Code : VPT 608

III. Credit Hours : 3+0

IV. Theory

Unit I

Cellular, sub-cellular and molecular targets and mechanism of toxicity.

Unit II

Cellular dysfunctions and their consequences, Mechanism of cell death in toxicity, repair and disrepair of toxic damage.

Unit III

Molecular mechanisms of target organ directed toxicity of xenobiotics- brain, hematopoietic system, GIT, liver, lungs, kidneys, reproductive system, skin, etc.

Unit IV

Mechanism of chemical mutagenesis, carcinogenesis, teratogenesis and radiation toxicity.

I. Course Title : Clinical Toxicology

II. Course Code : VPT 609

III. Credit Hours : 2+1

IV. Theory

Unit I

Scope of clinical and forensic toxicology. Toxicological investigation, management and antidotal therapy of poisonings.

Unit II

Clinical aspects of poisoning due metals, non-metals and pesticides.

Unit III

Clinical aspects of poisoning due to mycotoxins, animal and bacterial toxins, solvents and vapours, drugs and other food/ feed contaminants.

Unit IV

Forensic toxicology. GLP in toxicological evaluation.

V. Practical

General screening of biological material for toxicants, analysis of clinical samples for poisons, use of biomarkers in the assessment of toxicity.

I. Course Title : Ecotoxicology

II. Course Code : VPT 610

III. Credit Hours : 3+0

IV. Theory

Unit I

Basic principles of ecotoxicology. Sources of contamination and effects of pollutants on eco-health.

Unit II

Chemical contamination of air, water, soil and food by major agricultural and industrial chemicals – pesticides, hydrocarbons and metals. Fate of chemicals in the environment and target species.

Unit III

Toxic effects of radiations. Marine and wildlife as monitors of environmental quality, Bioaccumulation and Biomagnifications of toxicants.

Unit IV

Biomarkers of monitoring the impact of environmental pollutants, Environmental hazard and Risk identification from Mixture of chemicals, Contamination control and approaches to rehabilitating damaged ecosystems, Nanoparticletoxicology, ecological emergencies.

I. Course Title : Regulatory Toxicology

II. Course Code : VPT 611

III. Credit Hours : 2+1

IV. Theory

Unit I

Principles of risk assessment. Test protocols for toXicity studies of various national and international regulatory agencies.

Unit II

Regulatory essential dose levels in chemical risk assessment (NOEL, NOAEL, LOEL, LOAEL and AOEL). Recommended acceptable levels of environmental pollutants.

Unit III

Risk assessment in practice. Classification and marking/ branding of chemicals. Monitoring/ surveillance of chemicals. EXposure assessment and modelling.

Unit IV

Quality control in safety research (GLP). Operation of product register.

V. Practical

Good laboratory practice in toXicological research. Screening procedures in regulatory toXicology. Determination of MRL, ADI, NOEL, NOAEL, LOEL, LOAEL and AOEL. Visit to nearest industrial area.

I. Course Title : Special Problem

II. Course Code : VPT 690

III. Credit Hours : 0+1

IV. Practical

Short research problem(s) involving contemporary issues and research techniques.

Suggested Reading

- Baggot JD (Ed). 2001. *The Physiological Basis of Veterinary Clinical Pharmacology*. Blackwell Science.
- Barile FA (Ed). 2013. *Principles of Toxicology Testing*. CRC Press.
- Bisset NG (Ed). 1994. *Herbal Drugs and Phytopharmaceuticals*. CRC Press.
- Brunton LL (Ed). 2018. *Goodman and Gilman's The Pharmacological Basis of Therapeutics*. 13th Ed. McGraw-Hill.
- Chopra SR, Badhwar RL and Ghosh S. 1984. *Poisonous Plants of India*. 1st Ed., Academic Publishers, Jaipur.
- Derelanko MJ and Holinger MA. (Eds). 2002. *CRC Hand Book of Toxicology*, 2nd Ed. CRC Press.
- Fowler BA (Ed). 2013. *Computational Toxicology: Methods and Applications for Risk Assessment*. Academic Press.
- Ghosh MN (Ed). 2015. *Fundamentals of Experimental Pharmacology*. 4th Ed. Hilton and Co.
- Gibaldi M and Perrier D (Eds). 1982. *Pharmacokinetics*, 2nd Ed. Taylor and Francis.
- GibaldiM and PrescottLF (Eds). 1983. *Handbook of Clinical Pharmacokinetics*. ADIS Health Science Press.
- Hayes AW and Kruger CL (Eds). 2014. *Hayes' Principles and Methods of Toxicology*, 6th Ed. CRC Press.
- Klaassen CD and Watkins JB (Ed). 2015. *Casarett and Doull's Essentials of Toxicology*. 3rd Ed. McGraw-Hill.
- Klassen CD (Ed). 2018. *Casarett and Doull's Toxicology: Basic Sciences of Poisons*. 9th Ed., McGraw-Hill.
- Kulkarni SK (Ed). 2004. *Handbook of Experimental Pharmacology*. 3rd Ed. Vallabh Prakashan.
- Medhi B and Prakash A (Eds). 2010. *Practical Manual of Experimental and Clinical Pharmacology*. Jaypee Brothers.
- Riviere JE and Papich MG (Eds). 2018. *Veterinary Pharmacology and Therapeutics*. 10th Ed. Iowa State Univ. Press.
- Southwood R, Fleming VH and Huckaby G (Eds). 2018. *Concepts in Clinical Pharmacokinetics*. American Society of Health-System Pharmacists.
- Srivastava AK, Verma PK and Dumka VK (Eds). 2013. *Veterinary Toxicology*. Satish Serial Publishing House, New Delhi.
- Stine KE and Brown TM. (Eds). 2015. *Principles of Toxicology*. 3rd Ed. CRC Press.
- Vogel HG and Voge WH (Eds). 1997. *Drug Discovery and Evaluation: Pharmacological Assays*. Springer.

Restructured and Revised
Syllabi of Post-graduate Programmes
Vol. 3

Animal Production Sciences

- Animal Genetics and Breeding
- Animal Nutrition
- Livestock Production and Management
- Livestock Products Technology
- Poultry Science

Contents

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Animal Production Sciences

– Animal Genetics and Breeding

Preamble
(Animal Genetics and Breeding)

Livestock plays an important role in Indian economy. About 20.5 million people depend upon livestock for their livelihood. Livestock contribute 16% to the income of small farm households as against an average of 14% for all rural households. Livestock provides livelihood to two-third of rural community. It also provides employment to about 8.8 % of the population in India. India has vast livestock resources. Livestock sector contributes 4.11% GDP and 25.6% of total Agriculture GDP. The economy of farmer is greatly influenced by livestock keeping. The farmers in India maintain mixed farming system i.e. a combination of crop and livestock where the output of one enterprise becomes the input of another enterprise thereby realize the resource efficiency. The livestock serve the farmers in four different ways: income, employment, food and social security. So the conservation and development of indigenous livestock is the need of the hour. The study of the subject of Animal Genetics and Breeding and its application for conservation and improvement of livestock is very important.

Genetic improvement in domesticated animal populations that are used for agricultural production mainly involves selection of males and females that, when mated, are expected to produce progeny that perform better than the average of the current generation. Performance usually includes a combination of multiple characteristics, or traits, most of which are quantitative in nature. Animal breeding involves the selective breeding of livestock with the intention to improve desirable (and heritable) qualities in the next generation. This course introduces the steps required to design a program for breeding animals and teaches the genetic and statistical concepts that are needed to build a solid breeding program. By following this course the students can learn the key aspects of improving and increasing productivity and learn what it takes to create and maintain a healthy strong population. Students will learn how an animal breeder balances the need for improving the desirable qualities of the animals with the need for genetic diversity and long-term sustainability of the breeding program. Also students will learn about the scientific concepts in genetics that are applied in animal breeding, as well as how to apply the genetic models and computational methods that are used in animal breeding. Professionals working with animals will be able to use the knowledge from this course to understand the impact of breeding on animal populations and use genetic principles to make their decisions. This course will allow an advanced starting point for further studies, such as M.Sc. level courses in breeding.

Although animal breeding was practiced long before the science of genetics and the relevant disciplines of population and quantitative genetics were known, breeding programs have mainly relied on simply selecting and mating the best individuals on their own or relatives' performance. This is based on sound quantitative genetic principles, developed and expounded by Lush, who attributed much of his understanding to Wright, and formalized in Fisher's infinitesimal model. Analysis at the level of individual loci and gene frequency distributions has had relatively little impact. Now with access to genomic data, a revolution in which molecular information is being used to enhance response with "genomic selection" is occurring. The predictions of breeding value still utilize multiple loci throughout the

genome and, indeed, are largely compatible with additive and specifically infinitesimal model assumptions.

The main goal in animal breeding is to select individuals that have high breeding values for traits of interest as parents to produce the next generation and, to do so, as quickly as possible. To date, most programs rely on statistical analysis of large data bases with phenotypes on breeding populations by linear mixed model methodology to estimate breeding values on selected candidates. However, there is a long history of research on the use of genetic markers to identify quantitative trait loci and their use in marker-assisted selection but with limited implementation in practical breeding programs. The advent of high-density SNP genotyping, combined with novel statistical methods for the use of this data to estimate breeding values, has resulted in the recent extensive application of genomic or whole-genome selection in dairy cattle and research to implement genomic selection in other livestock species is underway. The high-density SNP data also provides opportunities to detect QTL and to uncover the genetic architecture of quantitative traits, in terms of the distribution of the size of genetic effects that contribute to trait differences in a population. Experimental results show that this genetic architecture differs among traits but that for most traits, over 50% of the genetic variation resides in genomic regions with small effects that are of the order of magnitude expected under a highly polygenic model of inheritance.

In indigenous livestock breed improvement program and conservation of indigenous livestock courses, different schemes like Rastriya Krishi Vikash Yojana (RKVY), Rastriya Gokul Mission (RGM) and National Programme for Bovine Breeding and Dairy Development (NPBBDD) launched by GoI under Ministry of Agriculture, Animal Husbandry, Dairying and Fisheries are included.

Addition of Courses

In M.V.Sc. degree programme, six new courses are proposed namely AGB-611 (Swine Breeding), AGB-612 (Pet Animal Breeding- dogs and cats), AGB-613 (Wild Animal Genetics and Breeding), AGB-614 (Equine Breeding), AGB-615 (Camel Breeding), AGB-616 (Yak and Mithun Breeding) and AGB-617 (Statistical Methods in Animal Breeding).

In Ph.D. degree programme, one new course is proposed namely AGB-707 (Statistical Software in Animal Breeding) based on inputs of stakeholders and contemporary requirement.

The course contents have been decided and modified as per suggestions of all the stakeholders during four workshops held at Durg, Guwahati, Hyderabad and Srinagar. Assuming the priority day-by-day, the areas which need to be strengthened in Animal Genetics and Breeding are: Molecular Techniques in Animal Breeding, Biometrical Techniques in Animal Breeding, Bio-informatics in Animal Genetics and Breeding, Breeding for different species having regional importance, viz., Swine, Camel, Equine, Yak and Mithun Breeding. Pet Animal Breeding is important in the sense that majority of people are fond of keeping pets where pedigreed dog and cats are the choice. Wild Animal Genetics and Breeding is an essential part for conservation of wild life now-a- days.

Deletion of Courses

In Ph.D., one course has been deleted namely AGB-707 (Utilization of non-additive genetic variance in farm animals) which appears to be redundant and/ or contents included elsewhere.

Changes of Name of Courses

Title of five courses in M.V.Sc. and five courses in Ph.D. have been modified as per the following Table:

Course Code	Old Title/ Existing	Modified Title
AGB 601	Animal Cytogenetics and Immunogenetics	Animal Cytogenetics and Immunogenetics I
AGB 602	Molecular Genetics in Animal Breeding	Molecular Genetics I
AGB 605	Biometrical Techniques in Animal Breeding	Biometrical Genetics I
AGB 608	Small Farm Animal Breeding (sheep, goat, swine and rabbit)	Sheep and Goat Breeding
AGB 610	Laboratory Animal Breeding	Laboratory Animal and Rabbit Breeding
AGB 701	Recent Advances in Animal Genetics	Molecular Genetics II
AGB 702	Recent Trends in Animal Breeding	Trends in Animal Breeding
AGB 703	Advances in Biometrical Genetics	Biometrical Genetics II
AGB 705	Bioinformatics in Animal Genetics and Breeding	Bioinformatics in Animal Breeding
AGB 706	Advances in Molecular Cytogenetics	Animal Cytogenetics and Immunogenetics II

Change of Credit Hours

For AGB 604 and AGB 605, credit hours have been reduced from 3+1 to 2+1. For AGB 610, credit hour has been increased from 1+0 to 2+0 to accommodate rabbit breeding components. For AGB 705, credit hour has been modified from 2+0 to 1+1 to accommodate practical classes.

For M.V.Sc. degree programme, out of the total of 20 credit hours from major, 15 credits hours have been decided as core (compulsory) courses and five credit hours from optional major courses. For Ph.D. degree programme, out of the total 12 credit hours 10 credit hours have been decided as core (compulsory) courses and two credits from optional major courses.

Course Title with Credit Load
M.V.Sc. in Animal Genetics and Breeding

Course Code	Course Title	Credit Hours
AGB 601*	Animal Cytogenetics and Immunogenetics I	2+1
AGB 602*	Molecular Genetics I	2+1
AGB 603*	Population and Quantitative Genetics	2+1
AGB 604*	Selection Method and Breeding System	2+1
AGB 605*	Biometrical Genetics I	2+1
AGB 606	Conservation of Animal Genetics Resources	2+0
AGB 607	Cattle and Buffalo Breeding	2+1
AGB 608	Sheep and Goat Breeding	2+0
AGB 609	Poultry Breeding	2+1
AGB 610*	Laboratory Animal and Rabbit Breeding	2+0
AGB 611	Swine Breeding	1+0
AGB 612	Pet Animal Breeding (Dogs and Cats)	1+0
AGB 613	Wild Animal Genetics and Breeding	1+0
AGB 614	Equine Breeding	1+0
AGB 615	Camel Breeding	1+0
AGB 616	Yak and Mithun Breeding	1+0
AGB 617	Statistical Methods in Animal Breeding	2+1
AGB 691	Seminar	1+0
AGB 699	Research	30

Course Contents
M.V.Sc. in Animal Genetics and Breeding

I. Course Title : Animal Cytogenetics and Immunogenetics I

II. Course Code : AGB 601

III. Credit Hours : 2+1

IV. Theory

Unit I (7 Lectures)

Physical and chemical basis of heredity; Development in animal cytogenetics and immunogenetics of farm animals; Inborn errors of metabolism and inherited disorders; immunoglobulin and their types; Antigen-antibody interactions; Immune response; ELISA.

Unit II (10 Lectures)

Chromatin structure of eukaryotes; Chromosome number and morphology in farm animals; Karyotyping and banding; Chromosomal abnormalities and genetic syndromes; DNA packing in chromosomes; Types of DNA; FISH chromosome painting and PRINS; SCH and RH panel mapping.

Unit III (10 Lectures)

Genetic variants in blood group systems of farm animals; Major histocompatibility complex: BoLA, BuLA; Genetics of biochemical variants and their applications; Immune response genes and concepts of disease resistance including major genes; Hybridoma and its significance; Concept of immunofertility; TLRs and interleukins.

Unit IV (3 Lectures)

Mutation and assays of mutagenesis; Sister chromatid exchanges.

V. Practical (15 Classes)

Identification of Barr bodies; *In-vitro* and *in vivo* preparation of somatic metaphase chromosomes; Screening of chromosomal abnormalities; Microphotography and karyotyping; Banding procedures for comparing the chromosomal complement; FISH and PRINS; ELISA; Immunocompetence tests.

VI. Suggested Reading

- Gersen SL and Keagle MB. 2013. *The Principles of Clinical Cytogenetics*. Springer.
- Hare WCD and Singh EL. 1999. *Cytogenetics in Animal Reproduction*. CABI.
- Panayi GS and David CS. 1984. *Immunogenetics*. Elsevier.
- Roitt I. 1997. *Essential Immunology*. Blackwell.
- Summer AT and Chandley AC. 1993. *Chromosome Today*. Chapman and Hall.

I. Course Title : Molecular Genetics in Animal Breeding

II. Course Code : AGB 602

III. Credit Hours : 2+1

IV. Theory

Unit I (8 Lectures)

Basic concepts in molecular genetics; Concepts of proteomics and genomics; Genesis and importance of molecular techniques; Genome organization: physical and genetic map, current status of genome maps of livestock; Gene expression and control.

Unit II (8 Lectures)

Molecular markers and their applications; RFLP, RAPD, Microsatellite/ Minisatellite markers, SNP marker, DNA fingerprinting.

Unit III (7 Lectures)

DNA sequencing; Genome sequencing; Genomic Library; Polymerase Chain Reaction (PCR) and its types (PCR-RFLP, AS-PCR, etc.) and applications; Transgenesis and methods of gene transfer; Recombinant DNA technology and applications.

Unit IV (7 Lectures)

Analysis of molecular genetic data; Quantitative Trait Loci (QTL) mapping and its application in animal breeding: Genome scan, candidate gene approach.

V. Practical (15 Classes)

Extraction and purification of genomic DNA; Gel electrophoresis; Restriction enzyme digestion of DNA and analysis; PCR-RFLP; PCR-SSCP; Bioinformatics tool for DNA sequence analysis; Isolation of RNA; cDNA synthesis; Statistical methods for analyzing molecular genetic data.

IX. Suggested Reading

- Akano IE. 1992. *DNA Technology*. IAP Academic Press.
- Brown TA. 2006. *Genome 3*. Garland Science Publishers.
- Clark D and Pazdernik N. 2012. *Molecular Biology*, 2nd ed. Elsevier.
- Micklos DA, Fryer GA and Crotty DA. 2003. *DNA Science*. Cold Spring Harbor.
- Setlow JK. 2006. *Genetic Engineering – Principles and Methods*, Springer.

I. Course Title : Population and Quantitative Genetics

II. Course Code : AGB 603

III. Credit Hours : 2+1

IV. Theory

Unit I (15 Lectures)

Genetic structure of population; Hardy Weinberg Law; Idealized population; Factors affecting changes in gene and genotypic frequencies; Systematic processes; Approach to equilibrium under different situations: Single autosomal locus with two alleles, single sex-linked locus, two pairs of autosomal linked and unlinked loci; Linkage equilibrium and disequilibrium; Combined effect of all forces changing gene frequency.

Unit II (10 Lectures)

Dispersive process - small population: random genetic drift; Effective population size; Regular and irregular inbreeding systems; Founder effect and bottleneck; Effective number of founders and ancestors.

Unit III (10 Lectures)

Quantitative genetics: Gene effects, population mean, breeding value; Variance and its partitioning; Genotype-environment interaction and correlation; Resemblance between relatives.

Unit IV (10 Lectures)

Genetic and phenotypic parameters (heritability, repeatability, correlations): Methods of estimation, uses, possible biases, precision, optimal designs; Scale effects and threshold traits.

V. Practical (15 Classes)

Estimation of gene and genotypic frequencies under different conditions; Estimation of inbreeding in regular and irregular systems; Estimation of effective population size; Computation of quantitative genetic effects; Estimation of variance components; Computation of heritability, repeatability, genetic, phenotypic and environmental correlations and their standard errors.

VI. Suggested Reading

- Bulmer MG. 1980. *The Mathematical Theory of Quantitative Genetics*. Clarendon Press.
- Crow JF and Kimura M. 2009. *An Introduction to Population Genetics*. Harper and Row.
- Falconer DS and Mackay TFC. 1996. *An Introduction to Quantitative Genetics*. Longman.
- Jain JP. 1982. *Statistical Techniques in Quantitative Genetics*. Tata McGraw-Hill.
- Pirchner F. 1983. *Population Genetics in Animal Breeding*. Springer.

I. Course Title : Selection Method and Breeding System

II. Course Code : AGB 604

III. Credit Hours : 2+1

IV. Theory

Unit I (6 Lectures)

Types of selection and their genetic consequences; Response to selection: Prediction and improvement.

Unit II (12 Lectures)

Theoretical aspects of accuracy and efficiency of selection bases; Prediction of breeding value using different criteria; Combined selection; Correlated response and efficiency of indirect selection.

Unit III (12 Lectures)

Selection for several traits; Different types of selection indices; Evaluation of short term and long term selection experiments: bidirectional selection, asymmetry of response, selection limit.

Unit IV (15 Lectures)

Different mating systems: assortative mating, inbreeding, out-breeding; Genetic and phenotypic consequences and applications of various mating systems in animal improvement; Heterosis; Selection for general and specific combining abilities; Genetic polymorphism and its application in genetic improvement: Basic concepts of marker-assisted selection (MAS) and genomic selection.

V. Practical (15 Classes)

Prediction of direct and correlated response; Computation of realized heritability and genetic correlation; Computation of selection index; Estimation of breeding values from different sources of information; Determining the accuracy of selection; Estimation of heterosis for different types of crosses; Estimation of GCA and SCA.

VI. Suggested Reading

- Falconer DS and Mackay TFC. 1996. *An Introduction to Quantitative Genetics*. Longman.
- Jain JP. 1982. *Statistical Techniques in Quantitative Genetics*. Tata McGraw-Hill.
- Tomar SS. 1996. *Text Book of Population Genetics*, vol. I. *Qualitative Inheritance*. Universal Publishers.
- Tomar SS. 2010. *Text Book of Animal Breeding*. Universal Publishers.
- Tomar SS. 2014. *Text Book of Population Genetics*, vol II. *Quantitative Inheritance*. Universal Publishers.

I. Course Title : Biometrical Genetics I

II. Course Code : AGB 605

III. Credit Hours : 2+1

IV. Theory

Unit I (8 Lectures)

Nature and structure of animal breeding data; Source of variation; Adjustment of data; Outliers and their removal; Basic concepts in statistical inference and experimental designs.

Unit II (7 Lectures)

Introduction to matrix algebra; Types of matrices and their operations; Determinants and their properties; Matrix inversion and its applications.

Unit III (15 Lectures)

Multiple regression and correlations; Fisher's discriminant function and its application; D^2 statistics in divergent analysis; Cluster analysis; Fixation index; Genetic distance estimation and phylogeny construction; Linear models and their types; Least-squares (LS) analysis; Generalized LS and weighted LS; BLUE, BLUP; Methods of estimation of variance components: ANOVA, ML, REML, MINQUE, MIVQUE; Bayesian approach.

Unit IV (15 Lectures)

Animal model; Reduced animal model; Sire model; Maternal grandsire model; Maternal effects model; Repeatability model; Random regression model; Threshold model; Multidimensional scaling (MDS) and principal component analysis (PCA); Database management and use of software in animal breeding.

V. Practical (15 Classes)

Collection, compilation, coding and transformation of animal breeding data; Matrix applications, determinant and inverse of matrices; Building of models for various types of data; Least-squares analysis of data; Estimation of BLUE and BLUP solutions; Formation of numerator relationship, dominance and identical by descent matrix; Estimation of variance components.

VI. Suggested Reading

- Henderson CR. 1984. *Application of Linear Models in Animal Breeding*. University of Guelph Press.
- Mather K and Jinks JL. 1977. *Introduction to Biometrical Genetics*. Chapman and Hall.
- Searle SR. 2014. *Linear Models*. John Wiley and Sons.
- Singh RK and Chaudhary BD. 2012. *Biometrical Methods in Quantitative Genetic Analysis*. Kalyani Publishers.

I. Course Title : Conservation of Animal Genetics Resources

II. Course Code : AGB 606

III. Credit Hours : 2+0

IV. Theory

Unit I (12 Lectures)

Domestic animal diversity in India: Origin, history and utilization; Present status and flow of AnGR and its contribution to livelihood security; Methodology for phenotypic and genotypic characterization of livestock and poultry breeds through systematic surveys; Management of breed; Physical, biochemical and performance traits and uniqueness of animals of a breed; Social, cultural and economic aspects of their owners/ communities rearing the breed.

Unit II (12 Lectures)

Methods for increasing effective population size of endangered breed/ species: Effective number of alleles, inbreeding effective size, variance effective size, minimum viable population size; Methodology for characterization of AnGR; nuDNA and mtDNA based diversity analysis and relationship among the breeds; Concept of conservation: *In-situ* and *ex-situ* (in-*vivo* and *in-vitro*); Models of conservation; Prioritization of breeds for conservation; Strategies for conservation of livestock and poultry genetics resources; Gene bank concept; Preservation of ecosystem.

Unit III (6 Lectures)

Status, opportunities and challenges in the conservation of AnGR; IPR issues on animal genetic resources/ animal products or by-products; Registration of livestock breeds and protection of livestock owner's rights in India; Breed societies and their role in conservation.

V. Practical -

VI. Teaching methods

Blackboard; PPT-Presentations; Application based practical approach; Research article discussion in the classroom

VII. Learning outcome

Conservation strategies of AnGR, their characterization and methods of conservation to protect biodiversity

VIII. Suggested Reading

- Nivsarkar AE, Vij RK and Tantia MS. 2000. *Animal Genetic Resources of Indian Cattle and Buffaloes*. ICAR.
- Oldenbroek K. 2007. *Utilisation and Conservation of Farm Animal Genetic Resources*. WA Publishers.
- Sahai R and Vij RK. 1997. *Domestic Animal Diversity, Conservation and Sustainable Development*. SI Publishers.
- Van Vleck LD, Pollak E and Bltenacu EAB. 1987. *Genetics for Animal Sciences*. WH Freeman.

I. Course Title : Cattle and Buffalo Breeding

II. Course Code : AGB 607

III. Credit Hours : 2+1

IV. Theory

Unit I (15 Lectures)

History of dairy cattle and buffalo breeding; Evolution of cattle and buffalo breeds and their characteristics; Population dynamics and production systems; Inheritance of important economic traits; Recording and handling of breeding data; Standardization of records; Computation of correction factors for the adjustment of the data; International Committee on Animal Recording (ICAR) and INAPH.

Unit II (12 Lectures)

Progeny testing under farm and field conditions; Evaluation of bulls by different models; Estimation of breeding values of the cows; Nucleus breeding system; Marker-assisted selection and genomic selection.

Unit III (12 Lectures)

Crossbreeding in cattle in India and abroad; Development of new breeds; Conservation of threatened breeds of cattle and buffaloes; Role of breed associations in dairy improvement; Breeding policy: national and state.

Unit IV (6 Lectures)

Import of exotic germplasm for breeding cattle in the tropics; Appraisal of buffalo and cattle breeding programme; Role of breed associations in dairy improvement.

V. Practical (15 Classes)

Performance recording; Standardization of records; Estimation of economic traits; Computation of genetic parameters; Genetic gain; Sire evaluation methods; Estimation of heterosis; Culling and replacement.

VI. Suggested Reading

- Chakravarty AK and Vohra V. 2011. *Sustainable Breeding in Cattle and Buffalo. Satish Serial Publications.*
- Lasley JF. 1972. *Genetics of Livestock Improvement*. IBH.
- Oldenbroek K and van der Waaij L. 2014. *Text book of Animal Breeding and Genetics*. Wageningen University and Research Centre (Free Online).
- Schmidt GM, Van Vleck LD and Hutjens MF. 1988. *Principles of Dairy Science*. WH Freeman.
- Van Vleck LD, Pollak EJ and Bltenacu EAB. 1987. *Genetics for Animal Sciences*. WH Freeman.

I. Course Title : Sheep and Goat Breeding
II. Course Code : AGB 608
III. Credit Hours : 2+0

VI. Theory

Unit I (8 Lectures)

Breeds; Economic traits; Population dynamics and production systems; Prolificacy; Breeding records and standardization; Computation of correction factors.

Unit II (12 Lectures)

Genetic parameters; Selection of males and female; Selection indices for sheep and goat; Breeding systems; Breeding strategies for improvement of production (meat, milk and wool) and reproduction (fertility and fecundity); Inbreeding and its effects on production traits; Group breeding schemes; Development of new breeds; Strategies for introgression of genes (fecundity and growth).

Unit III (10 Lectures)

Breeding policy; Sheep and goat improvement programme in India; Conservation of breeds; Culling and replacement; Equivalent Animal Death Rate (EADR).

VII. Suggested Reading

- Jindal SK. 2013. *Goat Production and Health Management*. New India Publishers.
- Karim SA. 2010. *Climate Change and Stress Management: Sheep and Goat Production*. Satish Serial Publications.
- Mulugeta A. 2016. *Sheep and Goat Production Text Book*. Lambert Academic Publishers.
- Prasad J. 2018. *Goat, Sheep and Pig, Production and Management*. Kalyani Publishers.
- Ross CV. 1988. *Sheep Production and Management*. Prentice-Hall.

I. Course Title : Poultry Breeding

II. Course Code : AGB 609

III. Credit Hours : 2+1

IV. Theory

Unit I (10 Lectures)

Origin and history of poultry species: Chicken, turkey, duck and quail; Poultry classes and breeds; Important qualitative traits in poultry including lethal; Economic traits of egg and meat-type chicken and their standardization; Different mating systems.

Unit II (10 Lectures)

Selection criteria and selection indices; Response to selection; Genetic controls; Genotype and environment interaction; Inbreeding and its effects on production traits in egg and meat-type chickens; Development of inbred lines and strains; Strain and line crosses; Introduction to diallel cross; Utilisation of heterosis and reciprocal effect; Recurrent selection, reciprocal recurrent selection and modified RRS; Specialized sire and dam lines; Genetic improvement programs in poultry; Selection strategies for the improvement of layers and broilers; Performance testing of commercial strains; Backyard poultry.

Unit III (4 Lectures)

Industrial breeding; Artificial insemination in chicken; Auto-sexing; Random Sample Test.

Unit IV (6 Lectures)

Biochemical variants and immunogenetics of poultry; Use of molecular genetics in poultry breeding; Quantitative trait loci; Marker-assisted selection and genomic selection; Conservation of poultry genetic resources.

V. Practical (15 Classes)

Inheritance of qualitative traits; Economic traits of egg-type and meat-type chicken; Procedures of standardization; Estimations of heritability, the correlation between various production traits; Inbreeding co-efficient and heterosis; Selection of sires and dams; Osborne index; Restricted selection index; Collection and evaluation of semen and insemination; Estimation of GCA and SCA.

VI. Suggested Reading

- Brereton G and Roadnight S. 2000. *21st Century Poultry Breeding*. Gold Cockerel Books.
- Crawford RD. 1990. *Poultry Breeding and Genetics*. Elsevier.
- Hutt FB. 2003. *Genetics of Fowl*. Norton Greek Press.
- Muir WM and Aggrey SE. 2003. *Poultry Genetics, Breeding and Biotechnology*. CABI.
- Singh RP and Kumar J. 1994. *Biometrical Methods in Poultry Breeding*. Kalyani Publishers.

I. Course Title : Laboratory Animal and Rabbit Breeding

II. Course Code : AGB 610

III. Credit Hours : 2+0

IV. Theory

Unit I (6 Lectures)

Introduction to laboratory animal genetics; Breeding colonies of mice, rats, hamsters, guinea pigs and rabbits and their maintenance; Use of primates in animal research.

Unit II (4 Lectures)

Selection methods and mating systems: Monogamous, polygamous and others.

Unit III (12 Lectures)

Development of genetically controlled laboratory animals; Rules for nomenclature: Inbred strains, outbred stocks, mutant stocks, recombinant inbred strains, transgenic strains; Gene targeting and production of 'gene knock-out' animals; Production and use of specific pathogen-free animals; Guidelines and SOPs for the establishment of lab animal house; Genetic control and monitoring; Record-keeping; Ethics of laboratory animal research: FELASA, CPCSEA and IAEA regulations.

Unit IV (8 Lectures)

Rabbit production and management systems; Rabbit breeds for meat and wool; Economic traits and their inheritance; Breeding records and standardisation; Selection methods and breeding systems.

V. Suggested Reading

- Hafez ESE. 1970. *Reproduction and Breeding Techniques for Laboratory Animals*. Philadelphia.
- Peter RC, Nephi MP, Steven DL and James IM. 1987. Rabbit Production, 6th ed. Vero Media Inc.
- Shinde AK, Swarnkar CP and Naqvi SMK. 2013. *Sheep and Rabbit Production and Utilization Technologies*. CSWRI Publications.
- Sirosis M. 2004. *Laboratory Animal Breeding: Principles and Procedures*. Elsevier.
- Tuffery AA. 1995. *Laboratory Animals: An Introduction for Animal Experimenters*. J Wiley and Sons.
- USDA. 2014. *A Complete Hand Book of Backyard and Commercial Rabbit Production*. Peace Corps (Free Online).
- Van Vleck LD, Pollak EJ and Bltenacu EAB. 1987. *Genetics for Animal Sciences*. WH Freeman.
- Weichbrod RH, Thompson GAH and Norton JN. 2018. *Management of Animal Care and Use Programs in Research, Education, and Testing*, 2nd ed. CRC Press.

I. Course Title : Swine Breeding

II. Course Code : AGB 611

III. Credit Hours : 1+0

VI. Theory

Unit I (7 Lectures)

History and development of swine industry; Different breeds of pigs; Economic traits; Breeding records and standardization; Computation of correction factors; Culling and replacement; Equivalent Animal Death Rate (EADR).

Unit II (6 Lectures)

Genetic parameters; Bases and methods of selection; Selection of boars and sows; Breeding systems; Breeding strategies for improvement of indigenous and pure exotic breeds; Inbreeding and its effects on performance traits; Exploitation of heterosis; Development of synthetic varieties/ breeds.

Unit III (2 Lectures)

Swine breeding policy; National swine improvement programme; Conservation of breeds.

VII. Teaching methods

Blackboard: PPT-presentations: Research article discussion in the classroom

VIII. Learning outcome

Get acquainted with different breeds of swine, breeding methods and swine improvement programmes in India

IX. Suggested Reading

- ATARI. 2019. *Pig Farming: Promising Agri-business in Punjab*. ATARI-I Publication (Free Online).
- Board E. 2008. *Handbook of Pig Farming,* Engineers India Research Institute Publications.
- Das A, Tamuli AK, Mohan NH and Thomas R. 2013. *Handbook of Pig Husbandry*, Today and Tomorrow Printers.
- Das A, Tamuli, MK, Thomas R and Banik S. 2012. *Scientific Pig Production Practices,* NRC on Pig Publication.
- FAO. 2009. *Farmer's Hand Book on Pig Production*. FAO Publication.
- Oldenbroek K and van der Waaij L. 2014. *Text Book of Animal Breeding and Genetics*. Wageningen University and Research Centre (Free Online).

I. Course Title : Pet Animal Breeding (Dogs and Cats)

II. Course Code : AGB 612

III. Credit Hours : 1+0

IV. Theory

Unit I (9 Lectures)

Breeds of dogs: Classification of breeds, important Indian and exotic breeds; Pedigree breeding and maintenance of breeding records; Kennel Club; Breed associations; Breeding management of dog.

Unit II (6 Lectures)

Breeds of cats: Classification of breeds, important Indian and exotic breeds; Pedigree breeding and maintenance of breeding records; Breeding management of cat.

V. Suggested Reading

- Battaglia CL. 1990. *Dog Genetics: How to Breed Better Dogs*. TFH Publications.
- Harmer H. 1974. *Dogs and How to Breed Them*, 2nd ed. Gifford Publications.
- Hedberg K. 1992. *The Dog Owner's Manual on Selecting, Raising and Breeding Dogs*. Watermark Press.
- Moore AS. 1981. *Breeding Purebred Cats: A Guide for the Novice and Small Breeder*. Abraxes Publication.
- Robinson R. 1997. *Genetics of Cat Breeders*. Science Direct Publications.
- Vella CM and McGonagle JJ. 1997. *Breeding Pedigreed Cats*. Howell Book House.
- Vella C and Shelton L. 1999. *Genetics for Cat Breeders and Veterinarians*. Elsevier.
- Vine LL. 1977. *Breeding, Whelping and Natal Care of Dogs*. Acro Publication, NY.
- White K. 1980. *Dog Breeding: A Guide to Mating and Whelping*. Bartholomew Publications.

I. Course Title : Wild Animal Genetics and Breeding

II. Course Code : AGB 613

III. Credit Hours : 1+0

IV. Theory

Unit I (4 Lectures)

Wildlife biodiversity of India; Adaptation and natural selection; Species and speciation; Population dynamics; Variation; Loss of genetic variation; Hardy-Weinberg equilibrium.

Unit II (6 Lectures)

Inbreeding: Inbreeding depression, effective population size, demographic bottleneck; Genetic considerations in the translocation of wild animals; Wild animal breeding in nature and captivity; Captive breeding projects and principles; Concept of landscape genetics.

Unit III (5 Lectures)

Conservation of wild animals; Cryopreservation of semen and embryos of endangered species; Frozen zoo concept; Genetic markers; Application of molecular and cytogenetic techniques in wildlife breeding; Genetic defects in wild animals; Wildlife Protection Act.

V. Suggested Reading

- Devera GK, Katerina VT and Charlotte KB. 2012. *Wild Animals in Captivity: Principles and Techniques of Zoo Management*. University of Chicago Press.
- Kleiman DG, Allen ME, Thompson KV and Lumpkin S. 1997. *Wild Mammals in Captivity-Principles and Techniques*. Chicago Press.
- Linda JS. 2017. *A Field Guide of Tracking Mammals in North East*. Countryman Press.
- Nicholas FW. 1987. *Veterinary Genetics*. OXford Science Publication.
- Parragon. 2006. *The Encyclopaedia of Wildlife*. Parragon Books Service Ltd.
- Ranjitsinh MK. 2017. *A Life with Wildlife: From Princely India to the Present*, Harper Collins Publications.
- Saha GK and Mazumdar S. 2017. *Wildlife Biology: An Indian Perspective*. PHI Learning Pvt Ltd.

I. Course Title : Equine Breeding

II. Course Code : AGB 614

III. Credit Hours : 1+0

IV. Theory

Unit I (4 Lectures)

Equine population in India; Domestic diversity, its origin, history and utilization; Breeds of native and exotic horses; Types and classes of light and work-horses.

Unit II (6 Lectures)

Cytogenetics of horses and donkeys; Breeding of horses and donkeys and production of mules; Foaling and care of foal; Important quantitative and qualitative traits and their inheritance; Recording and handling of breeding data; Standardization of records.

Unit III (5 Lectures)

Stallion and mare complementation; Judging criteria for elite animals; Conservation strategies; Selecting the mare and the stallion for breeding; Ongoing breed improvement programmes; Biotechnology in equine breeding programmes.

VIII. Suggested Reading

- McKinnon AO, Squres EL, Vaala WE and Varner DD. 2011. *Equine Reproduction*. Wiley Blackwell.
- Morel MCGD. 2008. *Equine Reproductive Physiology, Breeding and Stud Management*. CABI.
- Samper JC. 2008. *Equine Breeding Management and Artificial Insemination*. Science Direct Publications.

I. Course Title : Camel Breeding

II. Course Code : AGB 615

III. Credit Hours : 1+0

IV. Theory

Unit I (7 Lectures)

Population dynamics and economic importance; Breeds of the camel; Production systems and herd structure; Inheritance of important economic traits; Recording and handling of breeding data; Standardization of records; Cytogenetics of the camel; Behaviour and breeding management.

Unit II (5 Lectures)

Judging criteria for elite animals; Selection of breeding stock; Breeding seasons; Methods for detection of heat; Natural service and artificial insemination; Breed improvement programmes.

Unit III (3 Lectures)

Conservation strategies; Immune status of camel; Molecular genetics in camel breeding.

V. Suggested Reading

- Dmitriez NG and Ernst LK. 1989. *Animal Genetic Resources of the USSR*. FAO.
- Wilson RT. 1984. *The Camel*. Longman.
- Selected Research Articles

I. Course Title : Yak and Mithun Breeding

II. Course Code : AGB 616

III. Credit Hours : 1+0

IV. Theory

Unit I (7 Lectures)

Population dynamics and economic importance; Breeds/ types of yak and mithun; Production systems; Inheritance of important economic traits; Recording and handling of breeding data; Standardization of records; Cytogenetics of yak and mithun; Behaviour and breeding management.

Unit II (5 Lectures)

Judging criteria for elite animals; Selection of breeding stock; Breeding seasons; Methods for detection of heat; Natural service and artificial insemination; Breed improvement. programmes

Unit III (3 Lectures)

Conservation strategies; Molecular genetics in yak and mithun breeding.

V. Suggested Reading

- Das PJ, Deori S and Deb SM. 2017. *Arunachali Yak*. NRC on Yak, Dirang, India.
- Gupta SC, Gupta N and Nivsarkar AE. 1996. *Mithun - A Bovine of Indian Origin*.
- Nivsarkar AE, Gupta SC and Gupta N. 1997. *Yak Production*. ICAR Publication.
- Pal RN. 2003. *The Yak*, 2nd ed. FAO; RAP Publication.
- *Selected Research Articles*

I. Course Title : Statistical Methods in Animal Breeding

II. Course Code : AGB 617

III. Credit Hours : 2+1

IV. Theory

Unit I (12 Lectures)

Measures of central tendency; Measures of dispersion; Correlation and regression; Probability; Theory of distributions; Transformation of data; Sampling: Theory, need and properties; Estimators: Concept, standard error and importance.

Unit II (8 Lectures)

Basics of statistical inferences; Parametric tests: *Z*, *t* and *F* distribution; Non-parametric test: c^2 sign test, run test and rank test; Confidence interval.

Unit III (10 Lectures)

Analysis of variance: One and two way; Experimental designs: CRD, RBD and LSD; Missing plot techniques; Analysis of covariance.

V. Practical (15 Classes)

Measures of central tendency; Measures of dispersion; Correlation and regression; Transformation of data; Probability; Z, t, F and c^2 tests; CRD, RBD and LSD; Analysis of covariance

VI. Suggested Reading

- Gianola D and Hammond K. 1990. *Advances in Statistical Methods for Genetic Improvement of Livestock*. Springer.
- Gupta SC and Kapur VK. 2014. *Fundamentals of applied statistics*. Sultan Chand and Sons.
- Gupta SC. 2016. *Fundamentals of Statistics*. Himalaya Publishing House Pvt Ltd.
- Pillai SK and Sinha HC. 1968. *Statistical Methods for Biological Workers*. Ram Prasad and Sons.
- Snedecor GW and Cochran WG. 1989. *Statistical Methods*. Wiley India Publications.

Course Title with Credit Load
Ph.D. in Animal Genetics and Breeding

Course Code	Course Title	Credit Hours
AGB 701*	Molecular Genetics II	2+0
AGB 702*	Trends in Animal Breeding	2+0
AGB 703*	Biometrical Genetics II	2+1
AGB 704*	Advances in Selection Methodology	2+1
AGB 705	Bioinformatics in Animal Breeding	1+1
AGB 706	Animal Cytogenetics and Immunogenetics II	2+0
AGB 707	Statistical Software in Animal Breeding	1+1
AGB 791	Seminar I	1+0
AGB 792	Seminar II	1+0
AGB 799	Research	75

*Core courses

Course Contents
Ph.D. in Animal Genetics and Breeding

I. Course Title : Molecular Genetics II

II. Course Code : AGB 701

III. Credit Hours : 2+0

IV. Theory

Unit I (10 Lectures)

Eukaryotic genome: Gene families, pseudogenes, SnRNPs; Types of RNA including miRNA; Gene conversion; Tandem repeats; Minisatellites and microsatellites; Sequencing of EST.

Unit II (10 Lectures)

Transposable elements; Transcription and RNA processing; Translation; Regulation of gene expression; Differential expression analysis; Serial analysis of gene expression; Selective gene amplification; The proteasome and longevity of proteins; Gene editing; Gene targeting; Gene knock-out and silencing.

Unit III (10 Lectures)

Transgenic animals: Application, ethical issues; Gene therapy; Bio-pharming; Cloning; Genome imprinting; Epigenetic modification; Creation of SNP chips and microarray technology; Next-generation sequencing; Genomic selection.

V. Suggested Reading

- Brown TA. 2006. *Genome 3*. Garland Science Publishers
- Clark DP. 2012. *Molecular Biology*. Academic Cell
- Hugo van den Berg. 2015. *Cell Biology and Molecular Genetics*. IPO Publishers
- Pasternak JJ. 2005. An Introduction to Human Molecular Genetics*: Mechanisms of Inherited Diseases*. Wiley
- Puehler A and Timmis KN. 1984. *Advanced Molecular Genetics*. Springer
- Watson, JD, Tania AB, Bell SP, Gann A, Levine A and Losick R. 2017. *Molecular Biology of the Gene*. Pearson Education Publication

I. Course Title : Trends in Animal Breeding

II. Course Code : AGB 702

III. Credit Hours : 2+0

IV. Theory

Unit I (12 Lectures)

Identification of novel traits and their role in breed improvement programme; Development of mixed model equations; Advancement in biometrical methods including artificial neural network and Bayesian approach; Detection of QTL; Ancestry informative markers for admixture analysis.

Unit II (10 Lectures)

Formulation of detailed breeding plans; Breeding for disease resistance and functional traits; Breeding for climate resilience; Inheritance of animal behavior traits; Breeding for animal welfare; Impact analysis of different breed improvement programme in various livestock species.

Unit III (8 Lectures)

Advanced techniques in genetic manipulation for multiplication and improvement of livestock species: Use of sexed semen, gene introgression, and cloning, etc.

V. Suggested Reading

- Brah GS. 2016. *Animal Breeding: Principles and Applications*. *Kalyani Publishers*.
- Lynch M and Walsh B. 1998. *Genetics and Analysis of Quantitative Traits*. Oxford University Press.
- Morde RA and Thompson R. 2014. *Linear Models for the Prediction of Animal Breeding Values*. CABI.
- Oldenbroek K and van der Waaij L. 2014. *Text book of Animal Breeding and Genetics*. Wageningen University and Research Centre (Free Online).
- Tomar SS. 2010. *Textbook of Animal Breeding*. Universal Publishers.
- Zeggini E and Morris A. 2010. *Analysis of Complex Disease Association Studies*. Academic Press.

I. Course Title : Biometrical Genetics II

II. Course Code : AGB 703

III. Credit Hours : 2+1

IV. Theory

Unit I (8 Lectures)

Multivariate analysis; Discriminant function; D^2 analysis; Principal component analysis; Path analysis.

Unit II (8 Lectures)

Mating designs: Basis, diallel, partial diallel, NCD-1, 2, 3 for reciprocal and maternal effects.

Unit III (5 Lectures)

Prediction of recombinant inbred lines using genetic parameters; Advances ingenotype-environment interaction and selection indices.

Unit IV (9 Lectures)

QTL mapping; Analysis of SNP data for genomic selection; Advances in the estimation of variance component and prediction of breeding value: Threshold, dominance, random regression and survival models.

V. Practical (15 Classes)

Discriminant function; D^2 analysis; Principal component analysis; Path analysis; Estimation of GCA and SCA through diallel, partial diallel, NCD-1, 2, 3; Advances in construction of selection indices; QTL mapping; Analysis of SNP data for genomic selection; Advances in estimation of variance components.

VI. Suggested Reading

- Choudhuri S. 2014. *Bioinformatics for Beginners*. Academic Press.
- Daniel S and Daniel G. 2012. *Likelihood, Bayesian, and MCMC Methods in Quantitative Genetics*. Springer.
- Kute N and Shinde G. 2016. *Principles of Biometrical Genetics*. Daya Publications.
- Marther K. 1997. *Biometrical Genetics*. Springer.
- Michael JK and Harpal SP. 1996. *The Genetical Analysis of Quantitative Traits*. Springer.
- Pawar IS and Singh S. 2010. *Theory and Application of Biometrical Genetics*. CBS Publications.
- Weller JI. 2016. *Genomic Selection in Animals*. John Wiley and Sons.
- Womack JE. 2012. *Bovine Genomics*. John Wiley and Sons.

I. Course Title : Advances in Selection Methodology

II. Course Code : AGB 704

III. Credit Hours : 2+1

IV. Theory

Unit I (8 Lectures)

Fundamental theorem of natural selection; Selection in finite populations; Effect on genetic structure and variance; Design of selection experiments for testing selection theory.

Unit II (6 Lectures)

Measurement of genetic and environmental trends; Advances in selection indices: Multistage, restricted and retrospective selection indices.

Unit III (6 Lectures)

Empirical evaluation of selection theory: genetic slippage, limits to the selection, asymmetry of response, selection experiments, the effect of selection on variance.

Unit IV (10 Lectures)

Selection for threshold traits; Selection under single and multiple trait animal models; Direct and correlated response through various selection indices; Relationship between BLUP and selection index; Selection using markers and entire genome; Methods for analysing GS data like RR-BLUP, Bayes-1, 2 and 3, etc.

V. Practical (15 Classes)

Determination of culling levels and selection intensity; Estimation of direct and correlated response; Estimation of relative economic values; Construction of various selection indices; Prediction of breeding value using advance methods; QTL analysis using LDMAS and LEMAS.

VI. Suggested Reading

- Balakrishnan N, Nagaraja HN and Kannan N. 2007. *Advances in Ranking, Multiple Comparisons and Reliability*. Springer.
- Cameron ND. 1997. *Selection Indices and Prediction of Genetic Merit in Animal Breeding*. CABI.

  Daniel S and Daniel G. 2012. Likelihood, Bayesian and MCMC Methods in Quantitative Genetics. Springer.
- Draper NR and Smith H. 1998. Applied Regression Analysis. J Wiley and Sons.
- Henderson CR. 1984. *Applications of Linear Models in Animal Breeding*. CABI.
- Legarra A, Lourenco DAL and Vitezica ZG. 2018. *Bases for Genomic Prediction*. INRA (Free Online).
- Morde RA and Thompson R. 2014. *Linear Models for the Prediction of Animal Breeding Values*, CABI.

I. Course Title : Bioinformatics in Animal Breeding

II. Course Code : AGB 705

III. Credit Hours : 1+1

IV. Theory

Unit I (4 Lectures)

Overview of bioinformatics; Database concepts; Algorithms; Information resources for protein and genome databases: GenBank, EMBL, SWISSPROT, PROSITE.

Unit II (5 Lectures)

Nucleotide and protein sequence analysis; Pair-wise and multiple sequence alignments; Phylogeny; Big SNP data analysis methods; Micro-array processing; Clustering; Software for secondary database search and analysis.

Unit III (6 Lectures)

Genetic characterization; Use of bioinformatics tools for identifying QTL and selection of elite germplasm; GWAS; Development of DNA chips; NGS data analysis.

V. Practical (15 Classes)

Database development; Algorithms; Nucleotide and protein sequence analysis; Pair-wise and multiple sequence alignments; Phylogeny and dendrogram; Micro-array processing; Clustering; Secondary database search and analysis; Genetic characterization; Identification of QTL; GWAS; NGS data analysis.

VI. Suggested Reading

- Attwood TK and Parry-Smith DJ. 2001. *Introduction to Bioinformatics*. Benjamin-Cummings Publishing Company.
- Bishop M. 1999. *Genetics Databases*. Elsevier.
- Jiang R, Zhang X and Zhang MQ. 2013. *Basics of Bioinformatics*. Springer. Luke A. 1997.
- *DNA Sequencing: From Experimental Methods to Bioinformatics*. BIOS Scientific Publishers.
- Ramsden J. 2009. *Bioinformatics: An Introduction*. Springer.
- Stekel D. 2003. *Microarray Bioinformatics*. Cambridge University Press.
- Wu CH and McLarty JW. 2000. *Neural Networks and Genome Informatics*. Elsevier Science.
- Xiong J. 2006. *Essential Bioinformatics*. Cambridge University Press.

I. Course Title : Animal Cytogenetics and Immunogenetics II

II. Course Code : AGB 706

III. Credit Hours : 1+1

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IV. Theory

Unit I (8 Lectures)

Structure of eukaryotic chromosomes; Evolution of karyotype; Various *in- vitro* cell culture techniques; Cell lines and utility; Genotoxicity

Unit II (10 Lectures)

Somatic cell genetics; Stem cell genetics; Molecular cytogenetics and gene mapping; Linkage mapping; ISH; FISH; Radiation hybrid mapping; Fibre-FISH; PRINS; Positional cloning; Spectral karyotyping

Unit III (12 Lectures)

Image analysis; Chromosome painting; Chromosome walking; Micro-dissection of chromosomes; Structure and functions of major histocompatibility complex; T Cell receptor; CD4; Interleukins; Toll-like receptors and their functions

X. Suggested Reading

- Agarwal S and Naik S. 2008. *Fundamentals of Immunogenetics Principles and Practices*. IBD Publisher.
- Christiansen FT and Tait BD. 2012. *Immunogenetics: Methods and Applications in Clinical Practice*. Springer.
- Gersen SL and Keagle MB. 2013. *The Principles of Clinical Cytogenetics*. Springer.
- Litwin SD. 1989. *Human Immunogenetics*. CRC Press.
- Tyagi R. 2009. *Textbook of Cytogenetics*. Discovery Publishers.

I. Course Title : Statistical Software in Animal Breeding

II. Course Code : AGB 707

III. Credit Hours : 1+1

IV. Theory

Unit I (4 Lectures)

Data preparation and job control commands for statistical analysis of data; Introduction to statistical and standard software packages.

Unit II (6 Lectures)

Use of software for t-test, Chi-squares test, F-test, ANOVA (CRD, RBD and LSD), correlation and regression (simple, multiple, curvilinear, stepwise) and discriminant analysis.

Unit III (5 Lectures)

Graphic features of the software packages; Linear programming using appropriate software package; Least-squares analysis; Data mining techniques such as neural networks, genetic algorithms and fuzzy logic for predictive modelling.

V. Practical (15 Classes)

Data preparation and generation; Import and eXport of data from spreadsheet and database packages; Use of software for t-test, Chi-squares test, F-test, ANOVA (CRD, RBD and LSD), correlation and regression (simple, multiple, curvilinear, stepwise) and discriminant analysis; Graphic features of the software packages; Use of software for linear programming problem; Least-squares analysis; Use of software for neural networks and fuzzy logic models for prediction.

VI. Suggested Reading

- Balding DJ, Bishop M and Cannings C. 2001. *Handbook of Statistical Genetics*. J Wiley and Sons.
- Boldman K, Kriese LA, Van Vleck LD, Van Tassell CP and Kachman SD. 1995. *Manual for Use of MTDFREML*. ARS, USDA (Free online).
- Dempfle L. 1990. *Statistical Aspects of Design of Animal Breeding Programs*. Springer.
- Freund RJ, Mohr D and William WJ. 2010. *Statistical Methods*. Academic Press.
- Henderson CR. 1984. *Applications of Linear Models in Animal Breeding*. University Guelph Press.
- Isik F, Holland J and Maltecca C. 2017. Genetic *Data Analysis for Plant and Animal Breeding*. Springer.
- Lynch M and Walsh B. 1990. *Genetics and Analysis of Quantitative Traits*. OXford.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Animal Production Sciences

– Animal Nutrition

Course Title with Credit Load
M.V.Sc. in Animal Nutrition

Course Code	Course Title	Credit Hours
ANN 601*	Nutritional Biochemistry	1+0
ANN 602*	Energy and Protein Nutrition	2+0
ANN 603*	Minerals and Vitamin Nutrition and Feed Additives	2+1
ANN 604*	Feed and Fodder Technology	1+1
ANN 605*	Ruminant Nutrition	2+1
ANN 606*	Non-Ruminant Nutrition	2+1
ANN 607*	Research Methodology in Animal Nutrition	0+2
ANN 608	Companion Animal Nutrition	1+0
ANN 609	Nutrition of Laboratory, Wild and Zoo Animals	2+1
ANN 610	Non-Conventional Feed Resources	1+1
ANN 611	Introductory Clinical Nutrition	1+0
ANN 612	Rumen Biotechnology	1+0
ANN 691	Seminar	1+0
ANN 699	Research	30

Course Contents
M.V.Sc. in Animal Nutrition

I. Course Title : Nutritional Biochemistry

II. Course Code : ANN 601

III. Credit Hours : 1+0

IV. Theory

Unit I (12 Lectures)

Classification of carbohydrates and their functions. Digestion and metabolism of carbohydrate in ruminants and non-ruminants. Carbohydrate synthesis.

Unit II (8 Lectures)

Classification and properties of fats and their functions. Digestion and metabolism of fat in ruminants and non-ruminants. Fat synthesis

Unit III (12 Lectures)

Classification, structure, properties and function of proteins, amino acids and nucleic acids. Digestion and metabolism of proteins and other nitrogenous compounds in ruminants and non-ruminants. Protein synthesis. Control of metabolism

V. Suggested Reading

- Cheeke PR and Dierenfeld E. 2010. *Comparative Animal Nutrition and Metabolism*. CAB International.
- D'Mello JPF. 2003. *Amino Acids in Animal Nutrition*, 2nd ed. CAB International.
- Leeson S and Summers JD. 2001. *Scott's Nutrition of The Chicken*, 4th ed. University Books.
- Maynard LA, Loosli JK, Hintz HF and Warner RG. 1987. *Animal Nutrition*. Tata McGraw-Hill.
- McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA and Wilkinson RG. 2011. *Animal Nutrition*, 7th ed. Benjamin Cummings.
- Nelson DL and Cox MM. 2017. *Lehninger Principles of Biochemistry*, 7th ed. Macmillan Learning.

I. Course Title : Energy and Protein Nutrition

II. Course Code : ANN 602

III. Credit Hours : 2+0

IV. Theory

Unit I (8 Lectures)

Measures of feed energy. Partitioning of feed energy. Energy balance, Fasting catabolism. Direct and indirect calorimetry. Efficiency of energy and protein utilization.

Unit II (12 Lectures)

Rumen degradable protein (RDP), and rumen undegradable protein (UDP) and fermentation kinetics. Protein turnover. Quantification of microbial protein synthesis. Protein quality determination in ruminants and monogastrics. Supplementary value of amino acids. NPN metabolism, urea fermentation potential and metabolizable protein. Amino acids imbalance, antagonism and toxicity.

Unit III (12 Lectures)

Feeding standards: comparative appraisal and limitations. Determination of energy and protein requirements. Nutrients metabolism with special reference to milk, meat and wool production. Energy and protein requirement for maintenance, growth, pregnancy and lactation in farm animals.

V. Suggested Reading

- Blaxter K. 1989. *Energy Metabolism in Animal and Man*. Cambridge University Press.
- Bondi A. 1987. *Animal Nutrition*. Wiley InterScience.
- Cheeke PR and Dierenfeld E. 2010. *Comparative Animal Nutrition and Metabolism*. CAB International.
- Crampton EW and Harris LE. 1969. *Applied Animal Nutrition*. WH Freeman.
- Dryden GM. 2008. *Animal Nutrition Science*, 1st ed. CAB International.
- Maynard LA, Loosli JK, Hintz HF and Warner RG. 1987. *Animal Nutrition*. Tata McGraw-Hill.
- McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA and Wilkinson RG.
- 2011. *Animal Nutrition*, 7th ed. Benjamin Cummings.
- Pond WG, Church DB, Pond KR and Schoknecht PA. 2004. *Basic Animal Nutrition and Feeding*, 5th ed. Wiley.
- Singh UB. 1987. *Advanced Animal Nutrition for Developing Countries*. Indo-Vision.

I. Course Title : Minerals and Vitamin Nutrition and Feed Additives

II. Course Code : ANN 603

III. Credit Hours : 2+1

IV. Theory

Unit I (12 Lectures)

General role of minerals, factors affecting mineral requirements. Macro-minerals and micro-minerals, their, distribution, metabolism, physiological functions, Deficiencies and eXcesses, and sources and requirements. Probable essential minerals.

Unit II (6 Lectures)

Mineral interactions. Chelated minerals and concept of nano-minerals. Bioavailability studies in minerals. Impact of minerals on reproduction, fertility, and immunity. Soil-plant-animal-human relationship, development of area-specific minerals. Toxic minerals; their role in health and production of farm animals. Newly recognized trace minerals.

Unit III (10 Lectures)

Definition, history, classification, chemistry, functions, deficiencies and excesses, requirements and sources of water-soluble and fat-soluble vitamins. Role of vitamins in energy metabolism. Vitamin-mineral interrelationship. Vitamin toxicosis. Role of vitamins in reproduction, fertility and immunity.

Unit IV (4 Lectures)

Feed additives and nutraceuticals. Probiotics, prebiotics and synbiotics; eubiotics. Feed enzymes. Phytochemical feed additives; polyphenols and essential oils; organic acids and acidifiers.

V. Practical (16 Classes)

General principles of mineral estimation. Sampling and processing techniques. Use of atomic absorption spectrometry and ICP in mineral estimation. Estimation of macro- and micro-minerals. Formulation of mineral mixture for various species. Estimation of some important vitamins (vitamin A, E and C). Purified diets for mineral and vitamin studies. Calculation of mineral and vitamin requirements.

VI. Suggested Reading

- McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA and Wilkinson RG. 2011. *Animal Nutrition*, 7th ed. Benjamin Cummings.
- McDowell RL. 1989. *Vitamins in Animal Nutrition.* Academic Press.
- McDowell RL. 2003. *Minerals in Animal and Human Nutrition*, 2nd ed. Elsevier Science.
- Suttle NF. 2010. *Mineral Nutrition of Livestock*, 4th ed. CAB International.

I. Course Title : Feed and Fodder Technology

II. Course Code : ANN 604

III. Credit Hours : 1+1

IV. Theory

Unit I (4 Lectures)

Various feed mill equipment and their handling; layout and operations in feed mill (small, medium and large feed plants); automated feed mill: merits and demerits. Procurement of feed ingredients: specification and guidelines. Quality control of feed ingredients and finished feeds. BIS standard.

Unit II (4 Lectures)

Principles and process of material handling, weighing, grinding, mixing, pelleting, packaging and other major processing operations. Crumbling, flaking, popping and extrusion. Premixes. Codex Alimentarius, HACCP.

Unit III (4 Lectures)

Feed and fodder processing and preservation techniques. Densification, chemical and biological treatment of feeds/ fodders. Fodder conservation through hay and silages; Microbiological evaluation of processed and preserved feeds; Effect of preservation on the nutritional value of feed.

Unit IV (4 Lectures)

Feed storage and godown management; goods sanitation and hygiene of go-down. Traditional and modern farm-level storage structures. Factors affecting feedstuffs during storage. Liquid feed ingredients. Storage losses; insect pests and rodents control measures; Mycotoxins in feedstuffs and its control measures.

VII. Practical (16 Classes)

Quality control and inspection of feed materials. Qualitative tests for adulterants urea, urease, thiram. Identification of insect pests and fungi in stored products. Feed microscopy. Formulation and preparation premixes. Quality evaluation of silage and hay, Laboratory preparation of silage. Visit to feed plant: Hands-on training on preparation of feed and mineral mixture. Preparation of project report on plant layout and design, problems related to feasibility, record-keeping in different sections of a feed mill.

VIII. Suggested Reading

- Dryden G. 2008. *Animal Nutrition Science*. CAB International.
- Kundu SS, Mahanta SK, Singh S and Pathak PS. 2016. *Animal Feed Technology*. Satish Publishers
- Perry TW, Cullison AE and Lowrey RS. 2003. *Feeds and Feeding*, 6th ed. Pearson.
- Pond WG, Church DB, Pond KR and Schoknecht PA. 2004. *Basic Animal Nutrition and Feeding*, 5th ed. Wiley.
- Schofield EK (Ed.). 2005. *Feed Manufacturing Technology V*. American Feed Industry Association, Arlington.

I. Course Title : Ruminant Nutrition

II. Course Code : ANN 605

III. Credit Hours : 2+1

IV. Theory

Unit I (6 Lectures)

Functional anatomy of the digestive system of ruminants. Introduction to rumen microflora and fauna. Development of rumen. Feeds and fodders for ruminant feeding.

Unit II (12 Lectures)

Water requirements. Nutrient requirements and feeding of calves, heifers, dry, pregnant and lactating cows, buffaloes, sheep and goat. Peculiarities of digestive physiology, nutrition and feeding management of camels.

Unit III (6 Lectures)

Voluntary feed intake. Determination of digestibility, factors affecting digestibility. Manipulation of rumen fermentation.

Unit IV (12 Lectures)

Concept of complete feed and total mixed ration. Precision feeding. Phase feeding. Limiting nutrients and strategic feeding of high yielding ruminants. Concept of by-pass nutrients and their impact on production, reproduction and immune status.

Unit V (12 Lectures)

Nutritional approaches for increasing the functional properties of milk: role of CLA, omega fatty acids. Different systems of feeding buffalo for beef production. Feeding during stress and natural calamities. Feeding management of migratory/ nomadic small ruminants.

V. Practical (16 Classes)

Design and planning of feeding experiments. Identification of feed and fodder based on its composition. Ration formulation for large and small ruminants for different physiological stages. Estimation of digestibility and nutritive value of feeds and fodders by metabolism trial in dairy cattle. Determination of nutritive value of pastures by the use of range techniques. Collection and processing of rumen liquor. Estimation of rumen metabolic profile (pH, ammonia, lactate, and TVFA, etc.). Estimation of purine derivatives.

VI. Suggested Reading

- Church DC. 1988. *The Ruminant Animal: Digestive Physiology and Nutrition*, 2nd ed. Prentice-Hall.
- Dehority BA. 2003. *Rumen Microbiology*. Nottingham University Press.
- D'Mello JPF. 2003. *Amino Acids in Animal Nutrition*, 2nd ed. CAB International.
- Givens D, Axford R and Owen E. (Ed.). 2000. *Forage Evaluation in Ruminant Nutrition*. CAB International.
- Hynd PI. 2019. *Animal Nutrition: From Theory to Practice*. CAB International.
- McDowell RL. 2012. *Nutrition of Grazing Ruminants in Warm Climates*. Academic Press.
- Moran J. 2005. *Tropical Dairy Farming: Feeding Management for Small Holder Dairy Farmers in the Humid Tropics*. Landlinks Press
- NRC. 2001. *Nutrient Requirements of Dairy Cattle*, 7th rev. ed. National Research Council. National Academies Press.
- NRC. 2016. *Nutrient Requirements of Beef Cattle*, 8th rev. ed. National Academies of Sciences, Engineering, and Medicine. National Academies Press.
- NRC. 2007. *Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids*. National Research Council. National Academy Press.
- Pond WG, Church DB, Pond KR and Schoknecht PA. 2004. *Basic Animal Nutrition and Feeding*, 5th ed. Wiley.
- Shirley RL. 2012. *Nitrogen and Energy Nutrition of Ruminants*. Academic Press.10.
  Van Soest PJ. 1994. *Nutritional Ecology of the Ruminant*. Cornell University Press.

I. Course Title : Non-Ruminant Nutrition

II. Course Code : ANN 606

III. Credit Hours : 2+1

IV. Theory

Unit I (20 Lectures)

Feeding of poultry for meat and egg production. Ideal protein concept. Standard ileal digestible amino acids. Nutrient requirements for broilers and layers. Feeding of breeder hens; nutritional factors affecting hatchability. Feeding systems for poultry. Feed additives for poultry. Nutritional approaches for designer egg and meat production. Nutritional disorders in poultry and the role of nutrition in diseases prevention. Water intake and quality in poultry production.

Unit II (16 Lectures)

Nutrition and feeding of swine in different stages of growth and production. Nutritional factors affecting the quality of the products: lean meat production. Water intake and quality in pig production.

Unit III (12 Lectures)

Feeding of equines. Feeding of rabbits. Hindgut fermentation and its importance. Nutrient requirements of equines. Special features of equine feeding management. Nutritional management of colic and other health disorders. Nutrient requirements of rabbits for wool and meat production. Nutrition-related disorders in rabbits.

V. Practical (16 Classes)

Design and planning for poultry and swine feeding eXperiments. Calculation of nutrient requirements for broilers and layers. Formulation and compounding of general and least-cost rations, determination of the nutritive value of poultry and swine feeds by balance eXperiments. Formulation of rations for horses and rabbits. Visit poultry and piggery units, feed and fodder stores. Calculation of different measures of protein quality.

X. Suggested Reading

- Adamo G and Costanza A (Eds.). *Rabbits Biology, Diet and Eating Habits and Disorders*. Nova Biomedical.
- Cheeke PR. 1987. *Rabbit Feeding and Nutrition*. Academic Press, Inc.
- Chiba LI (Ed.). 2012. *Sustainable Swine Nutrition*. Wiley-Blackwell.
- de Blas C and Wiseman J. (Eds.). 2010. *Nutrition of the Rabbit*, 2nd ed. CAB International.
- D'Mello JPF. 2003. *Amino Acids in Animal Nutrition*, 2nd ed. CAB International.
- Frape D. 2010. *Equine Nutrition and Feeding*, 4th ed. Wiley-Blackwell.
- Hynd PI. 2019. *Animal Nutrition: From Theory to Practice*. CAB International.
- Leeson S and Summers JD. 2009. *Commercial Poultry Nutrition*, 3rd ed. Nottingham University Press.
- Leeson S and Summers JD. 2019. *Scott's Nutrition of The Chicken*, 4th ed. CBS Publishers and Distributors.
- NRC. 2007. *Nutrient Requirements of Horses*, 6th Rev. ed. National Research Council. National Academy Press.
- NRC. 1994. *Nutrient Requirements of Poultry*, 9th Rev. ed. National Research Council. National Academy Press.
- NRC. 2012. *Nutrient Requirements of Swine*, 11th Rev. ed. National Research Council. National Academy Press.
- Varga M. 2013. *Textbook of Rabbit Medicine*, 2nd ed. Butterworth-Heinemann.

I. Course Title : Research Methodology in Animal Nutrition

II. Course Code : ANN 607

III. Credit Hours : 0+2

IV. Practical

Unit I (6 Classes)

Principles of Common statistical tools for nutritional animalresearch eXperimentation.

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Unit II (20 Classes)

Preparation of standard solutions. Proximate analysis of feeds and fodders. Cell-wall partitioning using Van Soest methods. Markers in digestibility determination. *In-vitro/ in sacco* determination of digestibility and digestion kinetics. Determination of energy content of feed, faeces and urine using bomb calorimeter. Determination of blood metabolic profile.Unit III (6 *Classes*)Introduction and principles of GC, HPLC, AAS, ICP, tracer technique, flame photometer, NIR, SF_6, rumen-simulation technique, and amino acid analyzer.

IX. Suggested Reading

- Bate ST and Clark RA. 2014. *The Design and Statistical Analysis of Animal Experiments*. Cambridge University Press.
- Hofmann A and Clokie S (Eds.). *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology*, 8th ed. Cambridge University Press.
- Maynard LA, Loosli JK, Hintz HF and Warner RG. 1987. *Animal Nutrition*. Tata McGraw-Hill.
- McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA and Wilkinson RG. 2011. *Animal Nutrition,* 7th ed. Benjamin Cummings.
- Pounis G. 2018. *Analysis in Nutrition Research*. Academic Press.

I. Course Title : Companion Animal Nutrition

II. Course Code : ANN 608

III. Credit Hours : 1+0

IV. Theory

Unit I (4 Lectures)

Philosophy of companion animal nutrition. Digestion and absorption of nutrients in dogs and cats. Nutrient requirements for dogs and cats during different life stages: energy, protein, fat, minerals and vitamins. Critical nutrients for cats.

Unit II (4 Lectures)

Common feed ingredients and supplements for pets. Homemade diets. Commercial pet foods: types and nutritional profile. Processing techniques in pet food manufacturing. Pet food evaluation and quality control.

Unit III (4 Lectures)

Feeding management for dogs and cats of different age groups, viz., pregnancy, lactation, neonatal puppies and kitten, growth, adult maintenance, stress and geriatrics including feeding behaviour. Water requirements.

Unit IV (4 Lectures)

Deficiencies and eXcesses of nutrients. Nutritionally responsive disorders: inherited disorders of nutrient metabolism, diabetes mellitus, obesity, urinary tract health and kidney diseases. Parenteral nutrition for hospitalized pets.

IX. Suggested Reading

- Buffington C, Holloway C, Abood S. 2004. *Manual of Veterinary Dietetics*. Elsevier.
- Case LP, Daristotle L, Hayek MG, Raasch MF. 2010. *Canine and Feline Nutrition: A Resource for Companion Animal Professionals*, 3rd ed. Elsevier.
- Case LP. 2005. *The Dog: Its Behavior, Nutrition, and Health*, 2nd ed. Blackwell Publishing.
- McNamara JP. 2013. *Principles of Companion Animal Nutrition*, 2nd ed. Pearson.
- NRC. 2006. *Nutrient Requirements of Dogs and Cats*. National Research Council. National Academy Press.

I. Course Title : Nutrition of Laboratory, Wild and Zoo Animals

II. Course Code : ANN 609

III. Credit Hours : 2+1

IV. Theory

Unit I (12 Lectures)

Digestive structure and functions of laboratory animals: rats, mice, and guinea pigs. Nutritional requirements of various species of laboratory animals. Feeding of laboratory animals. Concept of purified diets in laboratory animals. Nutrition of non-human primates.

Unit II (10 Lectures)

Natural dietary habits of zoo animals. Feeding schedules of various classes captive and zoo animals and birds. Feeding orphan and neonates. Role of nutrition in the management of health disorders in zoo animals. Feeding of sick and old animals: parenteral nutrition.

Unit III (10 Lectures)

Feeding habits, and behaviour of wild animals. General aspects of digestive physiology of herbivores and carnivores. Nutrition of semi-wild animals like mithun and yak. Nutritive characteristics of forages for wild animals. Adequacy of forage plants for wild and zoo animals.

V. Practical (16 Classes)

Formulation and preparation of hygienic, balanced diets and feeding of laboratory animals. Characteristics of ration formulation and feeding schedules wild and zoo animals. Visit zoological parks and wildlife sanctuary, and collection of information on the feeding schedule of different categories of captive animals.

IX. Suggested Reading

- Barboza PS, Parker KL and Hume ID. 2008. *Integrative Wildlife Nutrition*. Springer.
- Clemons DJ and Seeman JL. 2011. *The Laboratory Guinea Pig*, 2nd ed. CRC Press/ Taylor and Francis.
- Gordon IJ and Prins HHT. 2008. *The Ecology of Browsing and Grazing*. Springer.
- Lane-Patter W and Pearson AEG. 1971. *The Laboratory Animal: Principles and Practice*, 2nd ed. Academic Press.
- NRC. 1995. *Nutrient Requirements of Laboratory Animals*, 4th rev. ed. National Research Council. National Academy Press.
- NRC. 2003. *Nutrient Requirements of Nonhuman Primates*. National Research Council. National Academy Press.
- NRC. 2011. *Guide for the Care and Use of Laboratory Animals*, 8th ed. National Research Council. National Academy Press.
- Pond WG, Church DB, Pond KR and Schoknecht PA. 2004. *Basic Animal Nutrition and Feeding*, 5th ed. Wiley.
- Robbins C. 1993. *Wildlife Feeding and Nutrition*, 2nd ed. Elsevier.
- Weichbrod RH, Thompson GAH and Norton JN (Eds.). 2018. *Management of Animal Care and Use Programs in Research, Education, and Testing*, 2nd ed. CRC Press/ Taylor and Francis.

I. Course Title : Non-Conventional Feed Resources

II. Course Code : ANN 610

III. Credit Hours : 1+1

IV. Theory

Unit I (8 Lectures)

Present and future feed requirements and current availability for livestock and poultry. Use of non-conventional feeds; By-products of agricultural, industrial, food processing units and forest by-products. Slaughterhouse by-products, aquatic weeds. Permissible levels of inclusion of various non-conventional feeds in the ration of different kinds of livestock. Formulation of economical rations using the non-conventional feed.

Unit II (5 Lectures)

Classification of toxic principles in animal feedstuffs. Chemico-physical properties of various anti-nutritional factors (ANFs). Rumen microbial adaptation to various ANFs. Effect of anti-nutritional factors on health and production indifferent species of livestock.

Unit III (3 Lectures)

Detoxification of toxin principles by various physical, chemical and biological techniques. Insecticide and pesticide residues, heavy metals residues in feeds and fodders.

V. Practical (16 Classes)

Qualitative methods for the presence/ detection of ANFs in feedstuffs. Estimation of mycotoxins in various feeds and fodders. Estimation nitrates, HCN, oxalates, protease inhibitors, tannins, saponins, gossypol, mimosine and heavy metals.

VI. Suggested Reading

- Devendra C. 1985. *Non-conventional Feed Resources in Asia and the Pacific*, 2nd ed. APHCA, FAO.
- FAO. 1995. *Tropical Feeds and Feeding Systems*. Proceedings of the First FAO Electronic Conference. Food and Agriculture Organization of the United Nations, Rome.
- FAO. 2004. *Assessing Quality and Safety of Animal Feeds*. Food and Agriculture Organization of the United Nations, Rome.
- Liner IE. 1980. *Toxic Constituents of Animal Food Stuffs*, 2nd ed. Academic Press.
- Singh UB. 1987. *Advanced Animal Nutrition for Developing Countries*. Indo-Vision.
- Speedy A and Sansoucy R. 1991. *Feeding Dairy Cows in the Tropics*. Food and Agriculture Organization of the United Nations, Rome.

Select articles from journals

I. Course Title : Introductory Clinical Nutrition

II. Course Code : ANN 611

III. Credit Hours : 1+0

IV. Theory

Unit I (8 Lectures)

Metabolic disorders and peri-parturient diseases: milk fever, ketosis, downer cow syndrome, retained placenta, sub-acute ruminal acidosis, laminitis, abomasal displacement, mastitis. Nutrient parasite interaction. Enterotoxaemia

Unit II (8 Lectures)

Nutritional amelioration of biotic and abiotic stress: heat and cold stress, transportation stress. Potential plant toxicity to grazing animals. Toxicity of grazing animals: signs of poisoning. Nitrite poisoning, toxic effects of goitrogens, glucosinolates. Nutritional management of reproductive disorders.

V. Suggested Reading

- Constable P, Hinchcliff KW, Done S and Gruenberg W. 2016. *Veterinary Medicine*, 11th ed. Saunders Ltd.
- Knight AP and Walter R. 2001. *A Guide to Plant Poisoning of Animals in North America*. Teton NewMedia.
- McDowell RL. 2012. *Nutrition of Grazing Ruminants in Warm Climates*. Academic Press.
- Select articles from Journals

I. Course Title : Rumen Biotechnology

II. Course Code : ANN 612

III. Credit Hours : 1+0

IV. Theory

Unit I (8 Lectures)

Rumen ecology. Manipulation of rumen fermentation for better utilization of fibrous feeds and reduction in methane production. Biotechnological applications for lignin degradation. Role of feed additives, chemicals, antibiotics and probiotics and their effect on rumen metabolism. Degradation of anti-nutritional factors in the rumen.

Unit II (8 Lectures)

Genetic manipulation, DNA recombinant technology for improvement in rumen fermentation. Factors influencing the fate of introduced microbes. Metagenomics for microbial diversity: concept and application.

VIII. Suggested Reading

- Dehority BA. 2003. *Rumen Microbiology*. Nottingham University Press.
- Dijkstra J, Forbes J and France J. 2005. *Quantitative Aspects of Ruminant Digestion and Metabolism*. CAB International.
- Kebreab E, Dijkstra J, Bannink A, Gerrits W and France J. 2006. *Nutrient Digestion and Utilization in Farm Animals*. CAB International.
- Millen DD, Arrigoni MDB and Pacheco RDL. (Eds.). 2016. *Rumenology*. Springer Nature.
- Van Soest PJ. 1994. *Nutritional Ecology of the Ruminant*. Cornell University Press.

Course Title with Credit Load
Ph.D. in Animal Nutrition

Course Code	Course Title	Credit Hours
ANN 701*	Modern Concepts in Feeding of Ruminants	2+0
ANN 702*	Forages in Animal Nutrition	1+0
ANN 703*	Recent Concepts in Feeding of Non-Ruminants	1+0
ANN 704*	Advances in Rumen Metabolism	1+1
ANN 705*	Advances in Mineral and Vitamin Nutrition	2+0
ANN 706*	Advanced Clinical Nutrition	1+1
ANN 707	Advanced Techniques in Nutritional Research	1+1
ANN 708	Advances in Feed Technology	1+0
ANN 709	Toxicants and Anti-Metabolites in Animal Nutrition	1+0
ANN 710	Nutrigenomics in Animal Nutrition	1+0
ANN 711	Equine Nutrition	1+0
ANN 791	Seminar-I	1+0
ANN 792	Seminar-II	1+0
ANN 799	Research	75

*Core courses

Course Contents
Ph.D. in Animal Nutrition

I. Course Title : Modern Concepts in Feeding of Ruminants

II. Course Code : ANN 701

III. Credit Hours : 2+0

IV. Theory

Unit I (20 Lectures)

Developments in ruminant digestive physiology. Advanced concepts in the determination of energy and protein requirements. Importance of energy and protein quality for milk and meat production. Recent concepts in protein and energy systems like CNCPS, net energy, metabolizable and available protein. Methods of estimation of energy and protein values of feeds for different physiological functions of livestock. Kinetics of nutrient metabolism. Hindgut fermentation. Efficiency of nutrient utilization for different production purposes. Hormonal regulation of nutrient partitioning.

Unit II (12 Lectures)

Concept of limiting amino acids for high yielders. Strategic feeding of high yielding dairy cows and meat-producing ruminants. Concept of phase feeding and precision feeding. Feeding during the transition period. Bypass nutrient technology. Rumen manipulation to optimize productivity and reduce methanogenesis.

V. Suggested Reading

- D'Mello JPF. 2003. *Amino Acids in Animal Nutrition*, 2nd ed. CAB International.
- McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA and Wilkinson RG. 2011. *Animal Nutrition*, 7th ed. Benjamin Cummings.
- McDowell RL. 2012. *Nutrition of Grazing Ruminants in Warm Climates*. Academic Press.
- NRC. 2001. *Nutrient Requirements of Dairy Cattle*, 7th rev. ed. National Research Council. National Academies Press.
- NRC. 2016. *Nutrient Requirements of Beef Cattle*, 8th rev. ed. National Academies of Sciences, Engineering, and Medicine. National Academies Press.

I. Course Title : Forages in Animal Nutrition

II. Course Code : ANN 702

III. Credit Hours : 1+0

IV. Theory

Unit I (10 Lectures)

Forages in ruminant production. Improvement in productivity of fodders and pasture: feed-food crops, silvi-pasture, horti-pasture, shrubs. Use of conserved forages in ruminant feeding. Factors affecting the nutritive value of cultivated and conserved forages. Hydroponics as an alternate to green fodder production.Top feeds, fodder trees and their effective utilization. Tree leaves as a source of condensed tannins: role in protein protection and GI parasite control.

Unit II (6 Lectures)

Methods in forage evaluation: calculated *in-vitro* DOMD and ME by using *in-vitro* gas production technique. Pasture consumption and evaluation studies.

V. Suggested Reading

- Givens D, AXford R and Owen E. (Ed.). 2000. *Forage Evaluation in Ruminant Nutrition*. CAB International.
- McDowell RL. 2012. *Nutrition of Grazing Ruminants in Warm Climates*. Academic Press.
- Minson D. 1990. *Forage in Ruminant Nutrition*. Academic Press.
- Shirley RL. 2012. *Nitrogen and Energy Nutrition of Ruminants*. Academic Press.

I. Course Title : Recent Concepts in Feeding of Non-Ruminants

II. Course Code : ANN 703

III. Credit Hours : 1+0

VI. Theory

Unit I (18 Lectures)

Latest concepts in nutrition and feeding in different phases of broiler, layer and breeder stocks. In-ovo and early chick nutrition. Nutritional disorders in modern poultry production and their amelioration. Nutritional factors affecting egg quality and hatchability in poultry. Feeding strategies for the production of designer eggs and meat. Omega fatty acids. Recent trends in amino acid nutrition. Advances in new generation feed and feed additives.

Unit II (14 Lectures)

Nutrition and feeding of pigs in various stages of production. Modern concepts in amino acids nutrition in swine production. Emerging concepts in feeds and feed additive for pigs. Role of vitamins and minerals in health and disease. Nutritional manipulation for lean meat and designer pork production. Carcass modifiers.

VII. Suggested Reading

- Chiba LI (Ed.). 2012. *Sustainable Swine Nutrition*. Wiley-Blackwell.
- D'Mello JPF. 2003. *Amino Acids in Animal Nutrition*, 2nd ed. CAB International.
- Hendriks WH, Verstegen MWA and Babinszky L. (Eds.). 2019. *Poultry and Pig Nutrition: Challenges of the 21st Century*. Wageningen Academic Publishers.
- Leeson S and Summers JD. 2001. *Scott's Nutrition of The Chicken*, 4th ed. University Books.
- Lewis AJ and Southern LL. 2000. *Swine Nutrition*, 2nd ed. CRC Press.

I. Course Title : Advances in Rumen Metabolism

II. Course Code : ANN 704

III. Credit Hours : 1+1

IV. Theory

Unit I (8 Lectures)

Rumen development. Rumen microflora: classification and their role in fermentation and digestion, microbial interactions, rumen kinetics, the nutrient requirement of rumen microbes. Dynamics of nitrogen metabolism in the rumen.

Unit II (8 Lectures)

Manipulation of rumen fermentation: physical, chemical and biological approaches. Trans-faunation and defaunation. Concept of metagenomics in rumen manipulation. Green-house gas production from rumen and mitigation strategies

V. Practical (16 Classes)

Rumen microbial and protozoal count. Estimation of rumen microbial protein. Estimation of nitrogen-fractions in rumen liquor. Volatile fatty acid fractionations. Rumen enzymes assay. Extraction of nucleic acids and quantification of rumen microbes by PCR.

VI. Suggested Reading

- Dehority BA. 2003. *Rumen Microbiology*. Nottingham University Press.
- Dijkstra J, Forbes J and France J. 2005. *Quantitative Aspects of Ruminant Digestion and Metabolism*. CAB International.
- Kebreab E, Dijkstra J, Bannink A, Gerrits W and France J. 2006. *Nutrient Digestion and Utilization in Farm Animals*. CAB International.
- Millen DD, Arrigoni MDB and Pacheco RDL. (Eds.). 2016. *Rumenology*. Springer Nature.
- Van Soest PJ. 1994. *Nutritional Ecology of the Ruminant*. Cornell University Press.

I. Course Title : Advances in Mineral and Vitamin Nutrition

II. Course Code : ANN 705

III. Credit Hours : 2+0

IV. Theory

Unit I (18 Lectures)

Role of minerals in nutrient metabolism. Mineral absorption, transport, metabolism and its regulation. Bio-availability of macro and micro minerals: factors affecting the bioavailability; bio-markers for mineral status. Mineral interactions. Dietary cation-anion difference (DCAD). Identification and correction of deficiencies and toxicities of minerals. Mineral tolerance in animals. Mineral requirements for growth, reproduction and lactation. Mineral toxicities concerning livestock feeding and their amelioration. Methods of mineral supplementation.

Unit II (14 Lectures)

Chemical nature of fat-soluble and water-soluble vitamins. Role of vitamins in nutrient metabolism. Advances in physiological functions and metabolism of vitamins. Vitamin deficiency: clinical signs and their management. Antimetabolites to vitamins. Hypervitaminosis. Vitamins as antioxidants. Role of vitamins in immunity and stress. Dietary supplementation of vitamins: forms, storage and stability.

V. Suggested Reading

- McDowell RL. 1989. *Vitamins in Animal Nutrition.* Academic Press.
- McDowell LR. 2003. *Minerals in Animal and Human Nutrition,* 2nd ed. Elsevier Science B.V.
- Suttle N. 2010. *The Mineral Nutrition of Livestock,* 4th ed. CAB International.

I. Course Title : Advanced Clinical Nutrition

II. Course Code : ANN 706

III. Credit Hours : 1+1

IV. Theory

Unit I (12 Lectures)

Metabolic disorders in farm animals. Modern concepts in the metabolic alterations leading to production diseases, viz., milk fever, ketosis, downer cow syndrome, retained placenta, sub-acute ruminal acidosis, laminitis, abomasal displacement and mastitis Optimum nutrition for peri-parturient dairy animals.

Unit II (10 Lectures)

Metabolic effects of infection: metabolism of carbohydrates, fats, protein and amino acids and minerals during various infection and inflammatory diseases. Role of cytokines in nutrient homeorrhesis. Nutrition-immunity interaction: Role of nutrients (fats, amino acids, minerals and vitamins) in the immune response. Metabolic alterations during abiotic stress and feeding management during stress situations.

Unit III (10 Lectures)

Nutritional manipulation and feeding of sick and hospitalized animals. Preventive and therapeutic nutrition. Optimum nutrition for the management of diseases of the hepatic, renal and gastrointestinal system. Convalescence diet. Feeding management of pre- and post-operated animals.

V. Practical (16 Classes)

Assessment of immunity: humoral immune response, cell-mediated immune response. Assessment of antioXidant status: SuperoXide dismutase, Catalase, Glutathione peroXidase, reduced glutathione (GSH), lipid peroXides. Formulation of diet for sick and diseased animals.

VI. Suggested Reading

- Cheeke PR and Dierenfeld E. 2010. *Comparative Animal Nutrition and Metabolism*. CAB International.
- Constable P, Hinchcliff KW, Done S and Gruenberg W. 2016. *Veterinary Medicine*, 11th ed. Saunders Ltd.
- Naylor JM and Ralston SL. 1991. *Large Animal Clinical Nutrition*. Mosby Inc.
- Walker S, Beckett G, Rae P and Ashby P. 201. *Clinical Biochemistry: Lecture Notes*, 9th ed. Wiley-Blackwell

I. Course Title : Advanced Techniques in Nutritional Research

II. Course Code : ANN 707

III. Credit Hours : 1+1

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IV. Theory

Unit I (16 Lectures)

Good laboratory practices. Analytical equipment in animal nutrition research. Estimation of minerals using atomic absorption spectrophotometer and ICP. Principles and applications and of GC, HPLC, amino acid analyzer, SF6, and electron microscopy. Remote sensing and geographic information system (GIS) in animal nutrition research. Analysis of feeds and fodders using NIR. Faecal inoculum as an alternative to rumen liquor for *in-vitro* studies.

VII. Practical (16 Classes)

RUSITEC. Estimation of minerals by atomic absorption spectrophotometer. Estimation of mycotoXins, oXalate, nitrates and tannin. Fatty acid analysis. Vitamin estimation.

VIII. Suggested Reading

- Kaneko J, Harvey J, Bruss M.(Eds.) 2008. *Clinical Biochemistry of Domestic Animals*, 6th ed. Academic Press.
- Krishna 2012. *Livestock Nutrition- Analytical Techniques*. New India Publishing Agency.

VIII.

I. Course Title : Advances in Feed Technology

II. Course Code : ANN 708

III. Credit Hours : 1+0

IV. Theory

Unit I (10 Lectures)

Good manufacturer practices (GMP) in feed plants. Planning and designing of feed plants of different capacities. Recent developments in feed processing: particle size reduction, pelleting, extrusion, expanding, conditioning, micronizing. Post pelleting applications. Automation in feed processing. Flow charts for preparation of feeds for various species. Mixer efficiency test, pellet durability test. Densification of bulk feeds. Silos of various capacity, silage preparation and silage additives.Laws and regulations of the feed manufacturing industry. Introduction to labour laws and standards, planning and production programme. Record-keeping.

Unit II (6 Lectures)

Roughage processing. Whole plant processing. Solid-state fermentation technology.Preparation of complete feeds and its processing.Formulation of premixes. Carriers and diluents. Liquid feed handling. Latest concepts in feed microscopy. Qualitativetests for rancidity.

V. Suggested Reading

- Langham J. 2013. *Recent Advances in Animal Feed Technology*. Random Exports.
- Moughan PJ and Hendricks WH. (Eds.). 2018. *Feed Evaluation Science*. Academic publishers.
- Perry TW, Cullison AE and Lowrey RS. 2003. *Feeds and Feeding*, 6th ed. Pearson.
- Schofield EK (Ed.). 2005. *Feed Manufacturing Technology V*. American Feed Industry Association, Arlington.

I. Course Title : Toxicants and Anti-Metabolites in Animal Nutrition

II. Course Code : ANN 709

III. Credit Hours : 1+0

IV. Theory

Unit I (12 Lectures)

Classification of toxicants in animal feeds. Plant origin toxicants, microbial origin toxicants, acquired toxicants (heavy metals, pesticide residues, drug residues), and their effects on animal health and production. Ameliorative measures. Detoxification of plant origin toxicants. Residual effects on animal products and the environment.

Unit II (4 Lectures)

Anti-metabolites in animal feedstuffs. Effects of anti-metabolites on animal health and production. Anti-vitamins

V. Suggested Reading

- Cheeke PR and Shull LR. 1985. *Natural Toxicants in Feeds And Poisonous Plants*. AVI Publishing Company Inc.
- FAO. 2004. *Assessing Quality and Safety of Animal Feeds*. Food and Agriculture Organization of the United Nations, Rome.
- Gremmels JF (Ed.). 2010. *Animal Feed Contamination Effects on Livestock and Food Safety*. Woodhead Publishing Ltd.
- Keeler RF, Van Kampen KR and James LF. 1978. *Effects of Poisonous Plants on Livestock*. Academic Press.
- Knight AP and Walter R. 2001. *A Guide to Plant Poisoning of Animals in North America*.

  . Teton NewMedia.
- Liner IE. 1980. *Toxic Constituents of Animal Food Stuffs*, 2nd ed. Academic Press.
- Osweiler G. (Ed.) 2011. *Ruminant Toxicology. An issue of Veterinary Clinics: Food AnimalPractice*. Elsevier
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I. Course Title : Nutrigenomics in Animal Nutrition

II. Course Code : ANN 710

III. Credit Hours : 1+0

IV. Theory

Unit I (4 Lectures)

Basic concepts of genetics and molecular biology. Nucleic acid structure and replication, transcription and translation.

Unit II (8 Lectures)

Introduction to nutrigenomics and nutrigenetics. Nutritional regulation of gene expression. Introduction to epigenetics, and its influence on early life nutrition and health.

Unit III (4 Lectures)

Concepts of proteomics and metabolomics. Microbiome and diseases of nutritional importance. Dietary influences on the microbiome.

V. Suggested Reading

- Carlberg C, Ulven SM and Molnár F. 2016. *Nutrigenomics*. Springer
- Caterina RDE, Martinez, JA and Kohlmeier M.(Eds.) 2020. *Principles of Nutrigenetics and Nutrigenomics*. Elsevier Inc.
- Dodds JW and Laverdure DR. 2015. *Canine Nutrigenomics - The New Science of Feeding Your Dog for Optimum Health*. Dogwise Publishing.
- Select articles from Journals

I. Course Title : Equine Nutrition
II. Course Code : ANN 711
III. Credit Hours : 1+0
IV. Theory

Unit I (8 Lectures)

Digestive function and metabolism of nutrients. Nutrient requirements of equines in different physiological stages. Feed ingredient for horses. Digestive disorders.

Unit II (8 Lectures)

Feeding foal, yearlings, mares and stallions for production and reproduction. Feeding for performance and nutrient metabolism during exercise. Nutritional management of race-horses. Diet formulation for all classes of horses.

V. Suggested Reading

- Frape D. 2010. *Equine Nutrition and Feeding*, 4th ed. Wiley-Blackwell.
- Geor R, Harris P and Coenen M (Eds). 2013. *Equine Applied and Clinical Nutrition*. Saunders, Elsevier.
- NRC. 2007. *Nutrient Requirements of Horses*, 6th Rev. ed. National Research Council. National Academy Press.
- Pagan JD. (Ed.). 2009. *Advances in Equine Nutrition IV*. Kentucky Nutrition Research.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Animal Production Sciences

– Livestock Production and Management

Course Title with Credit Load
M.V.Sc. in Livestock Production and Management

Course Code	Course Title	Credit Hours
LPM 601*	Cattle and Buffalo Production Management	2+1
LPM 602*	Sheep and Goat Production Management	2+1
LPM 603*	Swine Production Management	1+1
LPM 604*	Climatology and Livestock Production	1+1
LPM 605*	Behaviour and Welfare of Farm Animals	1+1
LPM 606*	Equine Production Management	1+1
LPM 607*	Companion Animal Production Management	1+1
LPM 608	Farm Hygiene and Waste Management	1+1
LPM 609	Integrated Livestock Farming Systems	1+1
LPM 610	Management and Conservation of Wild and Zoo Animals	1+1
LPM 611	Laboratory Animal Production Management	1+1
LPM 612	Livestock Business Management	1+1
LPM 613	Livestock Farm Machinery Management	0+2
LPM 614	Poultry Farm and Hatchery Management	1+1
LPM 615	Regional Animal Production Management	1+1
LPM 691	Seminar	1+0
LPM 699	Research	30

*Core courses

Course Contents
M.V.Sc. in Livestock Production and Management

I. Course Title : Cattle and Buffalo Production Management

II. Course Code : LPM 601

III. Credit Hours : 2+1

IV. Theory

Unit I (2 Lectures)

Development of dairy industry in India and the world. Present status and future prospects of dairying in India and the world. SWOT analysis of the dairy sector in different agro-climatic zones. Production systems in vogue under Indian conditions. Breeds of cattle and buffalo with more emphasis on breeds of economic importance.

Unit II (6 Lectures)

Housing/ Shelter management. Housing and equipment requirements for different classes of cattle and buffaloes. Layout plans and construction details for different sized farms in different climatic zones of India. Ventilation and lighting systems in dairy farms.

Unit III (8 Lectures)

Feed and fodder resources used for feeding cattle and buffaloes. Scientific technique and regimen of feeding and watering of different categories of cattle and buffaloes. Feed and fodder requirements of different categories of cattle and buffaloes. Supply of green fodder round the year. Enrichment of poor quality roughages. Non-conventional feeding resources. Pasture management.

Unit IV (8 Lectures)

Traits of economic importance and their inter-relationships. Selection and methods of breeding. Reproduction management - Pre-natal and post-natal care and management of dams. Care of neonates and young calves. Management strategies for reducing mortality in calves, optimizing age at first calving and calving interval. Improving breeding efficiency of dairy animals.

Unit V (8 Lectures)

Farm management - Routine management practices and farm labour management. Milking management - Machine milking and hand milking. Clean milk production- Techniques of harvesting clean milk, cooling and transportation. Different laws and practices governing the dairy sector to produce quality products on par with international standards. Health management of dairy animals. Summer and winter management of dairy animals. Draughtability and management of draught animals.

V. Practical (14 Classes)

Visits to different sized dairy farms and assessment of routine managemental practices. Analysis of various farm records for economic evaluation- Computation of practical and economical rations. Layout plans and housing details. Housing, milking, calf, heifer and adult management. Dairy Cattle and Buffalo judging and body condition scoring (BCS). Project preparation for commercial farms.

VI. Suggested Reading

- Arora SP. 1997. *Feeding of Dairy Cattle and Buffaloes*. Kalyani Publication.
- Dutta G. 1994. *Care and Management of Dairy Cattle and Buffaloes*, 3rd ed. ICAR.

- Flanders F and Gillespie J. 2015. *Modern Livestock and Poultry Production*, 9th ed. Delmar Cengage Learning Edition.
- Gupta PR. 2017. *Dairy India-2017*, 7th ed. Dairy India Yearbook, Thomson Press Ltd.
- ICAR. *Livestock Production and Management* - ICAR eCourse PDF eBook (online free).
- Phillips CJC. 2011. *Principles of Cattle Production*. CABI Publishing.
- Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
- Thomas CK, Sastry NSR and Ravikiran G. 2012. *Dairy Bovine Production*, 2nd ed. Kalyani Publishers.
- Tyler HD and Ensminger ME. 2006. *Dairy Cattle Science*, Pearson Prentice Hall Publishing.
- Selected articles from journals.

I. Course Title : Sheep and Goat Production Management

II. Course Code : LPM 602

III. Credit Hours : 2+1

IV. Theory

Unit I (2 Lectures)

Population structure and importance. Sheep farming under different systems of management. Advantages and limitations of sheep and goat farming. Genetic resources of sheep and goats with special emphasis on breeds of economic importance.

Unit II (6 Lectures)

Shelter management. Housing and equipment requirements for different classes of sheep and goats. Designing feeders and waterers. Layout plans and construction details for different size farms in different agro-climatic zones of India.

Unit III (8 Lectures)

Feed and fodder resources for small ruminants. Common property resources (CPR's) and their management. Principles and systems of feeding and watering different categories of sheep and goat. Pasture utilization and improvement.

Unit IV (8 Lectures)

Breeding Management, Traits of economic importance and their inter-relationship. Breeding seasons. Selection of breeding animals. Methods of detection of heat, use of teaser, flushing, tupping. Estrous synchronization, Natural Service, artificial insemination and off-season breeding in small ruminants. Care and managementof pregnant animals and breeding stock. Culling.

Unit V (4 Lectures)

Disease Management. Prevention and control measures including vaccination, deworming, dipping and spraying, etc. Transportation of small ruminants.

Unit VI (4 Lectures)

Meat, Methods of slaughter, dressing percentage. Wool: Shearing methods. Importance of wool, wool quality. Goat fibers: mohair, pashmina - Marketing of goat fibers/ wool. Milk, Milking, avoidance of goaty odour in milk, clean milk production and its therapeutic uses.

V. Practical (14 Classes)

Visits to modern sheep and goat farms and critical analysis of various managerial practices under different conditions. Study of practical housing management. Diseases control management. Shearing management. Record keeping and economics of sheep and goat farming for mutton/ chevon, wool/ fibre and milk. Preparation of project for commercial farming. Daily and periodical farm operations. Dipping and vaccination.

VI. Suggested Reading

- Bhat PN and Khan BU. 2009. *Goat Production*. Studium Press (India) Pvt. Ltd.
- Bhatt PN and Arora CL. 2009. *Sheep Production*. Studium Press (India) Pvt. Ltd.
- Devendra C and McLeroy GB. 1982. *Goat and Sheep Production in Tropics*. Longman.
- Devendra C and Burns M. 1983. *Goat Production in the Tropics*. CABI Publishing.
- Gupta JL. 2006. *Sheep Production and Management*. BS Publ.
- ICAR. 2014. *Handbook of Animal Husbandry*, 3rd ed. ICAR.
- Jindal SK. 2013. *Goat Production and Health Management*. New India Publishing Agency.
- Kaushik SK. 2017. *Sheep Production*. ICAR Publ.
- Peacock CP. 1996. *Improving Goat Production in the Tropics: A Manual for DevelopmentWorkers*, OXFam, UK.
- Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
- Solaiman SG. 2010. *Goat Science and Production*. Wiley-Blackwell.
- *Selected articles from journals.*

I. Course Title : Swine Production Management

II. Course Code : LPM 603

III. Credit Hours : 1+1

IV. Theory

Unit I (2 Lectures)

Population dynamic, Economic contribution of pigs, Advantages and limitations of swine rearing, Systems of management. Breeds of economic importance.

Unit II (2 Lectures)

Housing and rearing systems. Housing and equipment requirements for different classes of swine, layout plans and construction for different sized farms.

Unit III (3 Lectures)

Feeding principles and nutritional requirement of different classes of swine. Feeding schedule for different classes of swine. Traditional and scientific methods of swine feeding.

Unit IV (4 Lectures)

Traits of economic importance and their interrelationship. Selection of breeding stock. Reproductive parameters of swine. Methods for detection of heat. Mating systems. Care and management of pregnant sows, piglets, growers and boar. Summer management in swine.

Unit V (3 Lectures)

Health Management, Prevention and control measures including sanitation, vaccination, deworming, etc. Piglet anaemia and its management.

Unit VI (2 Lectures)

Methods of slaughter, dressing percentage, Methods of marketing and transportation. Use of by-products from the swine industry

V. Practical (14 Classes)

Visit modern piggeries and critical analysis of various types of managemental practices. Practical feeding and breeding management, disease control measures, Judging. Record-keeping. Economics of pig production. Formulation of economic rations for different classes of swine. Project formulation of commercial swine production.

X. Suggested Reading

- Acharya RM and Puneet Kumar. 2017. *Pig Production*. Satish Serial Publishing, Delhi
- Beyno N. 2014. *Pigs: A Guide to Management*, 2nd ed. Replika Press Ltd.
- Boden E. 1995. *Swine Practice*. WB London.
- ICAR. 2014. *Hand Book of Animal Husbandry*, 3rd ed. ICAR
- Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
- Sharda DP. 2000. *Swine Production*. ICAR publication
- *Selected articles from journals.*

I. Course Title : Climatology and Livestock Production

II. Course Code : LPM 604

III. Credit Hours : 1+1

IV. Theory

Unit I (4 Lectures)

Climatology and agro-climatic regions of India. Study of climatic factors and their measurement. Climatic stress in livestock (heat stress/ cold stress): effects, measurement and amelioration. Temperature-humidity index and thermo-neutral zone. Adaptation and acclimatization.

Unit II (4 Lectures)

Light: natural and artificial, photoperiod, mechanism of light action and responses. Application in livestock production.

Unit III (4 Lectures)

Performance of livestock introduced in different climates. Micro-climate modification in animal houses. Livestock and global warming.

Unit IV (4 Lectures)

Climate-resilient livestock production systems. Natural disasters-effects on livestock and mitigation measures.

V. Practical (14 Classes)

Visit modern weather forecast stations. Assessment of climate: Microclimatic conditions within the animal house, Measurement of Temperature, Relative humidity, wind velocity and intensity of light. Ambient temperature. Construction of climographs and hythergraphs. Heat tolerance test in bovines.

IX. Suggested Reading

- Collier RJ and Collier JL. 2012. *Environment Physiology of Livestock*. Wiley-Blackwell Co.
- Lal DS. 1998. *Climatology*. Sharda Pustak Bhavan, Allahabad.
- McDowell RE. 1972. *Improvement of Livestock Production in Warm Climates*. WH Freeman.
- Payne WJ and Wilson RT. 1999. *An Introduction to Animal Husbandry in the Tropics*. Blackwell Publishing, USA.
- Rainwater MCF. 1962. *Animal Climatology*. Indian Veterinary Research Institute, Izatnagar.
- Sejian V, Gaughan J, Baumgard L and Prasad C. 2015. *Climate Change Impact on Livestock: Adaptation and Mitigation*, 5th ed. Springer.
- Siddhartha K and Roger B. 1996. *Atmosphere, Weather and Climate*. ELBS.
- *Selected articles from journals.*

I. **Course Title : Behaviour and Welfare of Farm Animals**

II. **Course Code : LPM 605**

III. **Credit Hours : 1+1**

IV. **Theory**

Unit I (4 Lectures)

Introduction to Animal behaviour. Evolution of animal behaviour: Theories of animal behaviour. Importance of animal behaviour studies. Physiological basis of behaviour. Natural selection, proximate and ultimate causes, fitness, optimality theory, selfish genes, kin selection, and game theory. Influence of genetic, environmental and physiological influence. Daily and seasonal cycles of behaviour. Patterns of behaviour. Favourable and unfavourable behaviours of domestication.

Unit II (4 Lectures)

Ethogram construction for general behaviour management – interpretation - behaviour assisted animal management - flight zone, Animal learning and training-conditioning- operant and classical, animal behaviour based housing designs – Methods of studying animal behaviour- Vices – causes and prevention.

Unit III (2 Lectures)

Group formation. Social relationships like hierarchy and aggression, the process of socialization, locality and behaviour. Behavioural characters for management practices.

Unit IV (6 Lectures)

Animal welfare – concepts – animal rights – animal freedoms – animal welfare organizations Measurement of animal welfare: - indicators of animal welfare-improvement of animal welfare through selection- the welfare of livestock in commercial farms and captivity, environmental enrichment- Welfare of livestock during various management activities such as handling, transportation, etc., Legislation and regulations of animal welfare – welfare and economics.

V. **Practical (14 Classes)**

Behavioural characters for managemental practices. Behavioural adaptations under domestication. Analysis of behaviour in relation to climate. Analysis of social behaviour. Preparation of ethogram (time budgeting).

VI. **Suggested Reading**

- Agarwal VK. 2013. *Animal Behaviour* (Ethology) S. Chand and Company
- Albright JL and Arave CW. 1997. *The Behaviour of Cattle*. CAB International.
- Arora MP. 1995. *Animal Behaviour*. WB London.
- Benson BJ and Rollin BE. 2004. *The Well-being of Farm Animals: Challenges and Solutions*. Blackwell Publishing, USA.
- Bouenger EG. 1994. *Animal Behaviour*. WB London.
- Broom DM and Fraser AF. 2007 *Domestic Animal Behaviour and Welfare,* 4th ed. CABI.
- Fraser AF and Broom DM. 1990. *Farm Animal Behaviuor and Welfare*. CAB international
- Hafez ESE. 1969. *The Behaviour of Domestic Animals,* 2nd ed. Balliere, Timdall and Cassell.
- Houpt KA. 2018. *Domestic Animal Behavior for Veterinarians and Animal Scientists*. 6th ed. Wiley Blackwell.
- Kumar V. 1996. *Animal Behaviour*. WB London.
- Selected articles from journals.

I. Course Title : Equine Production Management

II. Course Code : LPM 606

III. Credit Hours : 1+1

IV. Theory

Unit I (2 Lectures)

Scope of equine husbandry in India. Equine population dynamics. Types and classes in equines. Breeds of economic importance.

Unit II (2 Lectures)

Housing and stable management, behaviour, stable vices and their management

Unit III (4 Lectures)

Feeding and breeding of equines. Care and management of stallion, broodmare, pregnant mare and foal.

Unit IV (2 Lectures)

Stud farms, Race clubs, Race-horses and their care, training, exercising, doping and horsemanship.

Unit V (4 Lectures)

Foot care and dental care in equines. General health management and diseases control. Colic, equine azoturia - prevention and management. Regulatory acts in equine disease control and welfare.

Unit VI (2 Lectures)

Transportation, Laws governing the import and export of equines, Horse passport and trading

V. Practical (14 Classes)

Visit institutional stables. Identification, ageing, soundness and selection. Passing of nasogastric tube, Shoeing and covering. Saddle fitting, Gaits of horses and horse colours.

VI. Suggested Reading

- Blanchard T, Varner D, Love C, Brinsko S, Rigby R and Schumacher J. 2002. *Manual of Equine Reproduction*. Mosby.
- Brown JH and Powell-Smith V. 1984. *Horse and Stable Management*. Blackwell Science.
- Frape D. 1986. *Equine Nutrition and Feeding*. Blackwell.
- Kacker RN and Panwar BS. 1996. *Text Book of Equine Husbandry*. Vikas Publ.
- Mills DS and Nankervis KJ. 1998. *Equine Behaviour: Principles and Practice*. Blackwell.
- Panwar BS and Yadav KN. 2010. *Equine Husbandry and Equestrian Sports*. IBDC Publishers.
- Pilliner S. 1994. *Care of the Competition Horse*. BT Batsford.
- Rose RJ and Hodgson DR. 2000. *Manual of Equine Practice*. WB Saunders.

I. Course Title : Companion Animal Production Management

II. Course Code : LPM 607

III. Credit Hours : 1+1

IV. Theory

Unit I (4 Lectures)

Various companion animals, evolutionary history, the process of domestication of dog and cat. Breeds of dogs and cats. Ownership. Selection of dog, cat and other companion animals. Dogs/ cat body: structure, movement and special senses.

Unit II (4 Lectures)

Reproduction and breeding management, care of newborn, weaning, reproductive problems of bitch/ queen, Socialization.

Unit III (4 Lectures)

Principles of the feeding of dog and cat, Feeding during different life stages and disease conditions, feeding behaviour, common nutritional problems and their preventive measures.

Unit IV (4 Lectures)

Basic Kennel and health management. Principles of training of dogs/ cats. Dog shows. Preparation for the shows, kennel clubs, important characters for judgment. Vaccination/ deworming schedules.

V. Practical (14 Classes)

Recognizing various breeds. Handling and Restraining of dogs/ cats, Routine management practices of dogs/ cats. Detection of oestrus, mating, whelping/ kittening (through demonstration). Kennel/ cattery design and management. Hygiene of kennel/ pens. Licensing and identification of companion animals. Visit dog hostels and dog park/ shows.

IX. Suggested Reading

- Case LP, Daristotle L, Hayek MG and Raasch MF. 2011. *Canine and Feline Nutrition: A Resource for Companion Animal Professionals*. 3rd ed. Mosby Elsevier Publishing.
- Chakrabarti A. 2006. *Train Your Dog: At Work and Show*, 2nd ed. Kalyani Publishers.
- Chakrabarti A. 2014. *Dogs their Care and Treatment*, 4th ed. Kalyani Publishers.
- Sharma MC, Pathak NN and Bhat PN. 1993. *Dogs*, *Breeding*, *Nutrition*, *Diagnosis*, *and Health Management*. CBS Publishers and Distributors.
- Smith FWK. 2012. *Veterinary Medical Guide to Dog and Cat Breeds*. Teton New Media, NY.
- Selected articles from journals.

I. Course Title : Farm Hygiene and Waste Management

II. Course Code : LPM 608

III. Credit Hours : 1+1

VI. Theory

Unit I (4 Lectures)

Animal air hygiene. Measure air pollutants and their sources. Factors affecting outdoor and indoor pollution. Methods to control these factors.

Unit II (4 Lectures)

Water Hygiene. Sources of drinking water-Impurities and inclusions. Hygienic requirements and standards for drinking water. Purification of water. Water conservation.

Unit III (4 Lectures)

Manure, Quantity of manure voided by domestic animals. Animal excreta a factor in the spread of disease. Hygienic and economic disposal of farm wastes. Drainage in livestock farms. Lagoons, Sewers, septic tanks, drains and traps.

Unit IV (2 Lectures)

Environmental protection act: Air (Prevention and control of pollution) act and water (Prevention and control of pollution) act.

Unit V (2 Lectures)

Factors affecting environmental pollution and their effect on livestock and livestock products for human consumption. Controlling measures thereof.

VII. Practical (14 Classes)

Assessment of air pollutants on animal health and production. Collection of water samples: Physical, chemical, bacteriological and microscopic examination. Bio-security measures. Modern techniques used in the disposal of farm wastes. Value-added products from farm wastes. Visit water filtration plants and study of filtration systems (rapid and slow-sand, etc.). Testing of drains in livestock farms.

VIII. Suggested Reading

- Baba MD. 2007. *Environmental Changes and Natural Disasters*. New India Publ.
- Overcash MR. 1983. *Livestock Waste Management*. CRC Press.
- Thapliyal DC and Misra DS. 1996. *Fundamentals of Animal Hygiene and Epidemiology*. International Book Distr. Co.

I. Course Title : Integrated Livestock Farming Systems

II. Course Code : LPM 609

III. Credit Hours : 1+1

IV. Theory

Unit I (4 Lectures)

Classification of livestock-based farming systems. Principles, Scope, drivers and tradeoffs in integrated livestock farming systems. Sustainability and ecological advantages of integrated livestock farming systems and their economic importance.

Unit II (4 Lectures)

Integration of various components of farming systems. Livestock-fish, arable farming, plantation crops and different livestock enterprises (cattle, buffalo, sheep, goat, pig, rabbit, poultry, beekeeping, silkworm, etc.) along with the bio-gas plant, FYM, vermicompost, solar and wind energy utilization

Unit III (4 Lectures)

New approach for changing farming systems in the light of global warming, carbon sequestration and mitigation of GHGs (reducing carbon and water footprints)

Unit IV (4 Lectures)

Project formulation and evaluation of various integrated livestock enterprises in light of reducing poverty, livelihood diversification, environmental sustainability and resource conservation.

V. Practical (14 Classes)

Visit modern integrated livestock farming units. Critical analysis of different subunits, economic analysis and preparation of feasibility reports

VI. Suggested Reading

- Ghosh B. 2007. *Integrating Crops and Livestock*, 1st ed. Gene-Tech Books.
- Little DC and Edwards P. 2003. *Integrated Livestock-fish Farming Systems*. FAO.
- Mukherjee TK, Moi PS, Panandam JM and Yang YS. (Eds.) 1992. *Integrated Livestock Fish Production Systems*. FAO/ IPT Workshop on Integrated Livestock-Fish Production Systems, University of Malaya, Kuala Lumpur.
- Raman KV and Balaguru T. (Eds.). 1992. *Farming Systems Research in India: Strategies for Implementation*. NAARM, Hyderabad.
- Rana SS. 2015. *Recent Advances in Integrated Farming Systems*. CSK HPKV, Palampur.
  Rangasamy A and Annadurai K. 2002. *Farming System in the Tropics*. Kalyani Publishers.
- Renard C. (Ed.). 1997. *Crop Residues in Sustainable Mixed Crop/ Livestock Farming Systems*. CABI.
- Speirs M and Opsen O. 1992. *Indigenous Integrated Farming System in the Sahel*. World Bank.
- Sunil Kumar and DR Palsaniya DR and Kiran Kumar T. 2017. *Farming systems: Issues and Strategies*. Satish Serial Publishing, New Delhi.
- Selected articles from journals.

I. Course Title : Management and Conservation of Wild and Zoo Animals

II. Course Code : LPM 610

III. Credit Hours : 1+1

IV. Theory

Unit I (2 Lectures)

Taxonomy and distribution of important Indian wild animals and birds – Ecology of wildlife sanctuaries and National parks - Principles and concepts of Zoo and captive wild animals- Status of forest in India - Biological and ecological basis of management of wildlife

Unit II (2 Lectures)

Rules and regulations of Zoo Authority of India - Wildlife protection act - Conservation of wild animals – feeding of captive animals and birds- Habitat Components-Cover, food, water, space and their development and conservation

Unit III (6 Lectures)

Wildlife health control - Population dynamics- and it's manipulation Movements – Corridors, – Mortality - Predator and prey relationship - Human-animal conflict - Refuge rehabilitation

Unit IV (6 Lectures)

Principles for the protection of wild and zoo animals - Breeding seasons - Breeding characteristics – puberty - pregnancy - parturition - postnatal survival of the young. Social factors among various species. Miscellaneous management procedures. Wildlife Census methods- captive animal breeding

V. Practical (14 Classes)

Visit wildlife sanctuary/ national park/ biosphere reserves/ conservation breeding centre and zoo. Restraining methods. Funding agencies for wildlife research and preparation of project proposals, Habitat analysis and design.

IX. Suggested Reading

- Agrawal KC. 2000. *Wildlife of India: Conservation and Management*. Nidhi Publishers.
- Berwick SH and Saharia VB. (Eds.). 1995. *The Development of International Principles and Practices of Wildlife Research and Management*. Oxford University Press.
- Bobbins CT. 1983. *Wildlife Feeding and Nutrition*. Daya Publ. House.
- Giles RH, Jr. 1978. *Wildlife Management*. WH Freeman.
- Giles RH, Jr. 1984. *Wildlife Management Techniques*, 3rd ed. Wildlife Society, Washington, DC.
- Hosetti BB. 2005. *Concepts in Wildlife Management*, 2nd ed. Daya Publ. House.
- Saha GK and Mazumdar S. 2017. *Wildlife Biology: an Indian Perspective*. PHI Learning Pvt. Ltd.
- Santra AK. 2008. *Handbook on Wild and Zoo Animals: A Treatise for Students of Veterinary, Zoology, Forestry and Environmental Science*. International Book Distributing Co.
- Sinclair ARE, Fryxel JM and Caughley G. 2006. *Wildlife Ecology, Conservation and Management*, 2nd ed. Blackwell.
- Singh SK. 2005. *Text Book of Wildlife Management*. International Book Distributing Co.
- Wildlife (Protection) Act 1972 (as amended up to 1991). Natraj Publ.
- *Selected articles from journals.*

Course Title : Laboratory

I. Animal Production Management

II. Course Code : LPM 611

III. Credit Hours : 1+1

IV. Theory

Unit I (2 Lectures)

Importance of rabbit, rats, mice, hamster and guinea pigs as laboratory animals.

Unit II (4 Lectures)

Systems of housing, layout and design for laboratory animals house. Feeding management of laboratory animals. Feeding regimen, Types of diets.

Unit III (6 Lectures)

Production of laboratory animal models for various experiments. Management of specific pathogen-free, gnotobiotic and germ-free animals. Concepts related to the welfare of laboratory animals. Sanitary and hygienic measures. Common diseases and their control measures. Biosecurity measures. Transportation.

Unit IV (4 Lectures)

Breeding, growth, sexual maturity, mating, gestation, parturition, litter size, weaning. Selection of breeding stock for replacement.

V. Practical (14 Classes)

Visit to laboratory animal house and critical analysis of various types of managerial practices. Handling and restraining of laboratory animals. Practical breeding methods. Disease control and special management. Ageing and identification. Economics of production.

VI. Suggested Reading

- Anonymous.1993. *Rabbit Management*. IBH and Oxford
- Banday MT, Shrivastava HP and Hamdani H. 2014. *Rabbit Production and Management*. New India Publishing Agency.
- Chakrabarti A and Biswas S. 2014. *Rabbit Health and Production*. Kalyani Publishers.
- Hau J and Van Hoosier GL, Jr. 2002. *Handbook of Laboratory Animal Science*, 2nd ed. CRC Press.
- ICAR. 2014. *Hand Book of Animal Husbandry*, 3rd ed. ICAR, New Delhi.
- NRC. 2011. *Committee for the Update of the Guide for the Care and Use of Laboratory Animals. Guide for the Care and Use of Laboratory Animals*, 8th ed. National Research Council, National Academy Press, Washington, DC.
- Rao TKS, Chauhan IS and Chauhan A. 2018. *Handbook of Laboratory Animal Production Management*. Kalyani Publishers.
- Reddy DV. 2007. *Applied Nutrition: (Livestock, Poultry, Human, Pet, Rabbit and Laboratory Animal Nutrition)*. IBH and Oxford.
- Ronald N and Penman S. 1991. *A Manual for Small Scale Rabbit Production*. South Asia Publ.
- Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
- Selected articles from journals.

I. Course Title : Livestock Business Management

II. Course Code : LPM 612

III. Credit Hours : 1+1

IV. Theory

Unit I (3 Lectures)

Management principles, Planning Techniques, strategic planning, organization structure, co-ordination and controlling techniques, Approaches to management.

Unit II (5 Lectures)

Key economic concepts, factors of production, farm enterprises, cost of production, opportunity cost, value of production, gross margin, farm profit, net farm family income, substitution, and efficiency: return to scarce resources, risk. SWOT analysis for different livestock species and products, Livestock production economics, theory of supply and demand, production relationships, production function, cost input variables, profit maximization.

Unit III (4 Lectures)

Economics and the market, market intelligence, newer concepts in marketing, market research and opinion polling, advertising research, market surveillance, etc.

Unit IV (3 Lectures)

Marketing channels, Marketing of livestock and livestock products and laws governing them, Pricing strategies, supply chain management, marketing agencies.

V. Practical (14 Classes)

Accounting records, fund flow statement, Cost and benefit analysis. Budgeting and control. Preparation of financial statements, depreciation accounting methods, trend and variance analysis, cost-volume profit analysis. Financial planning and forecasting. Estimation of working capital requirement. Break even analysis. Visit to livestock business firms and banks. Preparing projects for financing.

VI. Suggested Reading

- Acharya RM and Kumar P. 2013. *Dairy Production and Business Management*. Satish Serial Publishing, New Delhi.
- Bardhan D. 2013. *Textbook on Livestock Economics, Marketing and Business*. Satish Serial Publishing House.
- Bhaskaran S and Mohanty S. 2007. *Marketing of Livestock and Livestock Products in India*. ICFAI University Press.
- Das N. 2009. *Forage for Sustainable Livestock*. Satish Serial Publishing House.
- Gangadhar KS. 2009. *Livestock Economics: Marketing, Business Management and Accountancy*. New India Publishing Agency.
- George RP and Raj Kamal PJ. 2015. *Farm Economics, Entrepreneurship and Marketing*. Satish Serial Publishing, New Delhi.
- Kahan D. 2008. *Economics for Farm Management Extension*. FAO, Rome.
- Koontz H and O'Donnel C. 1999. *Essentials of Management*. Tata McGraw Hill.
- Kotler P. 2000. *Marketing Management - Analysis, Planning and Control*. Prentice Hall of India.
- Maheswari SN. 1998. *Management Accounting*. Tata McGraw Hill.
- Massie JL. 1995. *Essential of Management*. Prentice Hall of India. Moran J. 2009. *Business Management for Tropical Dairy Farmers*. Land Links Publishing.
- Srinivasan NP. 1998. *Management Accounting*. Sterling Publications.
- Selected articles from journals.

I. Course Title : Livestock Farm Machinery Management

II. Course Code : LPM 613

III. Credit Hours : 0+2

IV. Theory

Unit I (2 Lectures)

Visit to Instructional Livestock Farm Complex, Identification of various livestock farm machineries

Unit II (2 Lectures)

Familiarization with different parts and their functions of tractor and power tiller (for tillage implements for fodder land development).

Unit III (2 Lectures)

Irrigation of fodder field. Familiarization with different electric motors and diesel engines, use of sprinkler for irrigation.

Unit IV (2 Lectures)

Non-conventional energy source-Wind energy and its utilization in livestock farm.

Unit V (2 Lectures)

Post-harvest equipment/ machineries. Common terms used in harvesting of fodder crops; hay and forage harvesting equipment, mowers, field choppers, chaff cutters for silage making, different types of silos, forage harvesters, mechanical hay driers, conventional balers, hay stackers, straw combine.

Unit VI (2 Lectures)

Familiarization with different parts of milking/ shearing machines, handling, operation and cleaning after use, instruments used for milk packaging. Automatic feeders and waterers

Unit VII (2 Lectures)

Milk storing equipment, pasteurization equipment and transportation of milk, handling of equipment for preparation traditional milk products.

Unit VIII (2 Lectures)

Forage densifying machine/ Feed block machine and its use- preparation of complete feed block (CFB).

Unit IX (2 Lectures)

Visit to feed mill- use and maintenance of feed grinder and mixture machines in the farms. Visit milk processing unit

V. Suggested Reading

- Kutz M. 2007. *Handbook of Farm, Dairy, and Food Machinery*. William Andrew Inc.
- Malhotra K. 2012. *Handbook of Farm, Dairy, and Food Machinery*. Centrum Press.
- Selected articles from journals.

I. Course Title : Poultry Farm and Hatchery Management

II. Course Code : LPM 614

III. Credit Hours : 1+1

IV. Theory

Unit I (4 Lectures)

Poultry housing systems - cage vs floor system, litter management and lighting for poultry, rearing turkey, duck and quails, backyard poultry.

Unit II (4 Lectures)

Management of chicks, growing, laying and breeding flocks, broiler production, selection and culling of laying flocks. Health management. Management of birds during disease outbreaks.

Unit III (3 Lectures)

Procuring, care and pre-incubation storage of hatching eggs - Method of incubation, sanitation disinfection and management of hatchery. Biosecurity in poultry farms

Unit IV (2 Lectures)

Embryonic development and factors affecting fertility and hatchability of eggs.

Unit V (3 Lectures)

Chick sexing, packing and hatchery business - Transporting management of farm and hatchery waste.

V. Practical (14 Classes)

Observation and recording of Poultry Farm management - Brooding of chicks; selection of laying flocks - Disease preventive measures - Selection and care of hatching eggs; incubator operation, fumigation and candling setting and hatching, packaging of chicks - Waste management - Marketing of products.

IX. Suggested Reading

- Ensminger ME. 1992. *Poultry Science*. International Book Distr. Co.
- Hued LM. 2003. *Modern Poultry Farming*. Greenworld.
- Powell-Owen W. 2008. *Poultry Farming and Keeping*. Daya Books.
- Prasad J. 2005. *Poultry Production and Management*. Kalyani Publication
- Singh RA. 1996. *Poultry Production*. 3rd ed. Kalyani Publication

I. Course Title : Regional Animal Production Management

II. Course Code : LPM 615

III. Credit Hours : 1+1

The course content will be developed as per the need of the university

Course Title with Credit Load
Ph.D. in Livestock Production and Management

Course No.	Course Title	Credits
LPM 701*	Recent Developments in Large Ruminants Production Management	2+1
LPM 702*	Recent Developments in Small Ruminants Production Management	2+1
LPM 703*	Recent Developments in Swine Production Management	1+1
LPM 704*	Livestock and Environment	1+0
LPM 705*	Organic Livestock Production	1+0
LPM 706	Recent Developments in Welfare of Farm Animals	1+0
LPM 707	Entrepreneurship in Livestock Production	1+1
LPM 708	Precision Livestock Farming	1+1
LPM 709	Recent Developments in Poultry Production Management	2+1
LPM 791	Seminar-I	1+0
LPM 792	Seminar-II	1+0
LPM 799	Research	75

*Core courses

Course Contents
Ph.D. in Livestock Production and Management

I. Course Title : Recent Developments in Large Ruminants Production Management

II. Course Code : LPM 701

III. Credit Hours : 2+1

IV. Theory

Unit I (2 Lectures)

Present status of dairying in India *vis-à-vis* Global and south Asian scenarios, Production dynamics, Recent policy initiatives in dairy development. Conservation of indigenous germplasm

Unit II (4 Lectures)

Advances in housing management, viz., design, layout, construction materials, cost of construction suits to various agro-climatic zones of India. Low-cost houses for large ruminants. Ideal shelter management practices for better productivity, Advances in manure and waste disposal.

Unit III (6 Lectures)

Recent approaches in breeding and reproductive Management of dairy animals, Optimization of reproductive traits, Estrus synchronization, MOET, Sexed semen, Cloning and IVF.

Unit IV (4 Lectures)

Recent approaches in Feeding, Phased feeding, Transition period, Hydroponic fodder, Eco-feeding, standards for drinking water and water hygiene.

Unit V (4 Lectures)

Advances in health management of dairy animals, preventive measures for production-related diseases, bio-security measures, etc.

Unit VI (4 Lectures)

Milking management, automation, Sanitary and phytosanitary standards for the production of quality milk, post-harvest processing.

Unit VII (4 Lectures)

Establishing a Dairy Enterprise suitable for various economic strata with different sizes, SWOT analysis. Computerization of dairy enterprises, Best management practices.

Unit VIII (4 Lectures)

Advances in herd management and data analysis, Advances in the management aspects of buffaloes, salvaging of buffalo calves, Advances in work animal management.

V. Practical (14 Classes)

Critical analysis of various types of managerial practices at farms. Preparation of layout and designs for construction of sheds of various sizes in different agro-climatic zones. Cost analysis of dairy bovine housing. Organization of milking machines. Dairy Cattle and Buffalo judging – BCS. Farm record analysis. Project report preparation for commercial dairy farms.

VI. Suggested Reading

- Clarence HE. 2007. *Dairy Cattle and Milk Production*. Daya Publ. House.
- Moran J and Chamberlain P. 2017. *Blueprints For Tropical Dairy Farming: Milk Production in Developing Countries*. CSIRPO Publishing.
- Moran J. 2013. *Tropical Dairy Farming: Feeding Management for Small Holder Dairy Farmers in the Humid Tropics*. Landlinks Press.
- Singh U, Kumar S, Kumar A, Deb R and Sharma A. 2013. *Advances in Cattle Research*. Satish Serial Publishing House, New Delhi.
- Thomas CK, Sastry NSR and Ravi Kiran. 2012. *Dairy Bovine Production*, 2nd ed. Kalyani Publishers.

I. Course Title : **Recent Developments in Small Ruminants Production Management**

II. Course Code : **LPM 702**

III. Credit Hours : **2+1**

IV. Theory

Unit I (4 Lectures)

Relevance of small ruminants in the Indian economy. Population and production dynamics of small ruminants. Systems of rearing. Needs and possibilities for research in future.

Unit II (8 Lectures)

Recent approaches in breeding and reproductive management. Management during the breeding season, Mating seasons and their control. Recent approaches in reproductive biotechnologies, MOET, Cloning, transgenic, genomics and accelerated lambing.

Unit III (6 Lectures)

Recent approaches in feeding management, Pasture and grazing management, Phase feeding, Feed resources and feeding techniques under different systems.

Unit IV (6 Lectures)

Recent approaches in housing systems with reference to different agro-climatic zones and rearing systems.

Unit V (6 Lectures)

Prospects of management under stall-fed conditions, management of small ruminates during scarcity periods, Migratory pattern and flock management. Recent approaches in exploiting goat's, milk quality, safety and production aspects of dairy goats. Wool/ fibre production and its quality.

Unit VI (2 Lectures)

Recent approaches in health care management, Parasitic control in present ecological and environmental changes.

V. Practical (14 Classes)

Critical analysis of various farm practices, Preparation of layout and designs for construction of sheds of various sizes in different agro-climatic zones. Cost analysis of housing. Organization of shearing. Sheep and goat judging – BCS. Farm record analysis. Disease control management. Scorecard and grading of wool. Project report preparation for commercial sheep and goat units.

VI. Suggested Reading

- Devendra C and McLeroy GB. 1983. *Goat and Sheep Production in the Tropics*. Agrodok.
- Gupta JL. 2006. *Sheep Production and Management*. CBS.
- Jansen C and van den Burg K. 2004. *Goat Production in the Tropics*. 4th ed. © Agromisa Foundation, Wageningen.
- Karim SA. 2008. *Small Ruminant Production in India*. Satish Serial Publishing, New Delhi.
- Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
- Selected articles from journals

I. Course Title : Recent Developments in Swine Production **Management**

II. Course Code : LPM 703

III. Credit Hours : 1+1

VI. Theory

Unit I (2 Lectures)

Trends in population and production in India and world, Production systems followed in developed countries.

Unit II (6 Lectures)

Recent approaches in improvement of economic traits, Prenatal and postnatal development, care of newborn, Growth, breeding and reproduction, analysis of mating systems, Farrowing and lactation.

Unit III (3 Lectures)

Strategic management measures in feeding, Phase feeding, Split sex feeding and individual feeding. Automatic feeding and watering techniques, Feed resources and feeding systems.

Unit IV (2 Lectures)

Recent approaches in housing, environmental physiology, summer management, approaches in manure management.

Unit V (2 Lectures)

Strategies to reduce mortality in different classes, common diseases, health management, Biosecurity measures.

VII. Practical (14 Classes)

Critical analysis of various types of managerial practices at farms. Preparation of layout and designs for construction of sties for the backyard and commercial piggeries. Judging and BCS, Farm record analysis. Preparation of Project report for commercial and backyard piggeries. Marketing Analysis

VIII. Suggested Reading

- Katingi E. 2012. *Raising Pigs – Manuals and Other Useful Resources*. ICARDA and ILRI Publications. https://livestockfish.cgiar.org/2012/06/13/raising-pigs-manuals-and-other-useful-resources/
- Selected articles from journals.

I. Course Title : Livestock and Environment

II. Course Code : LPM 704

III. Credit Hours : 1+0

IV. Theory

Unit I (4 Lectures)

Effect of livestock on the environment- Role of ruminants in global warming, Slaughterhouse waste, Tannery waste, Stray and fallen animal impact. Strategies for mitigation of methane emission from the livestock sector, animal waste management. A life cycle assessment of the environmental impacts of livestock in different production systems.

Unit II (4 Lectures)

Effect of environment on livestock and quality of products: Heat and cold stress, Pollution, Heavy metals, Pesticide residues, etc., Management of micro and macro-environment with respect to animal well-being,

Unit III (4 Lectures)

Concept of Water, Carbon footprints and carbon sequestration of farm animals and products. Thermal load indices, Livestock comfort zones. Carbon trading, mechanisms and opportunities in the livestock sector.

Unit IV (4 Lectures)

Selection of breeds of livestock for hot climate. Recent advances in shelter management practices under the impending climate change scenario. Climate and reproduction. Environment and diseases.

V. Suggested Reading

- Cheeke PR. 1993. *Impacts of Livestock Production on Society, Diet/ health, and the Environment*. Interstate Publishers.
- FAO. 2009. *Livestock in the Balance*, FAO, Rome.
- ICAR. 2014. *Handbook of Animal Husbandry*. ICAR, New Delhi.
- Mudgal VD, Singhal KK and Sharma DD. 2003. *Advances in Dairy Animal Production*, 2nd ed. International Book Distributing Co.
- Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
- Sejain V, Naqvi SMK, Ezeji T, Lakritz J and Lal R. 2012. *Environmental Stress and Amelioration in Livestock Production*. Springer
- Sirohi SK, Walli TK, Singh B and Singh N. 2013. *Livestock Greenhouse Gas: Emissions and Options For Mitigation*. Satish Serial Publishing, New Delhi.
- Selected articles from journals

I. Course Title : Organic Livestock Production

II. Course Code : LPM 705

III. Credit Hours : 1+0

IV. Theory

Unit I (2 Lectures)

Historical background and origin, Organic livestock farming vis-a-vis conventional livestock farming, the current status of organic farming in India and world- objectives and importance of organic livestock farming. Opportunities and Problems of organic livestock farming in India.

Unit II (6 Lectures)

Key consideration, selection of animals, housing, feeding, breeding, health care, record keeping, processing and labelling and marketing. Conversion of livestock farm into an organic farm. ITKs used in organic livestock production.

Unit III (4 Lectures)

Organic farming standards in India and the world. IFOAM basic standards, WHO/ FAO Codex Alimentarius, NSOP of India, etc. Role of organic livestock farming in environmental Protection and biodiversity enhancement.

Unit IV (4 Lectures)

Accreditation of inspection and certification agencies. Organic certification mark. Guidelines for organic certification of livestock modalities in the certification of organic products. The economic value of organic livestock products, pricing strategy and marketing of organic products.

V. Suggested Reading

- Balasubramaniam R, Balakrishnan K and Sivasubramaniam K. 2013. *Principles and Practices of Organic Farming*. Satish Serial Publishing House, New Delhi.
- ICAR. 2014. *Handbook of Animal Husbandry*. ICAR, New Delhi.
- Paajanen T. 2011. *The Complete Guide to Organic Livestock Farming*. Atlantic Publishing Group Inc.
- Katherine M. 2009 *The Organic Dairy Handbook*. Northeast Organic Farming Association.
- Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
- Singh M, Sharma DK and Mishra UK. 2011. *Organic Dairy Farming*. Satish Serial Publishing House, New Delhi.
- Selected articles from journals

I. Course Title : Recent Developments in Welfare of Farm Animals

II. Course Code : LPM 706

III. Credit Hours : 1+0

IV. Theory

Unit I (2 Lectures)

Ethology: species-specific behaviour, changing with the season, physiological condition of animals, as a guide to animal welfare; not driving animals beyond their natural capacity, for better performance;

Unit II (6 Lectures)

Amelioration of climatic stress and avoidance of unnecessary injury, pain and stress to animals in animal houses, during handling, before and during slaughter, carting bullocks, feeding, milking, shearing, transportation, etc., including deprivance of quality feeds and water; this being a common feature;

Unit III (4 Lectures)

Providing safety, healthcare, feed and water to unproductive animals let off to free roam and injured or orphaned pets, birds and others; monkeys being common – Good management of goshalas and safe shelters for such animals – Conversion of their wastes into VAP to meet part costs of running shelters; Education of the general public, especially children to avoid wanton harm to animals via *Lectures* in schools, TV and radio talks, leaflets, etc.

Unit IV (4 Lectures)

Evaluation of animal welfare measures as an 'instrument' of good animal husbandry, production of quality products and enhanced income to farmers.

V. Suggested Reading

- *Animal Rights and Animal Welfare Publications* 1896-2009. https://www.lib.ncsu.edu/findingaids/mc00440
- Appleby MC, Mench JA, Anna Olsson I and Hughes BO. 2018. *Animal Welfare*. CABI.
- AWBI. Animal Protection Laws, Newsletters, etc. of Animal Welfare Board of India; http://www.awbi.org/section/4/publications/2
- GoI Gazzete. *Order on Animal Welfare* - http://www.moef.nic.in/legis/awbi/awbi18.html
- Phillips C. 2009. *The Welfare of Animals*: *The Silent Majority*. Springer.
- Webster J. 2005. *Animal Welfare: Limping Towards Eden*. Blackwell Publishing.
- Selected articles from journals.

I. Course Title : Entrepreneurship in Livestock Production

II. Course Code : LPM 707

III. Credit Hours : 1+1

I. Theory

Unit I (2 Lectures)

Understanding livestock entrepreneurship, Concept and characteristics of Entrepreneurship, Role of entrepreneur in relation to enterprise, Functions of the entrepreneur in the economy,

Unit II (4 Lectures)

Process of entrepreneurship development. Barriers in entrepreneurship. The institutional interface in the development of entrepreneurship, incubation centres, startups, PPP Prospective in the animal husbandry sector.

Unit III (6 Lectures)

Essential criteria for the development of entrepreneurship in livestock sector - basic requirements for entrepreneurship initiatives in livestock and allied sectors (i.e. techno-economic feasibility of the enterprises under different conditions, training and management skills, business acumen, business communication, inter-personnel skills for establishing an enterprise, etc.).

Unit IV (4 Lectures)

Entrepreneurial training/ development programmes at the State and National level, Livestock Insurance, Bank and Government support for entrepreneurship, Financial credit and financial management: general principles and practices, analyzing project appraisals and reports, capital, expenditure decisions, reinvestment and payback.

Unit V (2 Lectures)

Preparing projects for bank appraisal, banking requirements, Assessing project profits, Procurement management quality issues, standardisation, grading and packaging.

II. Practical (14 Classes)

Visit incubation centres, extrapolation of existing financial models in livestock entrepreneurship, Approach to the preparation of Entrepreneurial Project on livestock, Bankable project for a dairy enterprise (small/ large dairy unit), Bankable project for a sheep/ goat/ Ram lamb enterprise, Bankable project for a pig-enterprise, Bankable project for a Broiler enterprise (small/ medium/ large unit), Bankable project for a layer-enterprise

III. Suggested Reading

- George RP and Raj Kamal PJ. 2015. *Farm Economics, Entrepreneurship and Marketing.* Satish Serial Publishing, New Delhi.
- Kahan D. 2012. *Entrepreneurship in Farming.* FAO, Rome.
- Zama MMS, Rashid M and Kumar S. 2014. *Handbook of Livestock Entrepreneurship.* Narendra Publishing House.
- *Selected articles from journals.*

I. Course Title : Precision Livestock Farming

II. Course Code : LPM 708

III. Credit Hours : 1+1

IV. Theory

Unit I (2 Lectures)

Concepts of Precision Livestock Farming-Scope and limitations. Utilities of Precision tools in Livestock Farming, the present level of usage of precision tools in India

Unit II (6 Lectures)

Implementation of sensor systems and ICTs in animal health, productivity and welfare, Animal identification and tracking- Radio frequency identification (RFID), Livestock identification and traceback system (LITS), etc. Geo-tagging, Virtual fencing, GPS and GIS in the exploration of feeding resources and grasslands.

Unit III (6 Lectures)

Automation in water resource management. Development and evaluation of early warning and disease support systems for animal health and welfare.

Unit IV (2 Lectures)

Use of software's for database creation of the livestock farms, computation and analysis.

V. Practical (14 Classes)

GPS/ GIS Application in the exploration of breeding tracts of livestock, forage and grassland profiles. Exposure visit to precision livestock farms with automation, use of tools in reproduction and health care, use of different software in farm routines.

VI. Suggested Reading

- Halachmi I. 2015. *Precision Livestock Farming Applications*. Wageningen Academic Pub.
- Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
- *Selected articles from journals.*

I. Course Title : **Recent Developments in Poultry Production Management**

II. Course Code : **LPM 709**

III. Credit Hours : **2+1**

IV. Theory

Unit I (8 Lectures)

Planning, organization, executive and management of poultry farms and hatcheries of various sizes - an alternative in poultry production

Unit II (4 Lectures)

Demand, supply, the present status of poultry production in India.

Unit III (10 Lectures)

Problems and new management techniques in poultry for egg and meat in India vis-à-vis in other countries of the world - Automation in poultry houses, management of specific pathogen-free flocks.

Unit IV (10 Lectures)

Poultry development policies and planning for higher production constraints in development and solutions, Ethology in relation to avian welfare in intensive poultry production.

V. Practical (14 Classes)

Planning and preparation of research and commercial projects on broiler and layer production management.

X. Suggested Reading

- DAHD. 2015. *Poultry Farm Manual: A Reference Guide for Central and State Poultry Farms.* 2014-15. Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India.
- FAO. 2003. Live bird marketing. In: *Egg Marketing - A Guide for the Production and Sale of Eggs.* http://www.fao.org/3/Y4628E/y4628e09.htm#bm9
- Sreenivasaiah PV. 2006. *Scientific Poultry Production: A Unique Encyclopaedia*. International Book Distribution Co.
- *Selected articles from journals.*

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Animal Production Sciences
– Livestock Products Technology

Course Title with Credit Load
M.V.Sc. in Livestock Products Technology

Course No.	Course Title	Credits Hours
LPT 601*	Abattoir Practices and Meat Plant Operations	2+1
LPT 602*	Fresh Meat Technology	1+1
LPT 603*	Processing and Preservation of Meat	2+1
LPT 604*	Processing of Milk and Milk Products	1+1
LPT 605*	Packaging and Marketing of Livestock Products	1+1
LPT 606*	Microbiology and Quality Control of Livestock Products	1+1
LPT 607*	Slaughterhouse By-products Technology	1+1
LPT 608	In-Plant Training	0+2
LPT 609	Egg and Egg Products Technology	1+1
LPT 610	Market Milk Processing and Dairy Plant Practices	1+1
LPT 611	Processing and Marketing of Wool	1+1
LPT 612	Biotechnology of Foods of Animal Origin	1+1
LPT 613	Fish and Fish Products Technology	1+1
LPT 691	Seminar	1+0
LPT 699	Research	30

*Core courses

Course Contents
M.V.Sc. in Livestock Products Technology

I. Course Title : Abattoir Practices and Meat Plant Operations

II. Course Code : LPT 601

III. Credit Hours : 2+1

IV. Theory

Unit I (12 Lectures)

Handling and transportation of meat animals including poultry - Pre-slaughter handling and care of food animals – Ante-mortem inspection - Humane slaughter - Principles and methods of stunning - Ritual methods of the slaughter of food animals and poultry - Machinery for slaughter and dressing of food animals - Post-mortem inspection - Handling, disposal and condemnation of unfit materials.

Unit II (11 Lectures)

Abattoir - layout, designing, organization and operation - Maintenance of meat and poultry processing plants - Record keeping - Legislations and regulations for establishment and operation of slaughterhouses and meat processing plants.

Unit III (11 Lectures)

Sanitation of slaughterhouse - Sanitary practices in meat plant and its benefits - Solid and liquid waste management of slaughterhouse - Different methods of effluent treatment and designs of effluent treatment plants - State and Central Pollution Control Board norms.

V. Practical (17 classes)

Design and outlay of modern abattoir including poultry processing and effluent treatment plants for different capacities - Judging and grading of food animals - Procedure for the slaughter of food animals and poultry - Ante-mortem and post-mortem inspection - Recording of carcass data - carcass yield, meat bone ratio, etc. - Measurement of effluent characteristics - pH, BOD, COD, suspended solids, etc. - Visit slaughterhouse, poultry processing and effluent treatment plants - DPR for the establishment of an abattoir.

X. Suggested Reading

- Collins DS and Huey RJ. 2015. *Gracey's Meat Hygiene*, 11th Ed. John Wiley and Sons Ltd., UK.
- Jensen WK, Devine C and Dikeman M. 2004. *Encyclopaedia of Meat Sciences* Vol. I, II and III, 1st ed. Elsevier Academic Press, UK.
- Kerry J, Kerry J and Ledward D. 2005. *Meat Processing- Improving Quality*. Woodhead Publishing Ltd., UK.
- Sahoo J, Sharma DK and Chatli M. 2011. *Practical Handbook on Meat Science and Technology*, 1st ed., Daya Publishing House.
- Swatland HJ. 2004. *Meat Cuts and Muscle Foods*. Nottingham Univ. Press.
- Warriss P. 2010. *Meat Science: An Introductory Text*, 2nd ed. OXford Press.

I. Course Title : Fresh Meat Technology

II. Course Code : LPT 602

III. Credit Hours : 1+1

IV. Theory

Unit I (10 Lectures)

History, current development and prospects of meat and poultry industry in India – Skeletal muscle development – pre- and post-natal- Structure and chemistry of muscle including poultry – Muscle Proteins - sarcoplasmic and myofibrillar proteins – Stromal proteins – Types of muscle fibres - Post mortem changes – Rigor mortis - Conversion of Muscle to meat - Pre and post-slaughter factors affecting meat quality – Defects during the conversion of muscle to meat – PSE/ DFD/ Cold Shortening – Off odour development.

Unit II (7 Lectures)

Composition and nutritive value of meat and poultry - Qualities of fresh meat – pH, WHC, colour, odour, juiciness, texture/ tenderness and firmness - Chilling, ageing and conditioning of meat - Electrical stimulation - Carcass evaluation, grading and fabrication- Tenderization of meat.

V. Practical (17 Classes)

Evaluation/ estimation of physicochemical properties of fresh meat pH, colour, water holding capacity, ERV, shear force value, glycogen, R-value and myoglobin - Proximate analysis of meat - Estimation of drip loss - Determination of sarcomere length, fibre diameter and myofibrillar fragmentation index - Fractionation of sarcoplasmic, myofibrillar and stromal proteins - Carcass evaluation and grading - Meat cutting, retail and wholesale cuts.

IX. Suggested Reading

- Aberle ED, Forest JC, Gerrard DE and Mills E. 2013. *Principles of Meat Science*, 5th ed., Kend All/ Hunt Publishing Company, IOWA.
- Bender A. 1992. *Meat and Meat Products in Human Nutrition in Developing Countries*. FAO, Rome.
- Carlson CW, Greaser ML and Jones KW. 2001. *The Meat We Eat*, 14th ed. Interstate Publishers, INC.
- Jensen WK, Devine C and Dikeman M. 2004. Encyclopaedia of Meat Sciences Vol. I, II and III, 1st ed. Elsevier Academic Press, UK.
- Lawrie RA and Ledward DA. 2006. *Lawrie's Meat Science*, 7th ed. Woodhead Publishing Limited, Cambridge, England.
- Pearson AM. 1994. *Quality Attributes and their Measurement in Meat, Poultry and Fish Products*. Springer, New York.
- Swatland HJ. 2004. *Meat Cuts and Muscle Foods*. Nottingham University Press.

I. Course Title : Processing and Preservation of Meat

II. Course Code : LPT 603

III. Credit Hours : 2+1

IV. Theory

Unit I (8 Lectures)

Basic principles of meat preservation – dehydration, chilling, freezing, freeze-drying, thermal processing, direct microbial inhibition, irradiation, use of chemicals and antimicrobials - Curing and smoking - Hurdle technology concept.

Unit II (17 Lectures)

Principles of Meat Processing - Meat and non-meat ingredients and their roles - Additives - Processing techniques - comminution, chopping, blending, marination, massaging, tumbling, etc. - Cooking methods including microwaving – Development of meat products including ham, bacon, tandoori and barbeque - Emulsion formation – factors affecting emulsion formation - Emulsion based meat products - sausages, nuggets and patties - Enrobed, restructured, fermented and intermediate moisture meat products – Ready-to-cook, ready-to-eat and shelf-stable meat products - Canned and retort meat products – Traditional and ethnic meat products - Functional meat products.

Unit III (9 Lectures)

Sensory evaluation – Sensory physiology, types, methods, quality attributes - Factors influencing sensory measurements - Types of sensory panels - Selection of sensory panellists- Sensory evaluation tests- Layout and designing of sensory evaluation laboratory.

V. Practicals (17 Classes)

Estimation of tyrosine value, nitrite content, TBARS value, peroXide value - Preparation of Meat Products - Minced meat products - Emulsion based meat products – sausages, nuggets and patties - Ham and Bacon - Meat Pickles – Enrobed, restructured, fermented and shelf-stable meat products - Canned/ retorted Meat Products - Traditional and ethnic Meat Products - Kebabs - Sensory evaluation of meat products - Subjective and objective method of sensory evaluation - differential, descriptive, training tests, etc. – Test practices and training in the sensory lab - Determination of emulsion stability - Cooking yield - TeXture Profile Analysis.

VI. Suggested Reading

- Aberle ED, Forest JC, Gerrard DE and Mills E. 2013. *Principles of Meat Science*, 5th ed. Kendall Hunt Publishing Company, Iowa.
- Amerine MA, Pangborn RM and Roessler EB. 1965. *Principles of Sensory Evaluation of Food*. Academic Press, New York.
- Barbut S. 2005. Poultry Products Technology. CRC Press.
- Carlson CW, Greaser ML and Jones KW. 2001. *The Meat We Eat*, 14th ed. Interstate Publishers, INC.
- Kerry J, Kerry J and Ledward D. 2005. *Meat Processing- Improving Quality*. Woodhead Publishing Ltd., UK.
- Lawless HT and Heymann H. 2010. *Sensory Evaluation of Food - Principles and Practices*, 2nd ed, Springer-Verlag, New York Inc.
- Mountney GJ and Parkhurst CR. 2017. *Poultry Products Technology*, 3rd ed. Food Products Press, New York.
- Pearson AM and Gillett TA. 1996. *Processed Meats*, 3rd ed. Chapman and Hall, Inc, New York.

- Sharma BD, Wani S and Sharma N. 1997. *Sensory Evaluation Manual for Meat and Meat Products*. IVRI Publication.
- Toldrá F. 2010. *Handbook of Meat Processing*. Wiley-Blackwell.

I. Course Title : Processing of Milk and Milk Products

II. Course Code : LPT 604

III. Credit Hours : 1+1

IV. Theory

Unit I (6 Lectures)

Basic concepts of dairy plant organization and operation - collection, chilling, transportation - Heat treatments of Milk - Cleaning and sanitization of Dairy plants - Composition, nutritional, physico-chemical and functional properties of milk - Standards for milk and milk products.

Unit II (7 Lectures)

Manufacture of milk products - Flavoured Milk - Drying of milk and milk products - Evaporated and condensed milk - Milk powders – Butter - Ice cream and other frozen desserts - Manufacture of different fermented milk products - Manufacture of cheddar, mozzarella, cottage and processed cheese - Manufacture of indigenous milk products – paneer, channa, khoa, ghee, dahi and shrikhand - Rheology of milk products - Dairy by-products.

Unit III (4 Lectures)

Membrane filtration technology- principles and concepts - Manufacturing and functional properties of casein - Caseinates- Co-precipitates - Whey protein concentrates (WPC) - Lactose- Dairy whiteners.

V. Practical (17 Classes)

Platform tests - Determination of fat, SNF, TS, protein, lactose and ash contents of milk - Preparation of butter, ice cream, cheese – cheddar, mozzarella and cottage cheese, khoa, paneer, channa, ghee, dahi, yoghurt, casein, caseinate, co-precipitate, flavoured milk - Determination of degree of browning - Measurement of rheological properties of different milk products - Evaluation of sensory quality of milk and milk products - Visit dairy plants.

VI. Suggested Reading

- Aneja RP, Mathur BN, Banerjee AK and Chandan RC. 2002. *Technology of Indian Milk Products*. Dairy India. Chandan RC, Kilara A and Shah NP. 2008. *Dairy Processing and Quality Assurance*, 1st ed.Willey–Blackwell.
- Davis JG. 2010. *Milk Testing: A Laboratory Control of Milk*. Agribios.
- MIF. 2005. *Analysis of Milk and its Products: A lab Manual*, 2nd ed. Milk Industries Foundation. Biotech Books, Delhi
- Singh S. 2014. *Dairy Technology*, Vol. 1 and 2. New India Publishing Agency.
- Spreer E. 1993. *Milk and Dairy Products*. Marcel Dekker.
- Varnam AH and Sutherland JP. 1994. *Milk and Milk Products Technology*. Chapman and Hall, UK.
- Walstra P, Wouters JTM and Geurts, TJ. 2006. *Dairy Science and Technology*, 2nd ed. Taylor and Francis Group.
- Web BH, Johnson AH and Alford JA. 1987. *Fundamental of Dairy Chemistry*, 3rd ed. Westport AVI Publ.

I. Course Title : Packaging and Marketing of Livestock Products

II. Course Code : LPT 605

III. Credit Hours : 1+1

IV. Theory

Unit I (10 Lectures)

Principles of packaging - objectives and functions - Product characteristics affecting packaging requirements - Packaging materials and their characteristics - Different packaging systems for fresh, cured, dehydrated, freeze-dried and shelf-stable products of milk, meat and chicken - Aseptic packaging of milk - UHT milk - Vacuum packaging – MAP and role of different gases - Retort pouch processing - Active and intelligent/ smart (biosensors) packaging - Edible and biodegradable packaging - Nanotechnology for food packaging - Recycling of packaging materials - Labelling requirements – Barcoding and its importance - Packaging standards and regulations – Economics of different packaging systems.

Unit II (7 Lectures)

Marketing of Livestock Products - Types of markets - Marketing channels of live meat animals and Poultry - Existing systems - constraints and possible solutions - Value Chain of meat, poultry and processed products - strategies and interventions for better profitability – Meat retailing and establishment of retail outlets for meat and poultry - FSSAI, APEDA, EIA, GOI/ WTO regulations for the domestic market, import and export of livestock products.

V. Practical (17 Classes)

Different packaging materials and their properties - Determination of thickness, bursting strength, piercing strength, water vapour transmission rate, gas transmission rate, headspace gas analysis - Vacuum, shrink, MAP and retort packaging of meat and milk products - Visit milk and meat processing plants - Study of the value chain of livestock products including online marketing.

VI. Suggested Reading

- Aberle ED, Forrest JC, Gerrard DE and Mills EW. 2013. *Principles of Meat Science*, 5th ed. Kendall Hunt Publishing Company, Iowa.
- Fuquay JW, Fox PF and McSweeney PLH. 2011. *Encyclopaedia of Dairy Sciences*, 2nd ed. Elsevier Academic Press, UK.
- Jensen WK, Devine C and Dikeman M. 2004. *Encyclopaedia of Meat Sciences*, Vol. I, II and III, 1st ed., Elsevier Academic Press, UK.
- Robertson GC. 2012. *Food Packaging- Principles and Practices*, 3rd ed. CRC Press.
- *Selected Articles from Journals.*

I. Course Title : **Microbiology and Quality Control of Livestock Products**

II. Course Code : **LPT 606**

III. Credit Hours : **1+1**

IV. Theory

Unit I (9 Lectures)

Microorganisms associated with spoilage of livestock products - Factors affecting microbial growth - Contamination of livestock products - Microbial spoilage of meat, poultry, eggs, milk and their products - Physical and chemical changes produced by microbes in milk, meat, eggs and their products - Meat and milk-borne infections and intoxications - Control of microbial growth in livestock products - Antimicrobial resistance (AMR).

Unit II (8 Lectures)

Introduction to Good Laboratory Practices (GLP), Good Hygienic practices (GHP) and Good Manufacturing Practices (GMP), Sanitary and Phytosanitary measures (SPS) and Food Safety System Certification (FSSC) - Quality Control – Quality Assurance - principles and practices - Quality Management Systems – Food Safety and Standards Act (FSSAI, 2006 Act) - Codex regulation for food products safety - ISO 9001 - ISO 22000 - HACCP concepts - Risk-based quality assessment - Microbial quality control - FSSAI/ BIS standards for milk, meat and poultry, Chemical residues in livestock products and their effects on the health of the consumer.

VII. Practical (17 Classes)

Basic requirements for setting up of quality control laboratory - Sampling methods for the microbiological examination of different processing plants, products and equipment - Development of HACCP plan for milk and meat processing plants - Microbial evaluation of market samples of milk, meat and egg – Total Viable Count, coliform, etc. - Pathogens of Public Health importance - *E. coli*, *Salmonella*, *Staphylococcus aureus*, *Campylobacter* - Rapid detection methods of food pathogens.

VIII. Suggested Reading

- Aberle ED, Forrest JC, Gerrard DE and Mills EW. 2013. *Principles of Meat Science*, 5th ed. Kendall Hunt Publishing Company, Iowa.
- Bell C, Neaves P and Williams AP. 2005. *Food Microbiology and Laboratory Practices*, 1st ed. Blackwell Publishing.
- Collins DS and Huey RJ. 2015. *Gracey's Meat Hygiene*, 11th ed. John Wiley and Sons Ltd., UK.
- Frazier WC and Westhoff DC. 2013. *Food Microbiology*, 5th ed. McGraw Hill Publication.
- Fuquay JW, Fox PF and McSweeney PLH. 2011. *Encyclopaedia of Dairy Sciences*, 2nd ed. Elsevier Academic Press, UK.
- Jay JM, Loessner MJ and Golden DA. 2006. *Modern Food Microbiology*, 7th ed. Springer.
- Jensen WK, Devine C and Dikeman M. 2004. *Encyclopaedia of Meat Sciences*, Vol. I, II and III, 1st ed., Elsevier Academic Press, UK.
- Kerry J, Kerry J and Ledward D. 2005. *Meat Processing-Improving Quality*. Woodhead Publishing Ltd., UK.
- Pearson AM and Dutson TR. 1995. *Quality Attributes and their Measurement in Meat, Poultry and Fish Products*. Aspen Publishers, Inc, Maryland, USA.

I. Course Title : Slaughterhouse By-products Technology

II. Course Code : LPT 607

III. Credit Hours : 1+1

IV. Theory

Unit I (6 Lectures)

Status and scope of slaughterhouse by-products utilization - Trade practices - Planning, design and layout of by-products plant - Classification of by-products - edible and inedible - Rendering methods and products - Yield and characteristics of rendered fat and meat cum bone meal.

Unit II (6 Lectures)

Utilization of blood, horns and hooves, intestine, bones, feathers, bristles, glandular by-products and ruminal contents - Value-added by-products from slaughterhouse and poultry processing plants - Processing of animal by-products for pet foods - High-value low volume by-products – collagen sheets, scaffolds, bone morphogenic proteins, biopeptides, biodiesel, etc.- Legislation and regulations related to animal by-products.

Unit III (5 Lectures)

Flaying - Classification and factors affecting the quality of hides and skin - Physical and chemical characteristics of hide and skin - Grading and processing of hide and skin for the manufacture of leather - Preparation and quality control of gelatine and glue.

V. Practical (17 Classes)

Preparation of casing, neatsfoot oil, gelatin and glue - Demonstration of preparation of carcass meal, meat meal, bone meal, blood meal, feather meal, slime meal - Grading of casings - Collection and preservation of glandular by-products - Preparation of pet foods -Visit local by-products processing units - Quality evaluation of rendered animal fat.

VI. Suggested Reading

- Aberle ED, Forrest JC, Gerrard DE and Mills EW. 2013. *Principles of Meat Science*, 5th ed. Kendall Hunt Publishing Company, Iowa.
- Jensen WK, Devine C and Dikeman M. 2004. *Encyclopaedia of Meat Sciences*, Vol. I, II and III, 1st ed., Elsevier Academic Press, UK.
- Mann I. 1962. *Animal By-products: Processing and Utilization*. FAO, Rome. Ockerman HW and Hansen CL. 1999. *Animal By-product Processing and Utilization*. CRC Press.

I. Course Title : In-Plant Training

II. Course Code : LPT 608

III. Credit Hours : 0+2

IV. Practical (*34 sessions/ Hours equivalent to 34 credit hours of practical*)

LPT students shall undergo in-plant training in any one of the specialized area of Livestock Products Technology in an institute/ industry – private or public sector. After completion of the training, the student will submit a training report. The evaluation will be based on attendance, report submission and viva-voce examination.

V. Suggested Reading

- Interaction with Industry Persons.
- *Selected articles from Journals.*

I. Course Title : Egg and Egg Products Technology

II. Course Code : LPT 609

III. Credit Hours : 1+1

IV. Theory

Unit I (9 Lectures)

Status of egg production and processing in India - Structure, composition, nutritive value and functional properties of eggs - Grading, preservation, packaging and marketing of shell eggs - Quality evaluation of shell eggs and factors influencing egg quality - Defects and Spoilage of eggs.

Unit II (8 Lectures)

Layout and design of egg processing Unit - Principles and procedures involved in pasteurization, chilling, freezing, desugarization and drying of egg products - Quality standards of egg products - Packaging of egg products - Designer egg products.

V. Practical (17 Classes)

Evaluation of physical, chemical, functional and microbial quality of egg and egg products - Preservation of eggs - Preparation of value-added egg products - Visit egg-processing plant.

X. Suggested Reading

- Romanoff AL and Romanoff AJ. 1949. *Avian Egg*. John Wiley and Sons.
- Stadelman WL and Cotterill OJ. 2002. *Egg Science and Technology*, 4th ed. CBS.
- *Selected articles from Journals.*

I. Course Title : Market Milk Processing and Dairy Plant Practices

II. Course Code : LPT 610

III. Credit Hours : 1+1

IV. Theory

Unit I (5 Lectures)

Organization of procurement and pricing plans of raw milk - Operation of automatic milk collection stations - Reception of milk at Raw Milk Reception Dock (RMRD) - Assessing raw milk quality - Sanitary handling of milk - Milk standards and legislations.

Unit II (6 Lectures)

Unit operations in milk processing plants - Clarification – Bactofugation - Different chilling methods - Standardization - Homogenization (theories, methods and effects) - Heat treatments (thermization, boiling, pasteurization, sterilization (UHT and In-container) - Separation technologies (Microfiltration, Ultrafiltration, reverse osmosis, diafiltration, nanofiltration etc).

Unit III (2 Lectures)

Distribution methods for liquid milk - Consumer pricing - Traceability - Handling of unsold and returned milk- - Adulteration of milk and detection - Residues in milk and preventive steps

Unit IV (4 Lectures)

Fortified, special and functional market milk - A1 and A2 milk Design and layout of dairy plants of different capacities - Dairy by-products - Treatment of Dairy Effluents.

V. Practical (17 Classes)

Platform tests - Principles of rapid milk analyzers including milko-tester and operation of automatic milk collection stations - Raw milk quality, somatic cell count, bacteriological count - Estimation of homogenization efficiency - Assessment of efficiency of pasteurization, sterilization and boiling- Detection of adulterants.

X. Suggested Reading

- FAO. 2013. *Milk and Dairy Products in Human Nutrition*. FAO, Rome.
- Fuquay JW, Fox PF and McSweeney PLH. 2011. *Encyclopaedia of Dairy Sciences*, 2nd ed. Elsevier Academic Press, UK.
- Walstra P, Wouters JTM and Geurts, TJ. 2006. *Dairy Science and Technology*, 2nd ed., Taylor and Francis Group.

I. Course Title : Processing and Marketing of Wool

II. Course Code : LPT 611

III. Credit Hours : 1+1

IV. Theory

Unit I (10 Lectures)

Status and prospects of wool industry - Wool types and their uses - Growth and molecular structure of wool fibre - physical and chemical properties of wool - Grading of wool, Characteristics of speciality hair fibres and their uses- factors influencing the quality of wool and speciality hair fibres - principles and steps involved in the processing of wool and speciality hair fibres, Impurities in wool and their removal, Defects in wool.

Unit II (7 Lectures)

Physical, chemical and mechanical testing of wool - by-products of wool industry - Trade and Marketing of wool, specification and regulation for quality control - Characteristics of natural and synthetic fibres

V. Practical (17 Classes)

Physical, chemical and mechanical testing of wool and speciality hair fibres - Characterization of wool - grading of wool - Identification of natural and synthetic fibres - Visit the wool processing industry and acquaintance with various steps in the processing of wool and speciality hair fibres.

VI. Suggested Reading

- Bergen WV. 1963. *Wool Hand Book*, Vols. I and II. Interscience.
- Houck MM. 2009. *Identification of Textile Fibres*. Woodhead Publishing Limited, Cambridge, England.
- Johnson NAG and Russell IM. 2009. *Advances in Wool Technology*. Woodhead Publishing Limited, Cambridge, England.

I. Course Title : Biotechnology of Foods of Animal Origin

II. Course Code : LPT 612

III. Credit Hours : 1+1

IV. Theory

Unit I (10 Lectures)

Role of Biotechnology in improving productivity and quality of Meat, Milk and their products - Application of biotechnological tools in food preservation and packaging - Transgenic meat animal production - techniques - Genes influencing meat quality traits – Production of meat and milk with the desired composition - Application of enzymes in dairy and meat industry - Genetically modified enzymes - Biotechnologically produced food flavours and colours for animal products.

Unit II (7 Lectures)

Starter cultures in Meat and milk - Pre and probiotics, and their supplementation in animal origin foods - Biopreservation- Bacteriocin - Fermentation technology - Upstream and Downstream processing - Biosensors - Antimicrobial Peptides - Meat Species Identification- Molecular tools.

V. Practical (17 Classes)

Introduction of basic biotechnological techniques such as western blotting, enzyme isolation and identification, DNA extraction, amplification, different types of PCR, Acquaintance with RT-PCR, Multiplex PCR, gene identification and characterization - Biotechnological techniques for meat species identification and meat quality - Electrophoresis, Chromatography for fatty acids- Operation of Fermenters.

VI. Suggested Reading

- Kerry J, Kerry J and Ledward D. 2005. *Meat Processing - Improving Quality*. Woodhead Publishing Ltd., UK.
- Kowale BN, Kulkarni VV and Keshava Rao V. 2008. *Methods in Meat Science*. Jaypee Brothers Medical Publishers, New Delhi.
- Sahoo J, Sharma DK and Chatli MK. 2011. *Practical Handbook on Meat Science and Technology*, Daya Publishing House, New Delhi.
- Toldra F. (Ed). 2008. *Meat Biotechnology*, Springer Science, New York
- Webb BH, Johnson AH and Alford JA. 2005 *Fundamentals of Dairy Chemistry*, 2nd ed. CBS Publishers and Distributors Pvt. Ltd.
- Selected articles from Journals.

I. Course Title : Fish and Fish Products Technology

II. Course Code : LPT 613

III. Credit Hours : 1+1

IV. Theory

Unit I (9 Lectures)

Fishery resources, marine and freshwater fishes- Transportation and hygienic handling of fish - Fish Muscle structure, composition and nutritive value - Processing of fish - gutting, filleting, beheading, peeling, deveining, etc. - Preservation - chilling, freezing, etc. - Principles and procedure of canning, curing, smoking, dehydration - Surimi and other Fish based products.

Unit II (8 Lectures)

Quality control- identification of freshness of fish - Chemical and Microbial spoilage of fish, labelling and marketing of fish and fish products, utilization of fish processing waste. National and international regulations, standards, quality control and marketing of fish and fish products.

V. Practical (17 Classes)

Visit fish processing plant - Grading of live fish for freshness - Filleting and other techniques for the processing of fish - Proximate Composition of Fish - Physico-chemical and Microbial evaluation of fish quality - Preparation of Value added fish products.

VI. Suggested Reading

- Pearson AM. 1994. *Quality Attributes and their Measurement in Meat, Poultry and Fish Products*. Springer, New York.
- Suzuki T. 1981. *Fish and Krill: Protein Processing Technology*. Applied Science Publ.
- *Selected articles from Journals.*

Course Title with Credit Load
Ph.D. in Livestock Products Technology

Course No.	Course Title	Credits
LPT 701*	Modern Abattoir Practices and Animal By-Products Technology	1+1
LPT 702*	Advances in Meat Production and Fresh Meat Technology	1+1
LPT 703*	Developments in Processed Meat Technology	1+1
LPT 704*	Current Trends in Processing of Milk And Milk Products	1+1
LPT 705	Biotechnological Techniques and Quality Control of Livestock Products	1+1
LPT 706	Ethnic and Organic Meat and Milk Products	1+1
LPT 707	Industrial and Entrepreneurial Training	0+2
LPT 708	Current Trends in Disposal and Utilization of Waste From Meat and Dairy Industry	1+1
LPT 709	Advances in Egg and Egg Products Technology	1+1
LPT 791	Seminar I	1+0
LPT 792	Seminar II	1+0
LPT 799	Research	75

*Core courses

Course Contents
Ph.D. in Livestock Products Technology

I. Course Title : Modern Abattoir Practices and Animal By-Products Technology

II. Course Code : LPT 701

III. Credit Hours : 1+1

IV. Theory

Unit I (5 Lectures)

Current scenario of slaughterhouses and processing plants in India - Establishment and operation of a modern abattoir - Basic machinery and tools of slaughterhouse - Automation/ Robotics in meat and by-product processing – Latest developments in the evaluation of carcass quality – Chilling and freezing of carcass - Maintenance of cold storages.

Unit II (8 Lectures)

Latest machinery and tools used in by-products processing plant - New technologies for utilization of animal by-products as food, feed, pharmaceuticals and other miscellaneous products - Leather chemistry and processing technology - Latest Techniques in handling, preservation, tannery procedure, manufacture and testing of leather - Value addition in leather processing - Developments in gelatin, glue and natural casings production - Characterization, processing, yield and quality control of rendered fat and meat cum bone meal.

Unit III (4 Lectures)

Organization, layout and operation of dry and wet rendering plants. Latest trends in the disposal of slaughterhouse effluents and control of environmental pollution. Designs and function of effluent treatment plants.

V. Practical (17 Classes)

Plan and outlay of various components of a modern abattoir. Designs of ETP. Estimation of TS (suspended and dissolved) BOD and COD from abattoir effluents. Ante-mortem inspection of food animals, methods of stunning, stunning instruments. Slaughter and dressing of food animals. Electrical stimulation of carcasses. Post mortem inspection of carcasses of food animals - Visit municipal slaughterhouse, by-product processing plant, Effluent treatment plant and tanneries.

IX. Suggested Reading

- Biswas A and Kondaiah N. 2014. *Meat Science and Technology*, 1st ed. Jaya Publishing House.
- Collins DS and Huey RJ. 2015. *Gracey's Meat Hygiene*, 11th ed. John Wiley and Sons Ltd., UK.
- Jensen WK, Devine C and Dikeman M. 2004. *Encyclopaedia of Meat Sciences*, Vol. I, II and III, 1st ed. Elsevier Academic Press, UK.
- Kerry J, Kerry J and Ledward D. 2005. *Meat Processing- Improving Quality*. Woodhead Publishing Ltd., UK.
- Swatland HJ. 2004. *Meat Cuts and Muscle Foods*. Nottingham University Press.
- Warriss P. 2010. *Meat Science: An Introductory Text*, 2nd ed. OXford Press.
- *Selected articles from Journals.*

I. Course Title : Advances in Meat Production and Fresh Meat Technology

II. Course Code : LPT 702

III. Credit Hours : 1+1

IV. Theory

Unit I (7 Lectures)

Current status of meat production trends in India - Government policies - economics and viability – Traceability in the meat industry – Strategies for augmenting meat production - Salvaging male buffalo calf - Non-conventional meat resources.

Unit II (10 Lectures)

Pre- and Post-natal development of Muscle fibres - Genetic, nutritional and physiological aspects of muscle development - Ultrastructure of skeletal muscle - Modern tools for fibre typing of muscle - Chemical and biochemical aspects of rigor mortis and fresh meat quality – Odour, colour, water holding capacity - Texture profile - Artificial tenderization - Myofibrillar, sarcoplasmic and connective tissue proteins - Cytoskeletal proteins - Lipid profile - Meat in human nutrition - Meat and health issues.

VI. Practical (17 Classes)

Economics of establishing commercial meat animal production Unit - Extraction of sarcoplasmic and myofibrillar proteins and their fractionation - Estimation of Collagen content of Meat - Histochemistry of muscle tissues - Muscle fibre typing - Meat tenderization techniques.

VII. Suggested Reading

- Aberle ED, Forest JC, Gerrard DE and Mills E. 2013. *Principles of Meat Science*, 5th ed. Kendall Hunt Publishing Company, Iowa.
- Carlson CW, Greaser ML and Jones KW. 2001. *The Meat We Eat*, 14th ed. Interstate Publishers, Inc.
- Jensen WK, Devine C and Dikeman M. 2004. *Encyclopaedia of Meat Sciences*, Vol. I, II and III, 1st ed. Elsevier Academic Press, UK.
- Lawrie RA and Ledward DA. 2006. *Lawrie's Meat Science*, 7th ed. Woodhead Publishing Limited, Cambridge, England.
- Pearson AM and Dutson TR. 1997. *Advances in Meat Research. Healthy Production and Processing of Meat, Poultry and Fish Products*, Vol. 11. Springer.
- Swatland HJ. 2004. *Meat Cuts and Muscle Foods*. Nottingham Univ. Press.
- *Selected articles from Journals.*

I. Course Title : Developments in Processed Meat Technology

II. Course Code : LPT 703

III. Credit Hours : 1+1

IV. Theory

Unit I (5 Lectures)

Current trends in meat processing techniques - Functional properties of the tissue component in meat processing - Approaches for new product development - Latest equipment used for processing of meat products - Indigenous and heritage meat products - Curing and smoking - purpose, composition and methods of smoking - Liquid smoke - Processing of Ham, bacon, sausages, patties, meatloaves and tandoori chicken- Novel meat products - Non-thermal processing - Irradiation techniques - Canning/ retorting.

Unit II (8 Lectures)

Marination, massaging, tumbling and flaking techniques - Restructured/ reformed, intermediate moisture, fermented, enrobed, shelf-stable and dried meat products - Meat analogues and substitutes - Thermal processing of meat- Enzymatic and non-enzymatic browning reactions - Protein changes in processed meat products - Lipid changes - Protein and lipid interaction - Protein and carbohydrate interaction - Bioactive peptides.

Unit III (4 Lectures)

Functional and designer meat products - Role of omega-3 fatty acids in animal foods - Role of n-3 in PUFA enriched and CLA enriched meat and eggs - Packaging of meat and meat products - smart, active, intelligent packaging - Developments in sensory evaluation of meat products.

V. Practical (17 Classes)

Evaluation of texTural characteristics of meat products – Estimation of emulsifying capacity, emulsion stability- Estimation of Nitrosamines and PAHs - Preparation of emulsion-based, restructured, enrobed, cured and smoked, dried, fermented, intermediate moisture, ready to eat, and shelf-stable meat products-objective and subjective evaluation of meat products.

VI. Suggested Reading

- Aberle ED, Forest JC, Gerrard DE and Mills E. 2013. *Principles of Meat Science*, 5th ed. Kendall Hunt Publishing Company, Iowa.
- Barbut S. 2005. *Poultry Products Technology*. CRC Press.
- Jensen WK, Devine C and Dikeman M. 2004. *Encyclopaedia of Meat Sciences*, Vol. I, II and III, 1st ed. Elsevier Academic Press, UK.
- Kerry J, Kerry J and Ledward D. 2005. *Meat Processing- Improving Quality*. Woodhead Publishing Ltd., UK.
- Pearson AM and Gillett TA. 1996. *Processed Meats*, 3rd ed. Chapman and Hall, Inc, New York.
- Toldrá F. 2010. *Handbook of Meat Processing*. Wiley-Blackwell.
- *Selected articles from Journals.*

I. Course Title : **Current Trends in Processing of Milk And Milk Products**

II. Course Code : **LPT 704**

III. Credit Hours : **1+1**

IV. Theory

Unit I (8 Lectures)

Principles and practices of production of quality raw milk - Advances in methods of chilling of milk - Thermal processing of milk – Principles and methods - types of UHT processing plants - Advances in the packaging of milk and milk products - Rheology of milk products - Preservatives, antioXidants, antibiotics and different toXic residues in milk - Advances in bacteriological and physico-chemical analysis of milk and milk product – Different legal and voluntary standards for milk and milk products - A1 and A2 milk and their significance.

Unit II (4 Lectures)

Bacteriological, physical, chemical and nutritional effects of processing on milk - New concepts in milk processing – radiation, microwave processing and conduction heating of milk – By-products from the dairy industry and their utilization.

Unit III (5 Lectures)

Innovative mechanization in the manufacture of Indigenous dairy products - Advances in the utilization of dairy by-products - preservation of milk products - Application of immobilized enzymes in dairy products – Latest trends in cleaning and sanitation of dairy plant

V. Practical (17 Classes)

Quality evaluation of milk and milk products - Preparation of novel and indigenous milk products and their economics of production, quality and sensory evaluation - Use of Starter cultures - Maintenance of cultures - Demonstration of membrane processing technology - Preparation of DPR for Dairy plants of different capacities.

VI. Suggested Reading

- Fuquay JW, FoX PF and McSweeney PLH. 2011. *Encyclopaedia of Dairy Sciences*, 2nd ed. Elsevier Academic Press, UK.
- Herrington BL. 2000. *Milk and Milk Processing*. Green World Publishers.
- Walstra P, Wouters JTM and Geurts, TJ. 2006. *Dairy Science and Technology*, 2nd ed. Taylor and Francis Group.
- *Selected articles from Journals.*

I. Course Title : **Biotechnological Techniques and Quality Control of Livestock Products**

II. Course Code : **LPT 705**

III. Credit Hours : **1+1**

IV. Theory

Unit I (10 Lectures)

Biotechnological tools for microbial testing of food - Industrial cell culture – Bioreactor types and design – Upstream and downstream processing - Bacterial food additives and supplements - Characteristics and application of microbial starters in milk and meat fermentation - Biotechnology in production of designer livestock products - Bio-production of flavours and colour and their application in dairy products - Enzyme applications in dairy technology. - Utilization of nanotechnology in livestock products - Biotechnology for food safety - Cultured meat - Biotechnology in meat species identification.

Unit II (7 Lectures)

Importance of quality control for livestock products - Concept and application of HACCP - BIS, FSSAI and AGMARK standards - GMP and total quality management in the processing of livestock products - ISO-9000, ISO-14000 and ISO-22000 - Codex regulations of food product safety.

V. Practical (17 Classes)

Demonstration of the latest biotechnological techniques including DNA and protein-based techniques. Operation of bioreactors - Gene identification and characterization. Visit Milk/ Meat processing plants for an understanding of HACCP and other quality management systems.

VI. Suggested Reading

- Fuquay JW, Fox PF and McSweeney PLH. 2011. *Encyclopaedia of Dairy Sciences*, 2nd ed. Elsevier Academic Press, UK.
- Jensen WK, Devine C and Dikeman M. 2004. *Encyclopaedia of Meat Sciences*, Vol. I, II and III, 1st ed. Elsevier Academic Press, UK.
- Kerry J, Kerry J and Ledward D. 2005. *Meat Processing-Improving Quality*. Woodhead Publishing Ltd., UK.
- *Selected articles from Journals.*

I. Course Title : Ethnic and Organic Meat and Milk Products

II. Course Code : LPT 706

III. Credit Hours : 1+1

IV. Theory

Unit I (9 Lectures)

Historical developments, present scenario and prospects of ethnic meat and milk products in various parts of India - Ethnic meat products - haleem, biryani, chettinad recipe, pork vindaloo, Kebab, Goan sausages, Kashmiri wazwan and meat products of North Eastern Region (NER) - Ethnic milk products – churpi, kalari, kunda, etc. - Constraints in promoting ethnic meat products - Approaches for development and commercialization of ethnic meat products - Fermented and non-fermented ethnic milk and meat foods – Impact of Globalization and role of WTO in promoting ethnic meat and milk products from India.

Unit II (5 Lectures)

Entrepreneurship Development for Ethnic meat and milk Products – Formulation, composition, quality, safety and shelf life of ethnic meat and milk products of India - Geographical indicators for recognition of ethnic meat and milk products.

Unit III (3 Lectures)

Organic meat and milk products - introduction, registration, certification, marketing and scope.

V. Practical (17 Classes)

Preparation of ethnic meat products - haleem, biryani, chettinad recipe, pork vindaloo, Kebab, Goan sausages, Kashmiri wazwan and meat products of NER/ local region, Preparation of Ethnic milk products – churpi, kalari, Kunda, etc. - Composition, physico-chemical and microbial quality of ethnic milk and meat products - Packaging and marketing of ethnic milk and meat products.

VI. Suggested Reading

- Books on Indian Food.
- *Selected articles from Journals*

I. Course Title : Industrial and Entrepreneurial Training

II. Course Code : LPT 707

III. Credit Hours : 0+2

IV. Practical (34 Classes)

Preparation of basic feasibility report including raw material availability, marketing potential, economic viability and regulatory requirements for different livestock products related industry. Entrepreneurial training in an industrial establishment related to livestock products (17 sessions/ Hours equivalent to 17 credit hours of practical).Preparation of Detailed project reports (DPR) for the establishment of livestock products enterprises, viz. slaughterhouses, milk and meat processing plants, effluent treatment and byproducts utilization plants, etc..

V. Suggested Reading

- *Selected articles from Journals.* Through Interaction with Industry personnel.

I. Course Title : Current Trends in Disposal and Utilization of Waste From Meat and Dairy Industry

II. Course Code : LPT 708

III. Credit Hours : 1+1

IV. Theory

Unit I (8 Lectures)

Terminologies used in solid and liquid waste management systems - Public health significance - Classification, composition, functional elements and sources of solid waste from Meat and Dairy Processing plants and their management - Aerobic and anaerobic systems of liquid waste management.

Unit II (9 Lectures)

Waste handling, separation, storage, processing and utilization of Solid waste - Common solid waste disposal methods like rendering, composting, deep burial and incineration - Scope for zero waste management - Properties of dried sludge and its utilisation as manure - Economical aspects of waste treatment and disposal - Utilization of meat and dairy processing wastes - Application of nanotechnology in waste management - State and Central Pollution Control Board norms.

V. Practical (17 Classes)

Visit Sewage and Effluent Treatment Plants - Estimation of pH, dissolved oxygen, TSS, BOD and COD - Estimation of micronutrients in treated effluents - Design and schematic layout of various solid and liquid waste treatment plants.

VI. Suggested Reading

- *Selected articles from Journals.* Through Interaction with personnel of Municipal Corporation and Pollution Control Board.

I. Course Title : Advances in Egg and Egg Products Technology

II. Course Code : LPT 709

III. Credit Hours : 1+1

IV. Theory

Unit I (5 Lectures)

Advanced preservation techniques for egg and egg products - Maintenance of quality of eggs - Microbiology of egg - Spoilage of eggs and its prevention.

Unit II (8 Lectures)

Preparation of fast foods and role of egg in fast foods chains - Egg breaking and processing plants - lay-out and organization Preservation methods viz pasteurization, desugarization, freezing, dehydration, etc. – process and methods - Quality estimation of egg and egg products - Designer egg and egg products.

Unit III (4 Lectures)

Specifications, Standards and marketing of egg and egg products - Quality control of egg products.

VII. Practical (17 Classes)

Evaluation of physical, chemical and functional quality of egg and egg products - Detection of egg rots - Evaluation of microbiological quality of egg and egg products - Preservation techniques of eggs - Preparation of convenient, dehydrated and value-added egg products -Visit a modern egg processing plant

VIII. Suggested Reading

- Romanoff AL and Romanoff AJ. 1949. *Avian Egg*. John Wiley and Sons.
- Stadelman WL and Cotterill OJ. 2002. *Egg Science and Technology*, 4th ed. CBS.
- *Selected articles from Journals.*

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 3

Animal Production Sciences
– Poultry Science

Course Title with Credit Load
M.V.Sc. in Poultry Science

Course Code	Course Title	Credit Hours
PSC 601*	Poultry Breeding and Genetics	2+1
PSC 602*	Poultry Nutrition and Feeding	2+1
PSC 603*	Commercial Layer and Broiler Management	2+1
PSC 604*	Breeder Stock and Hatchery Management	2+1
PSC 605	Poultry Health and Biosecurity	2+1
PSC 606	Management of Other Avian Species	3+1
PSC 607*	Poultry Products Technology	2+1
PSC 608	Poultry Economics, Project Formulation and Marketing	2+1
PSC 609*	Physiology of Poultry Production	1+1
PSC 610	Commercial Poultry Nutrition	1+1
PSC 611	Poultry Welfare and Waste Management	2+0
PSC 691	Seminar	1+0
PSC 699	Research	30

*Core courses

Course Contents
M.V.Sc. in Poultry Science

I. Course Title : Poultry Breeding and Genetics

II. Course Code : PSC 601

III. Credit Hours : 2+1

IV. Theory

Unit I (12 Lectures)

Genetic classification of Poultry – Origin and breed characteristics of poultry- Mendel's laws of inheritance related to poultry - Qualitative and Quantitative traits in Poultry breeding – Additive and Non-additive – Dominance, Incomplete dominance, Epistasis and complementary gene actions – Lethals and mutations in poultry – Sex-linked, Sex limited and Sex influenced traits – Economic traits – Partitioning of variance - Heritability – Quantitative inheritance – Phenotype, Genotype and environment interactions.

Unit II (10 Lectures)

Systems of Breeding – Systems of Mating – Selection methods – Breeding programme for developing egg-type, meat type and rural poultry strains - Developing hybrids - Breeding and management of other species of Poultry- Formation and Management of inbred pure lines, grandparent and parent stock - Industrial breeding.

Unit III (12 Lectures)

Artificial insemination in chicken –Autosexing–Random Sample Test - Use of molecular genetics in poultry breeding-Quantitative trait loci and marker-assisted selection- Conservation of poultry genetic resources.

V. Practical (17 Classes)

Breeds of poultry – Estimation of qualitative and quantitative traits in poultry – Exercises on individual and family selection – Constructing multi-traits selection index and Osborne index-Estimating heritability – Breeding program for developing commercial hybrid layers, broilers and Japanese quail– Breeding programmes for rural poultry - Semen collection, evaluation, dilution and insemination in chicken and turkey – Breeding records –Use of computers to maintain breeding records and for selection– Estimation of effective population size, rate of inbreeding, response to selection and genetic and phenotypic responses.

IX. Suggested Reading

- Crawford RD. 1990. *Poultry Breeding and Genetics*. Elsevier.
- Falconer DS. 1997. *Introduction to Quantitative Genetics*. Benjamin Cummings.
- Hutt FB. 1949. *Genetics of the Fowl*. McGraw-Hill
- Muir WM and Aggrey SE. 2003. *Poultry Genetics, Breeding and Biotechnology*. CABI.
- Singh RP and Kumar J. 1994. *Biometrical Methods in Poultry Breeding*. Kalyani Publications

I. Course Title : Poultry Nutrition and Feeding

II. Course Code : PSC 602

III. Credit Hours : 2+1

IV. Theory

Unit I (8 Lectures)

Digestive system, digestion, metabolism and absorption of nutrients in poultry – Factors influencing the feed consumption in birds – Macro and micro-nutrients – Protein and amino acids - Nutrient requirements for various species of poultry – Factors influencing the nutrient requirements - Partitioning of energy - Calorie: protein ratio – Nutrient interrelationships.

Unit II (12 Lectures)

Feed ingredients composition - Feed storage techniques - Milling and quality control- Processing of feed – Types and forms of feeds and feeding methods - Commonly occurring antinutrients and toxicants in poultry feed ingredients – Mycotoxins and their prevention – Feeding chicks, growers, layers, broilers and breeders – Principles of computing feed – Balanced feeds - Least cost feed formulation and programming – Feeding in different seasons and stress conditions - Nutritional and metabolic disorders in poultry.

Unit III (8 Lectures)

Systems of feeding – restricted, forced, controlled and phase feeding -Use of Additives and Non-additives- enzymes, probiotics, prebiotics, antibiotics, herbs and other performance enhancers – Utilization of non-conventional feedstuff - Feeding of ducks, turkeys, Japanese quails and Guinea fowls.

Unit IV (6 Lectures)

Organic, functional, designer and SPF feed production - Production of feeds free from drug residue, pesticide residue and toxins – Regulations for Import and Export of feed and feed supplements.

V. Practical (17 Classes)

Physical and sensory evaluation of feed ingredients- sampling techniques for ingredients and compounded feed-Estimation of proximate principles of feed and feed ingredients – Computing various poultry feed formulae based on commonly available feed ingredients – Computer applications in feed formulations - Estimation of Aflatoxin, Calcium, Phosphorus, Sand, Silica and Salt – Mash, pellet and crumble feed preparation – Feeding procedures. Visit to feed mills –Hands-on training in feed analytical lab.

VI. Suggested Reading

- Bell DD and Weaver WD JR. 2002. *Commercial Chicken Meat and Egg Production*, 5th ed. Kluwer Academic Publishers.
- ICAR. 2013. *Nutrient Requirements of Poultry*. ICAR Publication.
- Leeson S and Summers JD. 2001. *Scott's Nutrition of the Chicken*. University Books.
- Leeson S and Summers JD. 2008. *Commercial Poultry Nutrition*, 3rd ed. University Books.
- Singh RA and Panda B. 1992. *Poultry Nutrition*. Kalyani Publishers.

I. Course Title : Commercial Layer and Broiler Management

II. Course Code : PSC 603

III. Credit Hours : 2+1

IV. Theory

Unit I (10 Lectures)

Development of Poultry Industry in India and the World – Systems of layer and broiler farming – Location and layout of the farm – Systems, types and design of houses – Poultry farm equipment - Automation in poultry houses and its maintenance - Environmentally controlled houses and their management -Deep litter and cage system of management- Litter materials -All in All out and Multiple batch systems of rearing layers and broilers –Brooding management - Lighting programme for egg-type and meat-type birds- Water quality standards, watering and water sanitation - Biosecurity and health management – Production indicesfor broilers and layers – Integration in broiler and layer production.

Unit II (12 Lectures)

Cages and modified cages for egg-type birds – Feeding management in layers - Medication and vaccination schedules and procedure for layers –Brooder, grower, pre-layer, layer and cockerel management – Management of layers during peak egg production and maintaining the persistency in production – Strategies to prolong the egg production beyond 72 weeks of age - Factors causing uneven growth andlow egg production - Monitoring egg production curve - Culling of unproductive birds – Record keeping –Management during different seasons – Induced moulting.

Unit III (10 Lectures)

Management of broilers during different seasons -Mash, crumble and pellet feeding of Broilers – Weekly growth rate, feed conversion and livability in broilers- Sex separate feeding – Feeding broilers for optimum growth rate and feed efficiency – Broiler farm records - Broiler farm routine, medication and vaccination schedule – Transport of broilers - Regulations and specifications for the production of export quality broilers.

V. Practical (17 Classes)

Layer farm layout– Design of different chick, grower and layer houses, their specifications – Selection and culling of layers, debeaking, dubbing, deworming, delicing, vaccination and other farm routines and operations – Farm sanitation, disinfection and waste disposal – Visit commercial layer farms including environmental controlled houses – Record keeping – Calculating Hen day egg production, Hen housed egg production and other economic traits – Calculating the cost of production of eggs and meat and economics–Location and layout for a broiler farm – Broiler house design – Visit to commercial broiler farms including environmental controlled houses – Broiler brooding, Medication, vaccination, transportation and farm routines - Record keeping - Calculating the cost of production of broilers – Feeding of broilers at different ages – Working-out feed efficiency.

VI. Suggested Reading

- Bell DD and Weaver WD, Jr. 2002. *Commercial Chicken Meat and Egg Production*, 5th ed. Kluwer Academic Publishers.
- Narahari D. 1997. *Commercial Broiler Production*. Emkay Publishers.
- Rajini RA. 2012. *Simply Poultry Science*. Alpha Publishers.
- Sapcota D, Narahari D and Mahanta JD. 2017. *Avian Poultry Production*, 2nd rev ed. New India Publishing Agency.
- Scanes CG, Brant G and Ensminger ME. 2003. *Poultry Science*, 4th ed. Prentice-Hall.
- Sreenivasaiah PV. 2015. *Textbook of Poultry Science*. Write and Print Publications.

I. Course Title : Breeder Stock and Hatchery Management

II. Course Code : PSC 604

III. Credit Hours : 2+1

IV. Theory

Unit I (9 Lectures)

Different types of commercial breeder flocks –Special care of breeder chicks – Breeder male and female management – Feeding the breeder flocks: Separate sex feeding, feed restriction in broiler breeders. Management for improving fertility and hatchability, Management of parent and grandparent farms - Management of pure lines – Artificial Insemination - Care and management of Hatching eggs.

Unit II (4 Lectures)

Vaccination of layer and broiler parents - Nutrient supplementation – Seasonal management of breeders – Lighting management in breeder farms - Flock testing and culling.

Unit III (12 Lectures)

Natural and Artificial incubation –Stages of embryonic development -Incubation principles – Location of hatchery – Layout and design of hatchery - hatchery equipment– Hatchery management - Ventilation and temperature control –Pre-incubation storage, Fumigation and sanitation – Hatchery operations, routine and schedule – Egg candling -Packaging and transportation of hatching eggs and chicks, hatchery troubleshooting- Factors affecting fertility and hatchability - Biosecurity and hatchery waste disposal – Control of vertically transmissible and hatchery borne diseases – Special incubator management during hot summer – Hatch analysis.

Unit IV (9 Lectures)

SPF egg production - Import and export regulations – Maintaining Salmonella and Mycoplasma free breeding flock –Application of HACCP and Good Management Practices (GMP) in hatchery management for better chick quality.

V. Practical (17 Classes)

Layout and blueprints for breeder farm and hatchery –Incubator management – Candling - Hatchery sanitation, fumigation procedures and hatchery hygiene – Pedigree hatching – Hatchery waste disposal and recycling – Calculating the cost of production of hatching eggs and day-old-chicks, management of bangers– Attending breeder farm routines and operation – Flock testing and culling of reactors – Analyzing hatchability results – Use of computers in hatchery operations - Economics of setting up of layer and broiler hatchery. Vaccinating day-old chicks and concept of in-ovo vaccination, visit to commercial breeder farm and hatchery.

VI. Suggested Reading

- Bell DD and Weaver WD, Jr. 2002. *Commercial Chicken Meat and Egg Production*, 5th ed. Kluwer Academic Publishers.
- Leeson S and Summers JD. 2009. *Broiler Breeder Production*. Context Products.
- Sreenivasaiah PV. 2006. *Scientific Poultry Production: A Unique Encyclopaedia*. International Book Distributing Co.
- Taylor LW. 2003. *Fertility and Hatchability of Chicken and Turkey*. John Wiley and Sons.

I. Course Title : Poultry Health and Biosecurity

II. Course Code : PSC 605

III. Credit Hours : 2+1

IV. Aim of the course

To impart knowledge about common diseases and disorders of poultry, diagnosis, vaccination, prevention, control and treatment. Biosecurity measures in the control of common poultry diseases.

V. Theory

Unit I (7 Lectures)

Common bacterial diseases: *Salmonella, Pasteurella, E.coli*, Fowl typhoid, Mycoplasma, Infectious *Coryza, Gallibacterium, Clostridium*

Unit II (9 Lectures)

Common Viral diseases: Newcastle, Infectious bronchitis, Infectious laryngeotracheitis, Marek's, Fowl poX, Infectious Bursal disease, Egg drop syndrome- 76, Avian Encephalomyelitis, Avian influenza, Duck viral hepatitis, Chicken Infectious Anaemia, etc.

Unit III (8 Lectures)

Common Fungal, parasitic and metabolic diseases: Aspergillosis, MycotoXicosis, Fatty liver haemorrhagic syndrome(FLHS), Gout, Ascites, leg weakness - Coccidiosis, Ecto- and endo-parasitic infestation of poultry, etc.

Unit IV (5 Lectures)

Diagnosis, vaccination, prevention, treatment and control of various poultry diseases.

Unit V (5 Lectures)

Principles of biosecurity - Locational, structural and operational biosecurity in Poultry farms – Water sanitation and control of water-borne diseases – Quarantine of poultry - Farm sanitation and disinfection procedures.

VI. Practical (17 Classes)

Ante-mortem and Post-mortem eXamination of birds – Sample collection – Despatchof samples – Processing of samples and detection of pathogens/ etiological agents
-Different sanitizers and disinfectants available and their uses. Care and contraindication of using different products. Personal hygiene and isolation – Different vaccines and routes of administration – Methods of medication – Water quality analysis, Field visit to poultry diagnostic lab.

VII. Teaching methods

- Classroom teaching with laboratory diagnosis
- Post-mortem eXamination
- Using Audio-visual capsules

VIII. Learning outcome

Gaining knowledge on poultry health and bio-security

IX. Suggested Reading

- Gordon RF and Jordan FTW. 1982. *Poultry Diseases*. ELBS
- Pattison M, McMullin P, Bradbury JM and AleXander D. 2008. *Poultry Diseases*, 6th ed. Elsevier.
- Saif YM. 2008. *Diseases of Poultry*. Blackwell Publishing House.
- Thyagarajan D. 2011. *Diseases of Poultry*, Satish Serial Publishing House.
- Vegad JL. 2015. *Poultry Diseases Farmers. A Guide for Farmers and Poultry Professionals*. International Book Distributing Co.

I. Course Title : Management of Other Avian Species

II. Course Code : PSC 606

III. Credit Hours : 3+1

IV. Theory

Unit I (15 Lectures)

Breeds and varieties of Turkey, Duck, Goose, Guinea fowl, Japanese quail, Emu and Ostrich – Incubation periods and incubation procedure for different species – Production standards - Housing, cage and equipment for other avian species under different systems of rearing.

Unit II (15 Lectures)

Management and rearing of Turkey, duck, goose, Guinea fowl, Japanese quail, emu and ostrich- Feeding standards and feeding, watering and rearing systems and procedure for different species of poultry - Breeding programmes for egg and meat production in different species.

Unit III (10 Lectures)

Different types of pet birds - Management and rearing of pet birds of regional importance (Pigeon, budgerigar, parakeets, love birds, macaws, doves, parrots, etc.) – Housing for pet birds, their habitat, feeding and breeding under captivity.

Unit IV (8 Lectures)

Common diseases affecting other avian species and their control – Regulations for import and eXport of different species of poultry – Prevention of eXotic diseases through the import of live birds.

Unit V (3 Lectures)

Concept and definition of organic poultry – status, certification and guidelines for organic poultry production – Government policies on organic poultry farming.

V. Practical (17 Classes)

Layout and design of housing and cages for other species of poultry. Visit commercial Japanese quail, turkey and duck farms. Incubation and care of hatching eggs and young ones – Rearing practices followed by duck, quails and turkey farmers under field conditions - Sexing of pet birds – Preparing project reports for different species and calculating the cost of production – Feeding pet birds and their chicks.

IX. Suggested Reading

- Cherry P and Morris T. 2011. *Domestic Duck Production: Science and Practice*. CABI
- CPDO. *Duck – Management Guide*. Central Poultry Development Organization Publication (online resource)
- CPDO. *Turkey – Management Guide*. Central Poultry Development Organization Publication (online resource)
- Mayer J and Donnelly TM. 2012. *Clinical Veterinary Advisor: Birds and Exotic Pets*. Elsevier.
- Pathak N. 2013. *Poultry and Ratite Nutrition*. Narendra Publishing House.
- Sapcota D, Narahari D and Mahanta JD. 2017. *Avian Poultry Production*, 2nd rev ed. New India Publishing Agency.
- Scanes CG, Brant G and Ensminger ME. 2003. Poultry Science, 4th ed. Prentice-Hall.

I. Course Title : Poultry Products Technology

II. Course Code : PSC 607

III. Credit Hours : 2+1

IV. Theory

Unit I (15 Lectures)

Physical and chemical composition and nutritive value of eggs and meat – Grading of eggs and meat by different standards - Egg quality deterioration - Factors affecting egg quality – Handling, processing, packaging materials, packaging, transport and marketing of eggs.

Unit II (8 Lectures)

Quality control of poultry meat – Preservation of egg and meat-Functional and value-added egg and meat products – Further processing of eggs and meat – Various egg and meat fast foods.

Unit III (11 Lectures)

Sanitary and phytosanitary measures to ensure food safety – Pre and Post oviposition value addition to the eggs and Post-processing value addition to the meat for eXport– Microbial safety of poultry products – Import and eXport of poultry products – Further processing of poultry for eXport – Implementation of GMP and HACCP procedures for food safety – CodeX regulations for poultry products safety – Traceability and branding of poultry products.

V. Practical (17 Classes)

Measuring internal and eXternal egg qualities – Measurement of meat quality - Preservation of table eggs, grading of eggs – Processing of chicken – Further processing of poultry – Preservation of poultry meat – Preparation of various eggs and poultry meat products and fast foods – Preservation, packaging and transport – Quality control of value-added poultry products – Measures of microbial safety of poultry products for eXport, visit to poultry processing plant.

IX. Suggested Reading

- Biswas A and Kondaiah N. 2014. *Meat Science and Technology*. Jaya Publishing House.
- Mead G. 2004. *Poultry Meat Processing and Quality*. Elsevier
- Mountney GJ and Parkhairst CR. 1995. *Poultry Products Technology*, 3rd ed. AVI Publ.
- Romanoff AL and Romanoff AJ. 1949. *The Avian Egg*. CAB international
- Sim JS and Nakai S. 1994. *Egg Use and Processing Technologies: New Developments*. CAB International.
- Stadelman WJ and Cotterill OJ. 1995. *Egg Science and Technology*, 4th ed. CRC Press.

I. Course Title : **Poultry Economics, Project Formulation and Marketing**

II. Course Code : **PSC 608**

III. Credit Hours : **2+1**

IV. Theory

Unit I (10 Lectures)

Glossary of terms used in poultry economics and projects – Measures of performance efficiency in the broiler, layer, breeder and other poultry species, hatcheries and other poultry-related operations – Production standards and goals for layer, broiler and breeders.

Unit II (12 Lectures)

Planning poultry enterprise – Minimum viable units - Bank norms for poultry projects – Poultry insurance– Methods to improve the production efficiency and reduce the production cost - Components of project reports and preparing projects and return on investment.

Unit III (12 Lectures)

Integration in Poultry production and marketing – Marketing channels for eggs and meat - Cost of production of the egg, broiler, hatching egg, day-old chick and compounded feed –New regulations on cage rearing of layers. Traceability and branding of poultry products. Export norms for poultry products.

V. Practical (17 Classes)

Preparing different poultry projects for bank finance – Calculating the cost of production of various products under various systems-case study – Preparation of Balance sheet, break-even points, Cost: Benefit ratio and other farm economic indices- Preparation of feasibility and viability reports.

IX. Suggested Reading

- Bell DD and Weaver WD, Jr. 2002. *Commercial Chicken Meat and Egg Production*, 5th ed. Kluwer Academic Publishers.
- Narahari D and Asha Rajini R. 2005. *Poultry Economics and Projects*. Pixie Publication India (P) Ltd.

I. Course Title : Physiology of Poultry Production

II. Course Code : PSC 609

III. Credit Hours : 1+1

IV. Theory

Unit I (7 Lectures)

Skeletal system of poultry – Comb pattern and plumage - Physiology of poultry digestive system- Digestion, metabolism and absorption of feed and water – Role of enzymes – Poultry circulatory system – Respiratory system – Physiology of growth.

Unit II (7 Lectures)

Poultry nervous system and its function – Excretory system – Male and female reproductive system - Semen production-semen characteristics- Semen extenders – Egg formation- Egg laying pattern-photo periodic responses – Role of endocrine glands and their functions - Neuroendocrine control of egg production - Ovulation and Oviposition – Clutch and Pause.

Unit III (3 Lectures)

Thermoregulatory mechanism – Stress due to adverse environmental factors – Acid-base balance

V. Practical (17 Classes)

Demonstration of various systems of birds – the structure of feather - Identification of endocrine glands and demonstration of hormones estimation in poultry production and reproduction - Haematology of poultry species - SGOT, SGPT, free fatty acids - Morphology of Poultry spermatozoa. Demonstration of artificial insemination in poultry.

X. Suggested Reading

- Etches RJ. 1995. *Reproduction in Poultry*. CAB International.
- Scanes CG. 2014. *Sturkie's Avian Physiology*. Elsevier.

I. Course Title : Commercial Poultry Nutrition

II. Course Code : PSC 610

III. Credit Hours : 1+1

V. Theory

Unit I (7 Lectures)

Breed specific nutrient requirements. Factors influencing the digestibility of nutrients – Reasons to assist the birds for digestion – Gut health management.

Unit II (4 Lectures)

Commercial use of feed ingredients by the industry – their drawbacks - Use of different feed additives and supplements: Enzymes, prebiotics, probiotics, postbiotics, phytobiotics, nucleotides, acidifiers, emulsifiers, and essential oils, etc. – Trace minerals: organic, inorganic and nanoparticles – Pre-digested proteins.

Unit III (6 Lectures)

Unconventional feed ingredients: Merits and demerits – Measures to counteract the demerits – Responsible use of them for reducing the cost of production – Least cost feed formulation – Phase feeding for layers and broilers – Juvenile nutrition.

VI. Practical (17 Classes)

Analytical methods for quick estimation of proximate principles and other nutrients – Use of latest technologies like NIR – Force-feeding, Challenge feeding – Factors preventing the birds from optimum feeding: Particle size, feed milling technologies, etc.– Seasonal variations in feeding practices, in-ovo feeding, visit to commercial poultry nutrition lab and feed mill.

VII. Suggested Reading

- ICAR. 2013. *Nutrient Requirements of Poultry*. ICAR Publication.
- Leeson S and Summers JD. 2001. *Scott's Nutrition of the Chicken*. University Books.
- Leeson S and Summers JD. 2008. *Commercial Poultry Nutrition*, 3rd ed. University Books.
- Singh RA and Panda B. 1992. *Poultry Nutrition*. Kalyani Publishers.

I. Course Title : Poultry Welfare and Waste Management

II. Course Code : PSC 611

III. Credit Hours : 2+0

IV. Theory

Unit I (14 Lectures)

Concept of poultry welfare – Different freedoms to the birds – Present housing systems with relation to the welfare – Welfare and productivity – Feed restriction – Economics - Welfare cages – Welfare in relation to country's requirement. Precautions and requirements before, during and after transport of birds from one place and another, thermal imaging, assessment of welfare in poultry

Unit II (20 Lectures)

Waste generated from poultry farms and hatcheries – Male chicks disposal - Hazards of waste for humans and environment – Spread of diseases – Fly problems – Leaching of toxic substances in groundwater – Emission of gases – Dust and smell problem – Disposal of carcasses – Means to mitigate the hazardous effects of wastes – Composting of manure and dead birds - Generation of biogas, electricity, rendering plant products for feeding other species – Wastewater recycling – Usage of slurry – Preparation of bio-fuel pellets, methods of recycling poultry feathers.

V. Suggested Reading

- Collins E (Ed.). 1999. *Poultry Waste Management Handbook*. NARES Series 132. Natural Resources.
- DAHD. 2015. *Poultry Farm Manual*. Department of Animal Husbandry, Dairy and Fisheries, GOI.
- Mench JA. 2017. *Advances in Poultry Welfare*. Woodhead Publishing
- Overcash MR, Humenik FJ and Miner RJ. 1983. *Livestock Waste Management*. CRS Press.

Course Title with Credit Load
Ph.D. in Poultry Science

Course Code	Course Title	Credits Hours
PSC 701*	Applied Poultry Nutrition	2+1
PSC 702*	Recent Trends in Commercial Poultry Production	2+1
PSC 703	Developments in Poultry Processing and Products Technology	2+1
PSC 704	Emerging Diseases of Poultry and Health Management	2+1
PSC 705	Applied Poultry Breeding	1+1
PSC 706	Poultry Economics, Marketing and Integration	2+1
PSC 707	Diversified Poultry Production	2+1
PSC 791	Seminar I	1+0
PSC 792	Seminar II	1+0
PSC 799	Research	75

*Core courses

Course Contents
Ph.D. in Poultry Science

I. Course Title : Applied Poultry Nutrition
II. Course Code : PSC 701
III. Credit Hours : 2+1

IV. Theory

Unit I (10 Lectures)

Developments in the nutrient requirement for egg and meat-type chicken - Concepts in various poultry feeding procedures and methods for optimal production - Factors influencing the nutrient requirements, feed intake and feed efficiency in poultry - Nutritional deficiencies - Protein and energy utilization – Digestibility of nutrients – Ileal digestibility of amino acids - Vitamins, minerals and their interactions in poultry rations.

Unit II (10 Lectures)

In ovo - juvenile nutrition for optimal growth rate and feed efficiency – Care in grower and pre-layer feeding - Nutrition and feeding of layers/ breeders during peak egg production - Nutritional requirements for higher egg production, broiler meat production, fertility and hatchability and other special purposes.

Unit III (10 Lectures)

Feeding of broilers for uniform growth and feed efficiency – Feeding to enhance egg quality and nutrients – Nutritive and non- nutritive feed additives in feed production – organic, functional and designer feed. Advances in feed milling technology – Specialty feed production to produce microbial safe foods, SPF eggs and organic foods.

Unit IV (4 Lectures)

HACCP implementation in feed quality control – Production of feed free from antibiotics, mycotoxins and pesticide residues.

V. Practical

Computation of specific and functional feeds – Estimation of available carbohydrate/ Metabolizable energy, Aflatoxin, anti-nutritional factors and other toxins in the feed. Evaluation of various feeds for its quality – Field methods of feed quality control including feed microscopy – Estimation of carotenes, cholesterol and peroxides. Quality control of functional poultry feeds – Maintaining the feed quality from production to consumption.

X. Suggested Reading

- Bell DD and Weaver WD, Jr. 2002. *Commercial Chicken Meat and Egg Production*, 5th ed. Kluwer Academic Publishers.
- ICAR. 2013. *Nutrient Requirements of Poultry*. ICAR Publication.
- Leeson S and Summers JD. 2001. *Scott's Nutrition of the Chicken*. University Books.
- Leeson S and Summers JD. 2008. *Commercial Poultry Nutrition*, 3rd ed. University Books.Nutrient
- Singh RA and Panda B. 1992. *Poultry Production*. Kalyani Publishers.
- *Selected articles from journals.*

I. Course Title : Recent Trends in Commercial Poultry Production

II. Course Code : PSC 702

III. Credit Hours : 2+1

IV. Theory

Unit I (7 Lectures)

Global trends in poultry production - Advances in broiler production in India – concepts in egg production – Latest concepts in breeder management – advances in hatchery operations for higher hatchability and chick quality – Use of artificial intelligence in poultry production.

Unit II (8 Lectures)

Optimal microclimatic condition in poultry houses and cages for higher production – Management of poultry in environmentally controlled houses – Management of poultry under adverse climatic conditions – advances in the management of other species of poultry - Behavioural patterns of poultry in different growing systems.

Unit III (7 Lectures)

Advanced management techniques for egg and meat production - advances in lighting management, feeding management, litter management and manure management.

Unit IV (5 Lectures)

Factors influencing egg production in different species of poultry – Factors influencing growth rate and egg production - Automation in poultry production.

Unit V (7 Lectures)

Regulations for cage-free egg production and organic chicken production – Functional feeds for functional foods – Production of HACCP and GMP certified table eggs, meat, chicks, hatching eggs and other value-added products for export. Advances in Biosecurity, welfare and waste management - Role of integration in poultry production.

V. Practical (17 Classes)

Performance study in the commercial layer, broiler, Japanese quail, duck, turkey and other species of poultry farms by Interpretation of the farm records - Management routines of different species of poultry - calculating the cost of production – Estimation of microclimatic conditions and comparing the productive traits– Modern poultry house and cage design for optimal efficiency and cost reduction.

VI. Suggested Reading

- Bell DD and Weaver WD, Jr. 2002. *Commercial Chicken Meat and Egg Production*, 5th ed. Kluwer Academic Publishers.
- Sreenivasaiah PV. 2006. *Scientific Poultry Production: A Unique Encyclopaedia*. International Book Distributing Co.
- Online sources of equipment manufacturers
- *Selected articles from journals.*

I. Course Title : Developments in Poultry Processing and Products Technology

II. Course Code : PSC 703

III. Credit Hours : 2+1

IV. Theory

Unit I (9 Lectures)

Global trends in egg and poultry processing -Indian scenario of poultry processing industry - Nutrients and Non-nutrient components in regular and value-added poultry products – various measures of egg and meat quality control – advances in value addition to poultry products.

Unit II (12 Lectures)

Concepts in poultry meat and egg preservation – Newer concepts in meat tenderization, canning, dehydration, curing, irradiation, etc. - Modified atmosphere packaging and other packaging techniques – Other processed products - Room temperature preservation of poultry fast foods by multi hurdle technology – Further processing to produce ready to eat products.

Unit III (5 Lectures)

Egg powder production - Egg desugarization - pasteurization – Functional properties of eggs – Industrial uses of eggs – Marketing trends in poultry meat and eggs.

Unit IV (8 Lectures)

Improving the product quality to meet Codex and European standards – Standards for the egg, meat and their products -Production of immunoglobulins, lecithin, lysozyme, sialic acid and other pharmaceutical products from eggs – Sanitary and phytosanitary measures for food safety.

VII. Practical (17 Classes)

Preparation of value-added products suitable for preservation at room temperature– Further processing – Barbecuing and Tandoori preparation – preparation of local specific poultry meat and egg products – Meatballs, meat patties, etc. - Quality estimation of egg, meat and their products - Preservation of meat and eggs - Measuring the microbial quality of poultry foods.

VIII. Suggested Reading

- Biswas A and Kondaiah N. 2014. *Meat Science and Technology*. Jaya Publishing House.
- Mead G. 2004. *Poultry Meat Processing and Quality*. Elsevier.
- Mountney GJ and Parkhairst CR. 1995. *Poultry Products Technology*, 3rd ed. AVI Publ.
- Owens CM. 2010. *Poultry Meat Processing*. CRC Press.
- Stadelman WJ and Cotteril OJ. 1995. *Egg Science and Technology*, 4th ed. CRC Press.
- *Selected articles from journals.*

I. Course Title : Emerging and Reemerging Diseases of Poultry and Health Management

II. Course Code : PSC 704

III. Credit Hours : 2+1

IV. Theory

Unit I (6 Lectures)

Concepts of disease prevention in poultry – Emerging and re-emerging avian diseases -Factors influencing immunosuppression/ immunity – Enhancing immunity in poultry.

Unit II (10 Lectures)

Water sanitation, hatchery sanitation procedures - Control of vertically transmissible diseases, hatchery borne diseases – non-infectious, metabolic and parasitic diseases in poultry and their control –Mycotoxins and their control.

Unit III (12 Lectures)

Stress alleviation – prevention and control of bacterial and viral diseases in poultry – Biosecurity measures – Control measures of problematic re-emerging diseases of poultry like Ranikhet, Avian influenza, Marek's disease, Infectious bursal disease, Infectious Bronchitis, Infectious laryngotracheitis, etc.

Unit IV (6 Lectures)

Flock management for Specific pathogen-free egg production – Maintaining the HACCP standards in poultry farms – developments in the EXIM policies for flock health – Concept of compartmentalization and zoning as per terrestrial code., geographical information system in disease control.

V. Practical (17 Classes)

Studying the Immune status of birds – Egg inoculation techniques in laboratory diagnosis – differential diagnosis of various poultry diseases by post-mortem, and laboratory techniques – Molecular diagnosis of diseases - Antibiotic sensitivity test – Designing Vaccination schedule for different poultry species – Disinfection and sanitation - Ectoparasite control, medication procedures.

VI. Suggested Reading

- Davison F, Kaspers B and Schat KA. 2008. *Avian Immunology*. Elsevier
- Pattison M, McMullin P, Bradbury JM and Alexander D. 2008. *Poultry Diseases*, 6th ed. Elsevier.
- Thyagarajan D. 2011. *Diseases of Poultry*. Satish Serial Publishing House.
- Vegad JL. 2015. *Poultry Diseases Farmers. A Guide for Farmers and Poultry Professionals.* International Book Distributing Co.
- *Selected articles from journals.*

I. Course Title : Applied Poultry Breeding

II. Course Code : PSC 705

III. Credit Hours : 1+1

IV. Theory

Unit I (7 Lectures)

Gene and genotypic frequency - Sex-linked, limited and influenced traits-Auto sexing- Qualitative and quantitative traits and its inheritance in poultry- methods of selection – family selection – selection for multi characteristics and construction of selection indices –Reciprocal recurrent selection – Recurrent selection, Marker assisted selection – Random bred control populations - Selection limit - Osborne's index – construction of selection index for multiple traits - Use of molecular genetics in poultry breeding.

Unit II (5 Lectures)

Exploitation of additive and non-additive gene action for commercial poultry production - Heterosis – Exploitation of hybrid vigour for commercial production of layers and broilers - Formation of synthetic lines – Development of strains in poultry - Comparative efficiency of different selection methods in poultry.

Unit III (5 Lectures)

Modern methods in commercial layer and broiler breeding, performance testing – Pure line-breeding – Inbreeding and hybridization - Diallele mating. Pedigree hatching. Genotype × Environment interaction.

V. Practical (17 Classes)

Construction of selection index – Analysis of breeding data collected from breeding records – Estimation of qualitative and quantitative inheritance - Estimation of variance, heritability and standard error of heritability by different methods – Repeatability - analysis of heritability for different traits – Estimation of inbreeding coefficient – Artificial insemination in poultry.

VI. Suggested Reading

- Crawford RD. 1990. *Poultry Breeding and Genetics*. Elsevier.
- Muir WM and Aggrey SE. 2003. *Poultry Genetics, Breeding and Biotechnology*. CAB International.
- Singh R and Kumar J. 1994. *Biometrical Methods in Poultry Breeding*. Kalyani Publishers.
- *Selected articles from journals.*

I. Course Title : Poultry Economics, Marketing and Integration

II. Course Code : PSC 706

III. Credit Hours : 2+1

IV. Theory

Unit I (11 Lectures)

Present practices and future trends in the production of egg and meat – Present trends in consumption – Demand and supply - Seasonal variations in production and consumption. Marketing channels- procedures of marketing for eggs and meat - Market intelligence -Advertising and branding of poultry products.

Unit II (14 Lectures)

Various poultry enterprises – choice of production size of business – input and output analysis – calculating cost of various inputs – calculating cost of production – Break-even point analysis - Price determination – Role of NECC, BroMark and other marketing agencies - Least demand and supply indices of performance – Performance targets and achievements - marketing and business management - market managerial skills and human resource development - cost and financial management.

Unit III (9 Lectures)

Future trends in broiler and egg production – Factors influencing the profit margin in poultry enterprises – Role of integration in Poultry business – Different types of integration.

V. Practical (17 Classes)

Study of marketing channels of egg and meat, calculating the cost of production of eggs, meat, day-old chick and feed – Calculating marketing costs - Preparing other related poultry projects. Use of social media in popularizing poultry and poultry products – Study of successful business models in the poultry sector.

VI. Suggested Reading

- Narahari D and Asha Rajini R. 2005. *Poultry Economics and Projects*. PIXIE Publications India (P) Ltd.
- Vashisht K. 2006. *Practical Approach to Marketing Management*. Atlantic.
- Online sources of NABARD website4. *Selected articles from journals*.

I. Course Title : Diversified Poultry Production
II. Course Code : PSC 707
III. Credit Hours : 2+1
IV. Theory

Unit I (9 Lectures)

Commercial hybrid strains of ducks for egg and meat production – Feeding and management – Housing – Specific diseases of ducks, prevention and their control
– Slaughter and processing of ducks – Economics of production of ducks, indigenous duck production system including polythene duck pond.

Unit II (8 Lectures)

Varieties of Japanese quail for meat and egg production – Cage and deep litter system of rearing of quails – Feeding and management – Housing – Emerging diseases affecting Japanese quail – Nutritive value of Japanese quail meat and egg - Economics of production of Japanese quail.

Unit III (9 Lectures)

Varieties/ breeds of Turkey, Guinea fowl, Geese, Emu and Ostriches – System of rearing – Feeding and management – Housing – Emerging diseases and theirprevention – Nutritive value of Turkey, Geese and Guinea fowl – By-products of Geese, Emu and Ostriches.

Unit IV (8 Lectures)

Scope and constraints in the marketing of diversified poultry products – Rearing and management of common pet birds and other birds of regional importance – Common diseases affecting pet birds and their prevention and treatment - Economics of production of different pet birds.

Practical (17 Classes)

Layout and design of housing for other species of poultry. Visit commercial Japanese quail, turkey and duck farms. Incubation and care of hatching eggs and young ones– Rearing practices followed for duck, quails and turkey farmers under field conditions – Designing of aviaries for pet birds - Different types of feed prepared for pet birds – Vaccination and medication for diversified poultry species - Preparing project reports for different species and calculating the cost of production.

Suggested Reading

- Cherry P and Morris T. 2011. *Domestic Duck Production: Science and Practice*. CABInternational.
- CPDO. *Duck – Management Guide*. Central Poultry Development Organization Publication (online resource)
- CPDO. *Turkey – Management Guide*. Central Poultry Development Organization Publication(online resource)
- Pathak N. 2013. *Poultry and Ratite Nutrition*. Narendra Publishing House.
- Thiyagarajan D. 2012. *Scientific Turkey Farming*. SSPH, New Delhi.

VOL. 6

Azadi Ka Amrit Mahotsav

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- Community Science

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12. Definitions of academic terms

1. Academic Year and Registration

- An academic year shall be normally from July to June of the following calendar year otherwise required under special situations. It shall be divided into two academic terms known as semesters. Dates of registration, commencement of instructions, semester end eXamination, end of semester and academic year, etc. The Academic Calendar shall be developed by the concerned University from time to time and notified accordingly by the Registrar in advance.
- An orientation programme shall be organized by the Director (Education)/ Dean PGS for the benefit of the newly admitted students immediately after commencement of the semester.
- On successful completion of a semester, the continuing students shall register for subsequent semester on the date specified in the Academic/ Semester Calendar or specifically notified separately. Every enrolled student shall be required to register at the beginning of each semester till the completion of his/ her degree programmes.

2. Credit requirements

Framework of the courses

The following nomenclature and Credit Hrs need to be followed while providing the syllabus for all the disciplines:

	Masters' Programme	Doctoral Programme
(i) Course work		
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	–
Seminar	01	02
(ii) Thesis Research	30	75
Total	70	100

Major courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken may be given *mark

Minor courses: From the subjects closely related to a student's major subject

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overallcompetence.

Common Courses: The following courses (one credit each) will be offered to all students undergoing Master's degree programme:

1. Library and Information Services
2. Technical Writing and Communications Skills
3. Intellectual Property and its management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approval of the Head of Department (HoD)/ Board of Studies (BoS).

Supporting Courses

The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. If required, the contents may be modified to suit the individual discipline with approval of the concerned BoS:

Code	Course Title	Credit Hours
STAT 501	Mathematics for Applied Sciences	2+0
STAT 502	Statistical Methods for Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 512	Basic Sampling Techniques	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1

Course Code	Course Title	Credit Hours
MCA 501	Computers Fundamentals and Programming	2+1
MCA 502	Computer Organization and Architecture	2+0
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques in Biochemistry	2+2

Syllabus of Common Courses for PG programmes

LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

To equip the students/ scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
- Writing of abstracts, summaries, précis, citations, etc.;
- Commonly used abbreviations in the theses and research communications;
- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading;
- Writing of a review article;
- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);

- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- Accentual pattern: Weak forms in connected speech;
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

Suggested Readings

1. Barnes and Noble. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language.*
2. *Chicago Manual of Style*. 14th Ed. 1996. Prentice Hall of India.
3. *Collins' Cobuild English Dictionary*. 1995.
4. Harper Collins. Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed.
5. Holt, Rinehart and Winston. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.
6. James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
7. Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
8. Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
9. Richard WS. 1969. *Technical Writing*.
10. Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
11. Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

1. Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
2. Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
3. *Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC and Aesthetic Technologies.

4. Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
6. Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralisation of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taXonomy.

Suggested Readings

1. Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
2. Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional

Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS and Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.
2. Punia MS. *Manual on International Research and Research Ethics*. CCS Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.
4. Singh K. 1998. *Rural Development - Principles, Policies and Management*. Sage Publ.

Mandatory requirement of seminars

- It has been agreed to have mandatory seminars one in Masters (One Credit) and two in Doctoral programmes (two Credits).
- The students should be encouraged to make presentations on the latestdevelopments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills.

3. Residential requirements

- The minimum and maximum duration of residential requirement for Masters' Degree and Ph.D. Programmes shall be as follows:

P.G. Degree Programmes	Duration of Residential Requirement	
	Minimum	Maximum
Masters' Degree	2 Academic Years (4 Semesters)	5 Academic Years (10 Semesters)
Ph.D.*	3 Academic Years (6 Semesters)	7 Academic Years (14 Semesters)

*Student may be allowed to discontinue temporarily only after completion of course work

In case a student fails to complete the degree programme within the maximum duration of residential requirement, his/ her admission shall stand cancelled. The requirement shall be treated as satisfactory in the cases in which a student submits his/ her thesis any time during the 4th and 6th semester of his/ her residentship at the University for Masters' and Ph.D. programme, respectively.

4. Evaluation of course work and comprehensive examination

- For M.Sc., multiple levels of evaluation (First Test, Midterm and Final semester) is desirable. However, it has been felt that the comprehensive examination is redundant for M.Sc. students.
- For Ph.D., the approach should be research oriented rather than exam oriented. In order to provide the student adequate time to concentrate on the research work and complete the degree in stipulated time, the examination may have to be only semester final. However, the course teacher may be given freedom to evaluate in terms of assignment/ seminar/ first test.
- For Ph.D., the comprehensive examination (Pre-qualifying examination) is required. As the students are already tested in course examinations, the comprehensive examinationshould be based onoral examinationby an external expert and the evaluation should cover both the research problem and theoretical background to execute the project. This shall assess the aptitude of the student and suitability of the student for the given research topic. The successful completion of comprehensive examination is to obtain the "Satisfactory" remark by the external expert.

5. Advisory System

Advisory Committee

- There shall be an Advisory Committee for every student consisting of not fewer than three members in the case of a candidate for Masters' degree and four in the case of Ph.D. degree with the Advisor as Chairperson. The Advisory Committee should have representatives from the major and minor fields amongst the members of the Post-graduate faculty accredited for appropriate P.G. level research. However, in those departments where qualified staff exists but due to unavoidable reasons Post-graduate degree programmes are not existing, the staff having Post-graduate teaching experience of two years or more may be included in the Advisory Committee as member representing the minor.
- At any given time, a P.G. teacher shall not be a Chairperson, Advisory Committee (including Master's and Ph.D. programmes) for more than five students.
- The Advisor should convene a meeting of the Advisory Committee at least once in a Semester. The summary record should be communicated to the Head of Department, Dean of the College of concerned, Director (Education)/ Dean PGS and Registrar for information.

Advisor/ Co-guide/ Member, Advisory Committee from other collaborating University/ Institute/ Organization

- In order to promote quality Post-graduate research and training in cutting edge areas, the University may enter into Memorandum of Understanding (MOU) with other Universities/ Institutions for conducting research. While constituting an Advisory Committee of a student, if the Chairperson, Advisory Committee feels the requirement of involving of a faculty member/ scientist of such partnering university/ Institute/ Organization, he/ she may send a proposal to this effect to Director (Education)/ Dean PGS along with the proposal for consideration of Student's Advisory Committee (SAC).
- The proposed faculty member from the partnering institution can be allowed to act as Chairperson/ Co-guide/ Member, SAC, by mutual consent, primarily on the basis of intellectual input and time devoted for carrying out the research work at the particular institution. The faculty member/ scientist of partnering institutions in the SAC shall become a temporary faculty member of the University by following the procedure approved by the Academic Council.

Allotment of students to the retiring persons

Normally, retiring person may not be allotted M. Sc. Student if he/ she is left with less than 2 years of service and Ph.D. student if left with less than 3 years of service. However, in special circumstances, permission may be obtained from the Director (Education)/ Dean PGS, after due recommendation by the concerned Head of the Department.

Changes in the Advisory Committee:

(i) Change of the Chairperson or any member of the Advisory Committee is not ordinarily permissible. However, in exceptional cases, the change may be effected with due approval of the Director of Education/ Dean PGS.

(ii) Normally, staff members of the university on extra ordinary leave or on study leave or who leave the University service will cease to continue to serve as advisors of the Post-graduate students of the University. However, the Director (Education)/ Dean PGS may permit them to continue to serve as advisor subject to the following conditions:
   (a) The concerned staff member must be resident in India and if he/ she agrees to guide research and must be available for occasional consultations;
   (b) An application is made by the student concerned duly supported by the Advisory Committee;
   (c) In case of a Ph.D. student, he/ she must have completed his/ her comprehensive examinations and the research work must be well in progress and it is expected that the student will submit the thesis within a year;
   (d) The Head of the Department and the Dean of the College concerned agree to the proposal;
   (e) The staff member, after leaving the University service is granted the status of honorary faculty's membership by the Vice-Chancellor on the recommendation of the Director (Education)/ Dean PGS for guiding as Chairperson or Member, Advisory Committee the thesis/ theses of the student(s) concerned only.

(iii) In case the Chairperson/ member of a Student's Advisory Committee retires, he/ she shall be allowed to continue provided that the student has completed his course work and minimum of 10 research credits and the retiring Chairperson/ member stays at the Headquarters of the College, till the thesis is submitted.

(iv) If the Chairperson/ member proceeds on deputation to another organization, he/ she may be permitted to guide the student provided his/ her new organization is at the Headquarters of the College and his/ her organization is willing for the same.

(v) The change shall be communicated to all concerned by the Head of Department.

6. Evaluation of research work

- It is highly desirablefor Ph.D. programme and this should be done annually as an essential part of research evaluation. The Student Advisory Committee shallreview the progress of research and scrutinize annual progress reports submitted by the student.
- Midterm evaluation of Ph.D. (to move from JRF to SRF) is a mandatory requirement for all the funding agencies. Hence, the second review of annual progress report need to be done after completion of two years. The successful completion enables the students to become eligible for SRF.

Prevention of plagiarism

- An institutional mechanism should be in place to check the plagiarism. The students must be made aware that manipulation of the data/ plagiarism is punishable with

serious consequences.

7. Learning through online courses

- In line with the suggestion in new education policy and the initiatives taken by ICAR and MHRD in the form of e-courses, MOOCs, SWAYAM, etc. and also changes taking place globally in respect of learning through online resources it has been agreed to permit the students to enrol for online courses. It is expected that the provision of integrating available online courses with the traditional system of education would provide the students opportunities to improve their employability by imbibing the additional skills and competitive edge.

The Committee recommends the following points while integrating the online courses:

1. Board of Studies (BoS) of each Faculty shall identify available online courses and a student may select from the listed courses. The interested students may provide the details of the on-line courses to the BoS for its consideration.
2. A Postgraduate student may take up to a maximum of 20% credits in a semester through online learning resources.
3. The host institute offering the course does the evaluation and provide marks/ grades. The BoS shall develop the conversion formula for calculation of GPA and it may do appropriate checks on delivery methods and do additional evaluations, if needed.

8. Internship during Masters programme

Internship for Development of Entrepreneurship in Agriculture (IDEA)

Currently, a provision of 30 credits for dissertation work in M.Sc./ M.Tech/ M.F.Sc./ M.V.Sc. programmes helps practically only those students who aspire to pursue their career in academic/ research. There is hardly any opportunity/ provision under this system to enhance the entrepreneurship skills of those students who could start their own enterprise or have adequate skills to join the industry. Therefore, in order to overcome this gap, an optional internship/ in-plant training (called as IDEA) in lieu of thesis/ research work is recommended which will give the students an opportunity to have a real-time hands-on experience in the industry.

It is envisaged that the internship/ in-plant training would enhance the interactions between academic organizations and the relevant industry. It would not only enable the development of highly learned and skilled manpower to start their-own enterprises but also the industry would also be benefitted through this process. This pragmatic approach would definitely result in enhancedpartnerships between academia and industry.

The main objectives of the programme:

1. To promote the linkages between academia and industry
2. To establish newer University – Cooperative R&D together with industry for knowledge creation, research and commercialization
3. Collaboration between Universities and industries through pilot projects
4. To develop methods for knowledge transfer, innovation and networking potential
5. To enhance skill, career development and employability

Following criteria for IDEA will be taken into consideration:

- At any point of time there will not be more than 50% of students who can opt under IDEA
- Major Advisor will be from Academia and Co-advisor (or Advisory Committee member) from industry
- Total credits (30) will be divided into 20 for internship/ in-plant training and10 for writing the report followed by viva-voce similar to dissertation

- Work place will be industry; however, academic/ research support would be provided by the University or both. MoU may be developed accordingly
- The IPR, if any, would be as per the University policy

9. Teaching assistantship

- Teaching assistantship shall be encouraged. This will give the required experience to the students on how to conduct courses, practical classes, evaluation and other related academic matters. This is an important part of Ph.D. training all over the world and it is expected to address the shortage of faculty in many institutions/ universities.
- The fulltime doctoral students of the University with or without fellowship may be considered for award of Teaching Assistantships in their respective Departments. The Teaching Assistantship shall be offered only to those doctoral students who have successfully finished their course work. Any consideration for award of Teaching Assistantships must have the consent ofthe supervisor concerned.
- Teaching Assistantships shall be awarded on semester to semester basis on the recommendation of a screening/ selection committee to be constituted by the Vice Chancellor. All classes and assignments given to the Teaching Assistants, including tutorials, practicals and evaluation work shall be under the supervision of a faculty member who would have otherwise handled the course/ assignment.
- Each Ph.D. student may be allowed to take a maximum of 16 classes in a month to UG/ Masters students.
- No additional remuneration shall be paid to the students who are awarded ICAR JRF/ SRF. The amount of fellowship to be paid as remuneration to other students (who are receiving any other fellowship or without any fellowships) may be decided by the concerned universities as per the rules in force.However, the total amount of remuneration/ and fellowship shall not exceed the amount being paid as JRF/ SRF of ICAR.
- At the end of each term, Teaching Assistants shall be given a certificate by the concerned Head of the Department, countersigned by the School Dean, specifying the nature and load of assignments completed.

10. Registration of project personnel (SRF/ RA) for Ph.D.

- A provision may be made to enable the project personnel (SRF/ RA) to register for Ph.D. However, this can be done only if they are selected based on some selection process such as walk-in-interview. The prior approval of PI of the project is mandatory to consider the application of project personnel (SRF/ RA) for Ph.D. admission
- The candidates need to submit the declaration stating that the project work shall not be compromised because of Ph.D. programme. Further, in order to justify the project work and Ph.D. programme, the number of course credits should not be more than 8 in a semester for the project personnel (SRF/ RA) who intend to register for Ph.D.

11. Compliance with the National Education Policy-2020

- While implementing the course structure and contents recommended by the BSMA Committees, the Higher Education Institutions (HEIs) are required to comply with the provisions of National Education Policy-2020, especially the following aspects:
- Given the 21st century requirements, quality higher education must aim to develop good, thoughtful, well-rounded, and creative individuals. It must enable an individual to study one or more specialized areas of interest at a deep level, and also develop character, ethical and Constitutional values, intellectual curiosity, scientific temper, creativity, spirit of service, and 21st century capabilities across

a range of disciplines including sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects. A quality higher education must enable personal accomplishment and enlightenment, constructive public engagement, and productive contribution to the society. It must prepare students for more meaningful and satisfying lives and work roles and enable economic independence (9.1.1. of NEP-2020).

- At the societal level, higher education must enable the development of an enlightened, socially conscious, knowledgeable, and skilled nation that can find and implement robust solutions to its own problems. Higher education must form the basis for knowledge creation and innovation thereby contributing to a growing national economy. The purpose of quality higher education is, therefore, more than the creation of greater opportunities for individual employment. It represents the key to more vibrant, socially engaged, cooperative communities and a happier, cohesive, cultured, productive, innovative, progressive, and prosperous nation (9.1.3. of NEP-2020).
- FleXibility in curriculum and novel and engaging course options will be on offer to students, in addition to rigorous specialization in a subject or subjects. This will be encouraged by increased faculty and institutional autonomy in setting curricula. Pedagogy will have an increased emphasis on communication, discussion, debate, research, and opportunities for cross-disciplinary and interdisciplinary thinking (11.6 of NEP-2020).
- As part of a holistic education, students at all HEIs will be provided with opportunities for internships with local industry, businesses, artists, crafts persons, etc., as well as research internships with faculty and researchers at their own or other HEIs/ research institutions, so that students may actively engage with the practical side of their learning and, as a by-product, further improve their employability (11.8 of NEP-2020).
- HEIs will focus on research and innovation by setting up start-up incubation centres; technology development centres; centres in frontier areas of research; greater industry-academic linkages; and interdisciplinary research including humanities and social sciences research (11.12. of NEP-2020).
- Effective learning requires a comprehensive approach that involves appropriate curriculum, engaging pedagogy, continuous formative assessment, and adequate student support. The curriculum must be interesting and relevant, and updated regularly to align with the latest knowledge requirements and to meet specified learning outcomes. High-quality pedagogy is then necessary to successfully impart the curricular material to students; pedagogical practices determine the learning eXperiences that are provided to students, thus directly influencing learning outcomes. The assessment methods must be scientific, designed to continuously improve learning and test the application of knowledge. Last but not least, the development of capacities that promote student wellness such as fitness, good health, psycho-social well-being, and sound ethical grounding are also critical for high-quality learning (12.1. of NEP-2020).

Definitions of Academic Terms

Chairperson means a teacher of the major discipline proposed by the Head of Department through the Dean of the College and duly approved by the Director of Education/ Dean Post Graduate Studies (or as per the procedure laid down in the concerned University regulations) to act as the Chairperson of the Advisory Committee and also to guide the student on academic issues.

Course means a unit of instruction in a discipline carrying a specific number and credits to be covered in a semester as laid down in detail in the syllabus of a degree programme.

Credit means the unit of work load per week for a particular course in theory and/ or practical. One credit of theory means one class of one clock hour duration and one credit practical means one class of minimum two clock hoursof laboratory work per week.

Credit load of a student refers to the total number of credits of all the courses he/ she registers during a particular semester.

Grade Point (GP) of a course is a measure of performance. It is obtained by dividing the per cent mark secured by a student in a particular course by 10, eXpressed and rounded off to second decimal place.

Credit Point (CP) refers to the Grade point multiplied by the number of credits of the course, eXpressed and rounded off to second decimal place.

Grade Point Average (GPA) means the total credit point earned by a student divided by total number of credits of all the courses registered in a semester, eXpressed and rounded off to second decimal place.

Cumulative Grade Point Average (CGPA) means the total credit points earned by a student divided by the total number of credits registered by the student until the end of a semester (all completed semesters), eXpressed and rounded off to second decimal place.

Overall Grade Point Average (OGPA) means the total credit points earned by a student in the entire degree programme divided by the total number of credits required for the P.G. degree, eXpressed and rounded off to second decimal place.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 6

Community Science
– Apparel and Textile Science

Modifications Suggested in Courses in the Revised Curricula

M.Sc. (Community Science) Apparel and Textile Science

Course Code	Course Title	Credit Hours	Remarks
	Core Courses (20 Credits)		
*ATS 501	Textile Chemistry	3(2+1)	Content updated
*ATS 502	Textile and Apparel Quality Analysis	3(2+1)	Two courses Merged
*ATS 503	Pattern Making and Draping	3(1+2)	Two courses Merged
*ATS 504	Woven Textile Design	3(2+1)	Content Modified
ATS 505	Wet Processing of Textiles	3(2+1)	Title changed
ATS 506	Computer Aided Textile and Apparel Designing	2(0+2)	
ATS 507	Textile and Apparel Industrial Management	3(3+0)	Content Modified
ATS 508	Historic Textiles and Costumes	2(1+1)	Content Modified
ATS 509	Textile Auxiliaries	3(2+1)	
ATS 510	Socio Psychological Aspects of Clothing	2(2+0)	
ATS 511	Sustainability in Textile and Apparel Industry	2(2+0)	New course
ATS 512	Textile and Apparel Product Development	2(1+1)	New course
ATS 513	Laboratory Techniques in Textile Research	2(0+2)	New course
ATS 514	Special Project	1(0+1)	
	Minor Courses (08 Credits)		
FN 505	Nutrition and Physical fitness	3(2+1)	Minor Courses
FN 509	Food safety and Standards	3(2+1)	may be selected
FN 513	Human Physiology	3(3+0)	from subjects
EECM 502	Development communication	3(2+1)	closely related to a
EECM 505	Dynamic communication skills	2(0+2)	student's major
EECM 507	Organisational development and HRD	2(1+1)	subject. Apart from these
EECM511	Climate change management	2(1+1)	courses, a student
HDFS 503	Methods and techniques of assessment in human development	3(2+1)	can register any course offered by

Course Code	Course Title	Credit Hours	Remarks
HDFS 506	Management of differently abled	3(2+1)	any other department
	Supporting Courses (06 Credits)		
	Research Methodology	3(2+1)	Course numbers will be assigned by the departments that offer these courses.
	Statistical methods and application	3(2+1)	
	Common Courses (05 Credits)		
	Library and Information Services	1(0+1)	Common to all disciplines. The course numbers will be assigned by the departments that offer these courses
	Technical Writing and Communications Skills	1(0+1)	
	Intellectual Property and its management in Agriculture	1(0+1)	
	Basic Concepts in Laboratory Techniques	1(0+1)	
	Agricultural Research, Research Ethics and Rural Development Programmes	1(0+1)	
ATS 591	Seminar	1(1+0)	
ATS 599	**Thesis/ Research**	**30**	Increased credits for Research
	Total	**70**	

*Core courses/ compulsory courses

Ph.D. (Community Science) Apparel and Textile Science

Course Code	Course Title	Credit Hours	Remarks
	Major Courses (12 Credits)		
*ATS 601	Textile Ecology	2(2+0)	
*ATS 602	Technical Textiles	3(2+1)	Modified
ATS 603	Technological Developments in Textiles and Apparel	2(2+0)	
ATS 604	Colour Application in Textiles	2(1+1)	Content updated
*ATS 605	Functional Clothing	3(2+1)	

Course Code	Course Title	Credit Hours	Remarks
ATS 606	Textile Conservation	2(1+1)	Modified
ATS 607	Operational Management in Textiles and Apparel	2(2+0)	New
ATS 608	Technology of Nonwovens	2(2+0)	
ATS 609	Special Project	2(0+2)	
	Minor Courses (06 Credits)		
CS/PGS 601	Research and Publication Ethics	2(1+1)	Minor Courses
FN604	Global Nutrition Problems	2(2+0)	may be selected
FN 608	Energy Metabolism	2(2+0)	from subjects
EECM 602	Impact Assessment of Development Programmes	3(1+2)	closely related to a student's major
EECM 603	Scaling Techniques for Behavioural Research	3(1+2)	subject. Apart from these
EECM 607	Media application and product promotion	4(2+2)	courses, a student can register any
HDFS 608	Qualitative research methods	3(2+1)	course offered by
RMCS 603	Globalization and Consumer Economics	3 (2+1)	any other department
RMCS 606	Environmental Issues and Challenges	2 (2+0)	
RMCS 607	Family Dynamics and Women Power	3 (2+1)	
Supporting Courses (05 Credits)			
A student can opt any course related to the topic of research offered by other faculties of agriculture university or SWAYAM portal or other online courses up to a maximum of 5 credits.			
ATS 691	Doctoral Seminar I (Major Field)	1(1+0)	
ATS 692	Doctoral Seminar II (Minor Field)	1(1+0)	
ATS 699	**Research**	**75**	Increased credits for Research
	Total	**100 Credits**	

*Core courses/ compulsory courses

Course Title with Credit Load
M.Sc. in Apparel and Textile Science

Course Code	Course Title	Credit Hours	Semester (I/II)
	Major Courses (20 Credits)		
*ATS 501	Textile Chemistry	3(2+1)	
*ATS 502	Textile and Apparel Quality Analysis	3(2+1)	
*ATS 503	Pattern Making and Draping	3(1+2)	
*ATS 504	Woven Textile Design	3(2+1)	
ATS 505	Wet Processing of Textiles	3(2+1)	
ATS 506	Computer Aided Textile and Apparel Designing	2(0+2)	
ATS 507	Textile and Apparel Industrial Management	3(3+0)	
ATS 508	Historic Textiles and Costumes	2(1+1)	
ATS 509	Textile Auxiliaries	3(2+1)	
ATS 510	Socio Psychological Aspects of Clothing	2(2+0)	
ATS 511	Sustainability in Textile and Apparel Industry	2(2+0)	
ATS 512	Textile and Apparel Product Development	2(1+1)	
ATS 513	Laboratory Techniques in Textile Research	2(0+2)	
ATS 514	Special Project	1(0+1)	
	Minor Courses (08 Credits)**		
FN 505	Nutrition and Physical fitness	3(2+1)	
FN 509	Food safety and Standards	3(2+1)	
FN 513	Human Physiology	3(3+0)	
EECM 502	Development communication	3(2+1)	
EECM 505	Dynamic communication skills	2(0+2)	
EECM 507	Organisational development and HRD	2(1+1)	
EECM511	Climate change management	2(1+1)	
HDFS 503	Methods and techniques of assessment in human development	3(2+1)	
HDFS 506	Management of differently abled	3(2+1)	
	Supporting Courses (06 Credits)		
	Research Methodology	3(2+1)	
	Statistical methods and application	3(2+1)	
	Common Courses (05 Credits)		
	Library and Information Services	1(0+1)	
	Technical Writing and Communications Skills	1(0+1)	
	Intellectual Property and its management in Agriculture	1(0+1)	

Course Code	CourseTitle	Credit Hours	Semester
	Basic Concepts in Laboratory Techniques	1(0+1)	
	Agricultural Research, Research Ethics and Rural Development Programmes	1(0+1)	
ATS 591	Seminar	1(1+0)	
ATS 599	Thesis/ Research	30	
	Total	70	

*Core courses/ compulsory courses; **Apart from the courses listed under minor courses, the student may opt courses from any other department related to the research undertaken.

Course Contents
M.Sc. in Apparel and Textile Science

I. Course Title : Textile Chemistry

II. Course Code : ATS 501

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: Chemistry of polymers

Polymerization- types, degree and characteristics; Structure of textile fibres- molecular bonding, length, orientation; Requirements of fibre forming polymers; Bi-component and Bi-constituent fibres- types, characteristics, application and spinning (fibre forming systems)

Unit II: Structure-property relations of natural fibres

Repeating units, bonds, reactive groups; Reactions of cotton, linen, jute, silk, wool, and minor natural fibres to, heat, light, various chemicals and microorganisms.

Unit III: Structure-property relations of Man-made and Synthetic fibres

Repeating units, bonds, reactive groups and reactions of viscose rayon, modal (HWM), polyester, nylon, acrylic, spandex to heat, light, various chemicals and microorganisms; Fibre Blending- principles, types and scope.

Unit IV: Introduction to high performance fibres

Aramid, Ultra-High Molecular Weight Polyethylene (UHMWPE), High Density Polyethylene (HDPE), Carbon, Fibres with Limited Oxygen Index (LOI), Glass and Special fibres.

V. Practicals

- Preparation of chemical solutions for fibre testing.
- Fibre testing – Natural fibres- cross sectional view of cotton, Jute, Linen, Wool and Silk.
- Cross sectional view of Man-made fibres – Viscose, polyester, acrylic and minor fibres.
- Effect of heat on cellulosic, protein and synthetic fibres.
- Effect of dilute and conc acids on cellulosic, protein and synthetic fibres.
- Effect of dilute and conc alkali on cellulosic, protein and synthetic fibres.
- Detection of acid damage on Cotton.
- Mercerization of cotton fibres and yarns- with and without tension.
- Effect of bleaching on textile fibres – Detection of damage due to over bleaching.
- Effect of finishing agents and solvents on cellulosic, protein and synthetic fibres.
- Detection of damage to cellulosic and protein fibres by acids and alkalies.
- Quantitative analysis of binary fibre blends.
- Conditioning and estimation of fibre blend ratio.
- Quantitative analysis of tertiary fibre blends.
- Conditioning and estimation of fibre blend ratio.
- End term Assessment.

VI. Suggested Reading

- Andrea Wynne. 1997. *Textiles*. Macmillian, USA
- Bernard P Corbman. 1983. *Textiles - Fiber to Fabric*. McGraw-Hill, USA
- Kathryn L Hatch 2014. *Textile Science*, West Pub, USA

- Lyle DS. 1976. *Modern Textiles*. John Wiley & Sons, UK
- Marjory L. Joseph. 1966. *Introductory Textile Science*. Rinehart & Winston, UK
- Mather RR, Wardman RH. 2011. *The Chemistry of Textile Fibres*. Royal Society of Chemitry, Cambridge.
- Needles HL. 2001. Textile Fibres, Dyes, Finishes and Processes. Standard Publishers Distributors, Delhi.
- Vilensky G. 1987. *Textile Science*. CBS, India
- Wingate IB. 1984. *The Fabrics - Their Selection*. Prentice Hall, USA
- Journal of Applied Polymer Science
  https://onlinelibrary.wiley.com/journal/10974628
- Journal of Textile Science & Engineering
  https://www.omicsonline.org/textile-science-engineering.php

I. Course Title : Textile and Apparel Quality Analysis

II. Course Code : ATS 502

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Quality analysis and control

Importance of quality analysis and control; Effect of moisture and humidity on properties of textiles; Standard conditions of testing; Sampling – methods and techniques for fibre, yarn and fabric

Unit II: Fibre and yarn testing

Fibre testing - length, linear density, maturity and strength; Yarn testing – yarncount, single and lea strength, twist, crimp and evenness.

Unit III: Fabric testing

Fabric testing – Geometrical properties - thread count, weight, thickness, strength - breaking, tearing and bursting; Abrasion resistance, pilling, crease recovery, stiffness, drapability, air permeability, thermal properties, flammability, water absorbency and repellency, dimensional stability, colour fastness; Comfort and fabric handle measurement.

Unit IV: Apparel quality Control

Yarn and fabric defects; Preliminary inspection- Quality specifications and standards in raw material purchasing – fabric and accessories; In-process inspection - Quality control in spreading, cutting and bundling products; Quality factors in sewing, pressing, folding and finishing; Quality aspects of trims and accessories; Tolerance limits for garment dimensions; Final inspection – general garment defects; Procedure for quality checking and reporting.

Unit V: National and international organizations for standards

National and international organizations for standards – BIS and other global standards; Quality auditing system – process and product audit, internal quality audit procedure.

V. Practicals

1. Sampling techniques of fibre, yarn and fabric.
2. Testing of fibre – length, maturity and linear density.
3. Yarn Testing – count, twist, crimp and evenness
4. Fabric testing – Geometrical properties - weight, thickness and fabric count
5. Fabric testing – abrasion resistance, pilling
6. Fabric testing – crease recovery, stiffness and drapability
7. Fabric testing – air permeability and thermal properties
8. Fabric testing – water permeability, wicking and dimensional stability
9. Breaking Strength– tensile strength of fibre, yarn and fabric
10. Estimation of tearing and bursting strength of fabrics
11. Processing, statistical analysis of the test data and interpretation of results
12. Garment Quality - Inspection of raw materials and analysis of defects in raw materials
13. Product quality analysis with respect to specification sheets- raw materials, product dimensions, construction and labeling.
14. Study of quality auditing system in the industry.
15. Quality analysis of low priced, medium priced and high priced garments available in market – fabric quality, workmanship, fitting and sizing
16. Visit to textile testing laboratory

VI. Suggested Reading

- AATCC. 2010. *Technical Manual*-Vol 85. American Association of Textile Chemist and Colorist, USA
- Angappan 1987. *Textile Testing*. SSM Institute of Technology, Komarapalayam, India.
- BIS.1982. *ISI Hand Book of Textile Testing*, BIS Publications, India.
- Booth JL. 1983. *Principles of Textile Testing*. Butterworth.
- Gerry Cooklin 1997. *Garment Technology for Fashion Designers*, John Wiley & Sons, UK
- Gerry Cooklin. 2006. *Introduction to Clothing Manufacture*, Wiley, UK
- Latham Barbara and Carr Harold. 1999. *The Technology of Clothing Manufacture*. Blackwell Science, UK
- Pradeep V Mehta. 1998. *Managing Quality in Apparel Industry*, New Age International, India
- Pradeep V Mehta. 2004. *An Introduction to Quality Assurance for the Retailers*, iUniverse, USA
- Ruth E Glock. 1990. *Apparel Manufacturing*. Macmillan Publ. USA
- Textile Research Journal- https://journals.sagepub.com/home/trj

I. Course Title : Pattern Making and Draping

II. Course Code : ATS 503

III. Credit Hours : 3 (1+2)

IV. Theory

Unit I: Advanced techniques of pattern making and draping

Advanced techniques of pattern making and draping: incorporating style lines and fullness.

Unit II: Contouring

Contouring – principles, contour guide patterns, classic, empire, surplice, off-shoulder designs, halters

Unit III: Bodice - Sleeve variations

Raglan sleeve variations – one-piece raglan, deep armhole raglan, armhole-princess raglan, yoke raglan with bell sleeve; Drop shoulder, exaggerated armholes, caftan

Unit IV: Pattern Grading and Fitting

Pattern grading – principles, grading bodice, sleeve, collar; Fitting – principles, standards, fitting problems and remedies

V. Practicals

1. Dart manipulation through pivotal transfer
2. Dart manipulation through slash and spread method
3. Methods of adding fullness and contouring
4. Developing designs with added fullness and contouring using darts
5. Developing designs with added fullness and contouring using pleats
6. Developing designs with added fullness and contouring using tucks & gathers
7. Contouring -application in classic and empire designs
8. Contouring -application in off-shoulder designs
9. Contouring -application in halter neckline designs
10. Contouring -application in surplice designs
11. Draping of dartless shirt designs
12. Incorporating style lines
13. Draping collars
14. Draping Cowls at neckline and underarm
15. Draping Cowls in skirts
16. Draping Built-in necklines
17. Draping Flounces
18. Draping Ruffles
19. Draping Peplums
20. Draping designs with knit fabrics and making patterns
21. Pattern making for variations in sleeves
22. Pattern making for variations in skirts
23. Pattern making for variations in trousers
24. Pattern grading- Bodice and sleeves
25. Pattern grading of skirts; men's and woman's garments
26. Designing garment 1 based on both the methods of pattern making and draping and making patterns
27. Designing garment 2 based on both the methods of pattern making and draping and making patterns
28. Designing garment 3 based on both the methods of pattern making and draping and making patterns

29. Construction of custom garment 1
30. Construction of custom garment 2
31. Construction of custom garment 3
32. Assessment of custom garments for quality and body fit

VI. Suggested Reading

- Amaden-Crawford C. 2018. *The Art of Fashion Draping*. V Edition Bloomsbury Publishing Inc, USA
- Bane A. 1996. *Creative Clothing Construction*. MC Graw-Hill
- Connie Amaden- Crawford. 1989. *The Art of Fashion Draping*. Fair Child Publ.
- Cooklin G. 2004 *Pattern Grading for women's Clothes*. Blackwell Publishing, France
- International Journal of Clothing Science and Technology https://www.emeraldinsight.com/loi/ijcst
- Janine Mee & Michal Purdy. 1987. *Modeling on the Dress Stand*. BSP Professional Books
- Joseph-Armstrong H. 2005. *Patternmaking for Fashion Design*. Pearson Education Inc. India
- Journal of TeXtile Engineering & Fashion Technology https://medcraveonline.com/JTEFT/
- Natalie Bray. 1994. *Dress Fitting*. Blackwell

Weekly Lecture Schedule

Duration (week)	Topics
1 & 2	Techniques of pattern making-drafting, flat pattern and draping
3 & 4	Use of style lines and fullness in pattern making
5,6 & 7	Understanding principles of contouring, surplice/off shoulder and halter designs
8 & 9	Types of Built -in necklines, cowls and collars
9,10 & 11	Introduction to advanced sleeve variations, eXaggerated armholes, pockets and bias-cut dresses.
12, 13 & 14	Types of Skirts and pants
15 & 16	Pattern adoption to knits

I. Course Title : Woven Textile Design
II. Course Code : ATS 504
III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Types of looms, scope and importance

Shuttleless looms –scope, importance and types -projectile, rapier, air jet, water jet weaving; multiple shed loom; Circular weaving; Tri-Axial looms; Pre-weaving processes for advance weaving; Automation in weaving.

Unit II: Woven designs and various weaves

Woven Design – fabric textures; Graphical representation of design, draft and peg plan; Classification of weaves; Warp weight and weft weight calculations; Twill weave and its modification; Colour and weave effects.

Unit III: Types of textured and decorative weaves

Construction of crepe, toweling- honeycomb, huck-a-back, bedford cord and curtain weaves-mockleno; Construction and production of complex structures - leno, double cloth, extra warp and extra weft figuring, terry pile and velveteens.

Unit IV: Specialty fabrics

Construction and production of damask and brocade fabrics using jacquard patterning devices; Methods of carpet making; Use of specialty fibres, specialty yarns, designing and production of specialty fabrics.

VII. Practicals

1. Weaving introduction – Procurement of yarn, setting up loom
2. Analysis of woven samples from different weaves
3. Construction of design, draft and peg plans for different weaves
4. Weaving samples of basic weave variations- plain and satin
5. Weaving samples of basic twill weave variations
6. Developing woven designs for weaving
7. Motif preparation and placement in different styles
8. Developing colour and texture plans
9. Weaving of the fabric with woven designs
10. Contd weaving of the fabric with woven designs
11. Documentation of traditional textile designs
12. Development of modified textile designs
13. Documentation of modified textile designs
14. Visit to Modern Weaving Mill with shuttleless looms
15. Portfolio development with woven samples and created designs
16. End term Assessment

VIII. Suggested Reading

- Grosick ZJ. 1975. *Watson's Textile Design &Colour*. Butterworths. Grosick ZJ. 1980.
- Grosick ZJ. 1989. *Watson's Advanced Textile Design - Compound Woven Structures*. Universal Publ.
- Gupta S. 1959. *Weaving Calculations*. DB Taraporawala Sons.
- Hayavadana J. 2017. Woven Fabric Design and Product Planning, Wood Head Publishers, New Delhi.
- Marjory J. 1972. *Illustrated Guide for Textiles*. RineHort & Winsoten, NewYork.
- Talukdar MK. *Weaving Machines, Mechanism and Management*. Mahajan Publications
- Mgbakoigba: Journal of African Studies- https://www.ajol.info/index.php/mjas
- ACM Digital Library- https://dl.acm.org/

I. Course Title : Wet Processing of Textiles

II. Course Code : ATS 505

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Chemistry of dyes and pigments

Theory of dyeing; Chemistry of dyes and pigments- composition, structure, properties, affinity towards fibres, method of application, fixing, after treatments and fastness properties; Dyeing with natural dyes and role of mordants.

Unit II: Advanced Dyeing and Printing Techniques

Dyeing of blends; Advanced dyeing techniques – macro, micro and nano; Dyeing machines used at the cottage and industrial level for fibre, yarn and fabric; Dyeing and printing defects and remedies; Advanced printing techniques- digital printing, 3D prints, automated flat bed and rotary screen printing; Assessment of colour fastness.

Unit III: Textile Finishes

Textile finishes – concept, scope and importance ; functional finishes on different fabrics – antimicrobial, soil and stain release, durable press, UV protective, flame retardancy; Comfort imparting finishes - application, uses, characteristics, problems and evaluation; Finishing with enzymes; Finishing of blended fabrics.

V. Practicals

1. Preparation of fabrics for dyeing
2. Preparation of fabrics for printing
3. Preparation of fabrics for finishing
4. Developing shade cards on different substrate with various classes of dyes and colour matching.
5. Developing shade cards and colour matching.
6. Natural dyes
7. Dyeing with different mordants
8. Advanced techniques of fabric printing
9. Identification of finishing agents
10. Application of finishing agents
11. Eco-friendly finishing of textiles
12. Assessment of properties of finished fabrics
13. Study of labels pertaining to finishes
14. Theme based project work –Theme selection
15. Project preparation
16. End-term assessment

VI. Suggested Reading

- Gopal Krishnan D and Karthik T. 2016. *Basics of Textile Chemical Processing*. Daya Publishing House, Astral International Pvt. Ltd., New Delhi.
- Hall AJ. 1955. *Handbook of Textile Dyeing & Printing*. The National Trade Press.
- Koushik CV and Josico AI. 2003. *Chemical Processing of Textiles: Preparatory processes and dyeing*. NCUTE, New Delhi.
- Nisbel H. 1978. *Grammer of Textile* Design. D.B. Taraporevale Sons.
- Prayag RS. 1988. *Textile Finishing*. Sri T Printers.
- Sekhri S. 2011. *Text Book of Fabric Science: Fundamentals to Finishing*. PHI Learning, Pvt.Ltd, New Delhi.
- Shanai. 1976. *Chemistry of Textile Axillaries*. Sevak Publ.
- Shenai VA. 1985. *Technology of Printing*, *Technology of Textile Processing*. Vol. IV. SevakPubl.
- Shenai VA. 1994. Technology of Dyeing. Sevak Publ.

- Shenia. 1995. *Technology of Bleaching & Mercerizing*. Sevak Publ.
- Story J. 1974. *The Thames & Hudson Manual of Textile Printing*. Thames & Hudson.
- Sule AD. 1997. *Computer Colour Analysis Textile Application*. New Age International.
- Vaidya A and Trivedi. 1975. *Textile Auxiliaries & Finishing Chemicals*. ATIRA, Ahemadabad.
- Vidyasagar PV. 1998. *A Handbook of Textiles*. Mittal Publ.
- Vilensky G. 1987. Textile Science. CBS.
- Wynne A. 1997. Textiles. Macmillian
- Journal of Saudi Chemical Society
  https://www.sciencedirect.com/journal/journal-of-saudi-chemical-society
- Chemistry International
  http://bosaljournals.com/chemint/

I. Course Title : Computer Aided Textile and Apparel Designing
II. Course Code : ATS 506
III. Credit Hours : 2 (0+2)
IV. Practicals

1. CAD commands
2. Textile designing softwares
3. Creation of textile designs (2D and 3D)
4. Application of Textile designs for different end uses.
5. Creating stripes using various commands
6. Creating checks using various commands
7. Creating weave library
8. Assigning weaves to the designed stripes and Checks for weaving.
9. Introduction to commands from different tool groups- file menu, freehand, geometric, selection, selection utility, colour utilities and general utilities.
10. Practicing on above tools
11. Developing motifs by scanning and drawing using the CAD commands
12. Creating full design/ repeat using drop devices.
13. Creating weaves and storing in Jacquard weave library.
14. Assigning weaves to the design plan.
15. Learning print commands- simulation and graph/ point paper.
16. Developing a computer aided portfolio of different motifs
17. Introduction to different software - Command bars and assistants. Menu bar andoptions. Drawing tools.
18. Colour rendering;
19. Fill, pattern and repeat
20. Creation of Special effects Layers and layer settings;
21. Apparel pattern making modules.
22. Development of basic pattern through CAD.
23. Principles of pattern making and basic blocks.
24. Adaptation of styles
25. Fundamentals of grading and marking.
26. Introduction to draping mode.
27. Outlining, creation of grid and editing the object
28. Draping scanned pictures
29. Texture mapping and creating effects
30. Development of library and printing designed patterns
31. Preparation of portfolio of developed designs,
32. Product designing and development of trims, foot wears, hand bags, buttons,buckles, belts, hats, scarf and jewellery.

V. Suggested Reading

- Davis L Msrisn. 1980. *Visual Design in Dress*. Prentice Hall.
- Luther C. 2008. *Career in Textile and Fashion Designing*. Abhishek Publications, Chandigarh
- Prakash K. 1994. *Impression – A Classic Collection of Textile Designs*. Design Points.
- Prakash K. 1995. *Traditional Indian Motifs for Weaving & Textile Printing*. Design Points.
- Rene Weiss Chase. 1997. *CAD for Fashion Design*. Prentice Hall.
- Srivastva M and Deepthi SS. *Computer aided designing* – e-manual (TXAD). ecourse.iasri.res.in.
- Vastrad J, Sakshi and Deepthi SS. Computer aided designing – textile designing – e-manual (TXAD). ecourse.iasri.res.in.
- Winfred Aldrich. 1992. *CAD in Clothing & Textiles*. BSP Professional Books.
- Yates MP. 1996. *Textiles – A Handbook for Designers*. W.W. Norton.
- International Journal of Fashion Design, Technology and Education https://www.tandfonline.com/toc/tfdt20/current

I. Course Title : Textile and Apparel Industry Management
II. Course Code : ATS 507
III. Credit Hours : 3 (3+0)

IV. Theory

Unit I: Indian Textile industry

Textile industry- history, development and status; export and import policies of Government; Textile research associations; Textile crafts councils.

Unit II: Status of garment industry in India

Status of garment industry in India-production, marketing, distribution, consumption and export trends over last five years; problems of apparel industry and remedial measures. Complexity of management in garment industries: objective and expectations.

Unit III: Management in Apparel industry

Classification of apparel industry- large, medium, small and role of MSMEs; Infrastructural facilities and personnel management in apparel industry; Techniques in managerial application of cost volume profit analysis; Productivity analysis, case studies.

Unit IV: Trade related organisations

Apparel parks, apparel export promotion council, National fashion and design institutes; GATT, TUF, ISO 9001: 2015, 14001: 2015 and 26000: 2010 standards; WTO and its impact on textile and apparel industries; Effect of trade globalization on apparel industry.

Unit V: Automation in apparel and textile industries

Recent advancements in CAD/CAM applications; automation in the industry; role of robotics in productivity management

V. Suggested Reading

- Cooklin G. 1997. *Garment Technology for Fashion Designers.* Blackwell.
- Dickerson K. 1995. *Textiles & Apparels in Global Economy*. Merrill Prentice Hall.
- Glock R. 1990. *Apparel Manufacturing.* Macmillan.
- Karpan 2004. *Change in Trends in Apparel Industry.* Abishek Publ.
- Kathryn MG.1978. *Fashion Innovation & Marketing.* Macmillan Co.
- Mehta PV. 1998. *Managing Quality in Apparel Industry*. New Age International.
- Uncertain Supply Chain Management
  http://m.growingscience.com/beta/uscm/
- University of Wollongong Research
  https://ro.uow.edu.au/

I. Course Title : Historic Textiles and Costumes

II. Course Code : ATS 508

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Study of traditional textiles

Study of traditional dyed, printed, embroidered and non-woven textiles in terms of fibre content, fabrics, motifs, colours, designs and dyes used in Egypt, Greece, Rome, France, America, Japan and China.

Unit II: Study of traditional costumes

History and evolution of traditional costumes and accessories for men and women of Egypt, Greece, Rome, Japan, France, America and China.

V. Practicals

1. Collection and documentation of traditional textile prints and surface designs of Egypt & Greece
2. Collection and documentation of traditional textile prints and surface designs of Rome & France
3. Collection and documentation of traditional textile prints and surface designs of America & Japan
4. Collection and documentation of traditional textile prints and surface designs of China
5. Developing textile surface designs with combination of motifs of different countries
6. Developing textile surface designs with combination of motifs of different countries
7. Documentation of various styles of men's garments of various countries
8. Documentation of various styles of women's garments of various countries
9. Designing and adaptation of outfits for men from historic costumes according to current trends.
10. Designing and adaptation of outfits for women from historic costumes according to current trends.
11. Visit to the museum 1
12. Visit to the museum 2
13. Reporting and Presentation of the visits
14. End term Assessment

VI. Suggested Reading

- Annalce G. 1987. *One World of Fashion*. Fair Child Publ.
- Bhatnagar P. 2005. *Decorative Design History in Indian Textiles and Costumes*. Abhishek Publication, Chandigarh.
- Blanche P. 1965. *History of Costumes from the Ancient Egyptian to the Twentieth Century*. Harper & Row.
- Jack Cassin-Scott. 1994. *The Illustrated Encyclopedia of Costume and Fashion*. Studio Vista.
- Meadows CS. 2003. *Know Your Fashion Accessories*. Fairchild Books, NewYork.
- Peacock J. 1996. *A Complete Guide to English Costume Design and History - Costume* 1066–1990's. Thames & Hudson.

  Hudson, London.
- Stecker P. 1996. *Fashion Design Manual*. Mac Millan.
- International Journal of Scientific Research in Science and Technology- http://ijsrst.com/
- DigitalCommons@University of Nebraska – Lincoln- https://digitalcommons.unl.edu/

I. Course Title : Textile Auxiliaries

II. Course Code : ATS 509

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Introduction to auxiliaries

Textile auxiliaries– definition, classification, selection and uses in processing

operations.

Unit II: Surface active agents

Chemistry and synthesis of surface-active agents - essential requirements of surfactants, classification and biodegradability; Physical principles of cleansing efficiency; Scouring, bleaching and mercerizing auxiliaries.

Unit III: Dyeing and Printing auxiliaries

Dyeing auxiliaries - Wetting, leveling, stripping, dye fixing, swelling, dispersing agents and carriers; Printing auxiliaries – thickeners and their classification, wetting, hygroscopic, antifoaming, reducing, oxidizing agents and pigment binders, fixers and miscellaneous auxiliaries.

Unit IV: Finishing auxiliaries

Stiffening, cross linking, optical brighteners, softeners, water proof/repellents, flame proof/ retardants, soil release, anti-pilling, antimicrobial, moth and mildew proofing; methods of producing nanoparticles of auxiliaries for textile finishing.

V. Practicals

1. Textile auxiliaries-An Introduction
2. Market survey of different Textile auxiliaries
3. Analysis of the surfactant properties of surfactant 1
4. Analysis of the surfactant properties of surfactant 2
5. reparation of detergent
6. Preparation of sizing combination 1
7. Preparation of sizing combination 2
8. Analysis of the sized samples
9. Selection of suitable combinations
10. Assessment of whiteness index of fabrics finished with various bleach 1
11. Assessment of whiteness index of fabrics finished with various bleach 2
12. Assessment of whiteness index of fabrics finished with optical brightening agent 1
13. Assessment of whiteness index of fabrics finished with optical brightening agent 2
14. Assessment of whiteness index of fabrics finished with detergent 1
15. Assessment of whiteness index of fabrics finished with detergent 2
16. End term Assessment

VI. Suggested Reading

1. Bogley M. 1977. *Textile Dyes, Finishing and Auxiliaries*. Garland Publ.
2. Fiscus G and Grunenwald D. 1996. *Textile Finishing: A Complete Guide*. Textile Institute, Manchester.
3. Hall KJ. 1966. *Textile Finishing*. Heywood.
4. NPCS Board of Consultants and Engineers (2019). *Handbook on Textile Auxiliaries, Dyes and Dye Intermediates Technology*, Asia Pacific Business Press Inc., New Delhi
5. Textile Finishing Chemicals: An Industrial Guide http://library.aceondo.net/ebooks/Home_Economics/Textile_Finishing_Chemicals.pdf
6. Chemosphere- https://www.journals.elsevier.com/chemosphere
7. Journal of Hazardous Materials https://www.journals.elsevier.com/journal-of-hazardous-materials
8. *Textile auxiliaries and chemicals* https://www.academia.edu/30859937/Textile_Auxiliaries_ and_Chemicals_Ebook

I. Course Title : Socio-psychological Aspects of Clothing

II. Course Code : ATS 510

III. Credit Hours : 2 (2+0)

IV. Theory

Unit I: Clothing

Clothing-origin, theories, functions and modern philosophy of clothing in relation to culture; Clothing symbolism; Factors effecting clothing -fashion, fad, custom, tradition, culture contact, status, age, education, technology and role of legislation.

Unit II: Socio-psychological aspects of clothing

Socio-psychological aspects of clothing-first impression, individual values, interest, attitude, motivation in clothing choices, self-respect, self-enhancement, self-expression, gender desirability and individuality, clothing and society, clothing and social behaviour, influence of religion; beliefs, customs and traditions; clothes and conformity; cloths and occupation; socio-psychological impact of clothing among different age groups; significance of uniforms and national costumes. Clothes for conformity, mobility, aesthetic appearance. Health and sanitation related to clothing.

Unit III: Consumer behaviour

Consumer behaviour: concept and importance, consumer needs and motivations, consumer perspective and viewpoints; environmental influence; individual differences. Consumer resourses: involvement and motivation; knowledge, attitudes; individual differences in behaviour; psychological processes.
Consumer decision-making processes; model of consumer decision-making; consumer analysis and marketing strategy; retailing; consumer trends; market segmentation; diffusion of innovation; Counterfeitconsumerism and role of media.

Unit

IV: Marketing concept

Marketing concept; Types of customers; Understanding consumers and customer demand; Market segmentation and consumer adopter categories- their characteristics, psychographics and the interrelationship with production, price zones and marketing strategies in relation to fashion cycle; Theories of fashion adoption; Role of fashion influencers.

V. Suggested Reading

- Cranz RLM. 1972. *Clothing Concepts*. Collier Macmillan.
- Horn MJ. 1981. *The Second Skin – An Interdisciplinary Study of Clothing*. Hughton Miffin and Hill House.
- Marion S. 1963. *Dress Selection and Design*. The Macmillan Co.
- Mary Kefgen and Phyllis 1971. *Individuality in Clothing Selection & Personal Appearance*. The Macmilliam Co.
- Ryan MS. 1966. *Clothing - A Study in Human Behaviour*. Winston
- Stecker P. 1996. *Fashion Design Manual*. Mac Millan.
- European Scientific Journal http://eujournal.org
- Journal of Fashion Marketing and Management: An International Journal https://www.emeraldinsight.com/loi/jfmm

I. Course Title : Sustainability in Textile and Apparel Industry
II. Course Code : ATS 511
III. Credit Hours : 2 (2+0)

VI. Theory

Unit I: Impact of textile sector on environment

Environmental threats in textile and apparel industry- raw materials and processes; Banned dyes and chemicals in India; Concept of green supply chain; Certified organic, renewable and low impact raw material; Reduced toxicity in fiber processes and treatments; Effluent Treatment Plants; Concept of zero wastage and lean manufacturing; Pre -consumer and post-consumer textile wastage; 3-R approach and its advantages; Environmental friendly packaging and eco labeling; Certified agencies imparting eco label.

Unit II: Natural dyes

Natural dyes – importance, classification of natural pigments; extraction methods including the concept of supercritical dyeing, microwave and ultrasonication, mordants and dyeing methods; Role of natural dyes in safeguarding the environment.

Unit III: Reduced energy processes

Reduced energy processes; Use of alternative sources of energy during product lifecycle; Importance of carbon credits in textile and apparel manufacturing.

VII. Suggested Reading

- Blackburn RS. 2009. *Sustainable Textiles INNBUNDET*. Woodhead Publishing House.
- Miraftab M and Horrocks AR. 2004. *Ecotextiles: The Way Forward for Sustainable Development in Textiles*. Woodhead Publishing House.
- Subramanian SM. *Sustainability in the Textile Industry* (Textile Science and Clothing Technology).
- Wang Y. *Handbook of Sustainable Textile Production. 1st Edition. Recycling in Textiles*. Woodhead Publishing House.
- *Journal of Environmental Science and Health*
  https://www.tandfonline.com/toc/lesa20/current
- *Ecological Economics*
  https://www.sciencedirect.com/journal/ecological-economics

I. Course Title : Textile and Apparel Product Development

II. Course Code : ATS 512

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Textile and apparel product development

Textile and apparel product development – concept, history, objective; product design, product life cycle and new product development. Merchandising – role, responsibilities, use of calendar, branding, labelling and retailing.

Unit II: Product testing

Product – testing, economics, standards and specifications; product quality control; technical services, positioning and marketing.

Unit III: Organizational behaviour

Organizational behaviour; accounting; product intellectual property law.

Unit IV: Commercial product development

Commercial product development - Role of computers and related software in product development. e-marketing – concepts and application.

V. Practicals

- Product review- Analyzing existing products of textile in terms of design, life cycle and assessment of market need for new product development.
- Development of survey Performa for preparation of product profile of Textile product-1.
- Development of survey Performa for preparation of product profile of Textile product-2.
- Development of survey performa for preparation of product profile of Apparel product-1.
- Development of survey performa for preparation of product profile of Apparel product-2.
- Survey on selected products from textiles field.
- Survey on selected products from apparel field.
- Product testing and analysis of selected textiles – quality, serviceability, material.
- Product testing and analysis of selected textiles – construction, performance.
- Product testing and analysis of selected textiles – Products standard ,specifications and cost.
- Product testing and analysis of selected apparels – quality, serviceability, material.
- Product testing and analysis of selected apparels – construction, performance.
- Product testing and analysis of selected apparels – Products standard, specifications and cost.
- Product planning on the basis of- market needs, aesthetic, functional requirements and producibility.
- Production of new product- with aesthetic, functional requirements and producibility.
- Project work.

VI. Suggested Reading

- Bhargav R. 2005. *Design Ideas and Accessories*. Jain Publ.
- Harold C and Pomeroy J. 1996. *Fashion Design and Product Development*. Blackwell Science.
- The International Journal of Advanced Manufacturing Technology https://link.springer.com/journal/170
- References, Conservation and Recycling https://www.sciencedirect.com/journal/References-conservation-and-recycling

I. Course Title : Laboratory Techniques in Textile Research

II. Course Code : ATS 513

III. Credit Hours : 2 (0+2)

IV. Practical

1. Preparation of buffers for pre-processes.
2. Preparation of reagents for pre-processes.

3-4. Preparation of standard solutions for pre-processes.

5-6. Demonstration on Microencapsulation– Preparation and application; assessment through TEM.

7-8. Demonstration on Microencapsulation– Preparation and application; assessment through SEM.

9-10. Demonstration on Microencapsulation– Preparation and application; assessment through FTIR.

11. Demonstration on Nano synthesis – Preparation and application; assessment through TEM.
12. Nano synthesis – Preparation and application; assessment through SEM.
13. Nano synthesis – Preparation and application; assessment through and FTIR.
14. Optimization of variables for various dyes.
15. Optimization of variables for various printing.
16. Optimization of conditions for various finishing treatments.
17. Optimization of conditions for various enzyme treatments.
18. Analysis of water- pH, TDS.
19. Analysis of dye eXtracts.
20. Analysis of finishing eXtracts.

21-22. Analysis of water -dye effluents, BOD, COD, anions, cations.

23. Laboratory techniques for assessing colour strength.
24. Laboratory techniques for assessing reflectance.
25. Laboratory techniques for assessing Spectrophotometry-visible, ultraviolet.
26. Laboratory techniques for assessing Spectrophotometry-infrared and chromatographic techniques.
27. Use of different scales to assess light fastness.
28. Use of different scales to assess washing fastness.
29. Use of different scales to assess rubbing fastness.
30. Management and interpretation of data generated.
31. Statistical analysis of test results in SPSS package.
32. End term Assessment.

V. Suggested Reading

- Roger Carpenter. 1999. *Vision Research: A Practical Guide to Laboratory Methods*, OXford University Press, OXford
- Research papers on functional testing, performance of teXtiles, Herbal treated/ Nano finished/ microencapsulated apparels and teXtiles, etc.
- Equipment manuals on Nano synthesis - assessment through SEM,TEM and FTIR.
- E book on- Principles of TeXtile Finishing by Asim Kumar Roy Choudhury
- E book on -A Practical Guide to TeXtile Testing By K. Amutha

Course Title with Credit Load
Ph.D. in Apparel and Textile Science

Course Code	Course Title	Credit Hours
	Major Courses (12 Credits)	
*ATS 601	Textile Ecology	2(2+0)
*ATS 602	Technical Textiles	3(2+1)
ATS 603	Technological Developments in Textiles and Apparel	2(2+0)
ATS 604	Colour Application in Textiles	2(1+1)
*ATS 605	Functional Clothing	3(2+1)
ATS 606	Textile Conservation	2(1+1)
ATS 607	Operational Management in Textiles and Apparel	2(2+0)
ATS 608	Technology of Nonwovens	2(2+0)
ATS 609	Special Project	2(0+2)
	Minor Courses (06 Credits)	
CS/PGS 601	Research and Publication Ethics	2(1+1)
FN604	Global Nutrition Problems	2(2+0)
FN 608	Energy Metabolism	2(2+0)
EECM 602	Impact Assessment of Development Programmes	3(1+2)
EECM 603	Scaling Techniques for Behavioural Research	3(1+2)
EECM 607	Media application and product promotion	4(2+2)
HDFS 608	Qualitative research methods	3(2+1)
RMCS 603	Globalization and Consumer Economics	3 (2+1)
RMCS 606	Environmental Issues and Challenges	2 (2+0)
RMCS 607	Family Dynamics and Women Power	3 (2+1)
	Supporting Courses (05 Credits)**	
ATS 691	Doctoral Seminar I (Major Field)	1(1+0)
ATS 692	Doctoral Seminar II (Minor Field)	1(1+0)
ATS 699	Research	75
	Total	**100 Credits**

*Core courses/ compulsory courses; **A student can opt any course related to the topic of research offered by other faculties of agriculture university or SWAYAM portal or other online courses up to a maximum of 5 credits.

Course Contents
Ph.D. in Apparel and Textile Science

I. Course Title : Textile Ecology

II. Course Code : ATS 601

III. Credit Hours : 2 (2+0)

IV. Theory

Unit I: Textile ecology

Textile ecology – concept and importance; Industrialization, eco-balance and sustainability; Air, noise and water pollution by mechanical and chemical textile processing units and their effect. Organic and coloured cotton, natural dyes and detergents.

Unit II: Treatment and disposal of textile effluents

Particulate matter and pollution control devices ; Treatment processes of sewage. Waste minimization and management strategies; Recovery and reuse of water and chemicals

Unit III: Banned dyes and chemicals used in Textile industries

Banned dyes, heavy metals, pesticides and auxiliaries in Textile and related industries. Health hazards of textile workers and their remedial measures; Colour removal technologies

Unit IV: Indian and international environmental legislations

Indian and international environmental legislations. Eco-standards, eco-labeling, management and auditing. Management of packaging waste.

V. Suggested Reading

- Bogley M. 1977. *Textile Dyes*, *Finishing and Auxiliaries*. Garland Publication, New Wood, London.
- Fiscus G and Grunenwald D. 1996. *Textile Finishing: A Complete Guide*. Textile Institute, Manchester.
- Mark KH, Woodlings and Atlas SM. 1971. *Chemical after Treatment of Textiles*. John Wiley & Sons.
- M Clark. 2011. *Handbook of textile and industrial dyeing*, Woodhead Publishing, New Delhi.
- Patricia Dolez. 2017. *Advanced Characterization and Testing of Textiles*. Woodhead Publishing,California.
- Shahid-ul-Islam and Butola B.S. 2019. *The Impact and Prospects of Green Chemistry for Textile Technology*. A volume in The Textile Institute Book Series
- Slater K. 2003 *Environmental Impact of Textiles-Production*, *Processes and Protection* Woodhead publication
- http://scvswap.com/2015/05/09/ecological-balance-and-its-importance/
- https://www.eionet.europa.eu/gemet/en/concept/2441
- https://www.textileschool.com/368/what-is-eco-textiles/
- https://scialert.net/fulltextmobile/?doi=jas.2005.1843.1849

I. Course Title : Technical textiles
II. Course Code : ATS 602
III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Introduction to technical textiles

Technical teXtiles- importance, classification, types of fibres and materials.

Unit II: Developments in nano fibre and micro fibres

Types of nano and micro fibres, performance characteristics, production and application; Developments in nano fibre based non-wovens

Unit III: Technical textiles in industrial applications

Agro tech, Build tech, Geo tech, Mobil tech, pack tech, indu tech and oeko tech.

Unit IV: Technical textiles in personal environment

Medi tech, Pro tech, Sport tech, Home tech and Cloth tech.

Unit V: Smart textiles

Factors affecting the selection and uses of smart teXtiles, phase change materials, chromic materials, shape memory materials. Conductive materials and other functional materials- characteristics and its applications.

V. Practicals

1. Introduction to all types of Technical teXtiles – showcasing the fabric samples and their applications.
2-3. Survey for technical teXtiles in the market and collection of swatches.
4. Identification of swatches, preparation of technical teXtile portfolio.
5. Preparation of nano particles for an end-use and their characterization.
6. Application on teXtiles.
7. Assessment of the functional property of nano finish on teXtiles.
8-9. Agri tech applications- mulch formation for nursery raising (interface with Agricultural college).
10. Medi tech applications – preparation of any anti-microbial finishing solution for application on hospital teXtiles/ patient monitoring/ similar application.
11. Application of anti-microbial finish on fabric.
12-13. Assessment of anti-microbial finish on fabric – visit to the lab having microbiology facility.
14-15. Mini project (group activity)- Designing technical teXtiles/ smart teXtiles using phase change materials/ shape memory materials/ dopplers, etc. for specific functional performance.

VI. Suggested Reading

- Cooklin. 2012. *Garment Technology for Fashion Designers.* Wiley-Blackwell Publications Inc., New Jersey
- K Amutha. 2016. *A Practical Guide to Textile Testing.*Woodhead Publishing, Cambridge, UK.
- Patricia Dolez. 2017. *Advanced Characterization and Testing of Textiles.* Woodhead Publishing, USA.
- Susan M Watkins. 1995. *Clothing the Portable environment*. Iowa State University Press. Ames
- VT Bartels. 2011. *Handbook of Medical Textiles*. Woodhead Publishing Series in TeXtiles. Woodhead Publishing, USA.
- https://www.trade.gov/topmarkets/pdf/TeXtiles_Top_Markets_Report.pdf*2016 Top Markets Report Technical Textiles A Market Assessment Tool for U.S. Exporters U.S. Department of Commerce | International Trade Administration | Industry & Analysis (I&A) May 2016*

- http://nasdonline.org/1246/d001050/health-hazards-in-agriculture-an-emerging-issue.html
- https://careertrend.com/info-8239121-materials-do-firefighters-wear.html
- https://www.technicalteXtile.net/articles/advances-in-protective-fabrics-2560?no_redirect=true
- http://teXtilelearner.blogspot.in/2014/04/applications-of-agro-teXtiles.html
- http://www.fibre2fashion.com/industry-article/1579/agro-teXtiles-a-rising-wave?page=1
- http://www.bch.in/agro-teXtiles.html
- http://www.technicalteXtile.net/agro-teXtiles/
- http://www.ijarse.com/images/fullpdf/1373424521_APPLICATION_OF_TEXTILE_IN_AGRICULTURE.pdf

I. Course Title : Technological Developments in Textiles and Apparel
II. Course Code : ATS 603
III. Credit Hours : 2 (2+0)
IV. Theory

Unit I: Recent advances in manufacture of textile and garments

Recent researches in production and manufacture of textile fibres, yarns, fabrics and garments. Chemical processing of natural and synthetic textiles and their conversion into clothing.

Unit II: Developments in the field of functional textiles

Developments in the field of functional textiles; Use of special techniques in textile processing.

Unit III: Innovations in garment technology and apparel manufacturing

Innovations in apparel designing; Developments in garment manufacturing technology; Advances in retailing; merchandising; biological and psychological aspects of clothing.

Unit IV: Research issues

Thrust areas of contemporary research and future projections Suggested Reading

- http://www.craftmark.org/sites/default/files/Gota%20Patti%20Craft.pdf
- http://www.cohands.in/handmadepages/pdf/91.pdf
- http://blog.ninecolours.com/gota-patti-all-about-sophestication/
- http://handicrafts.nic.in/CmsUpload/2039201602393132%20craft%20process.pdf
- http://shodhganga.inflibnet.ac.in/bitstream/10603/35363/6/07_chapter%201.pdf
- http://jalsnet.com/journals/Vol_1_No_1_June_2014/7.pdf
- https://www.journals.elsevier.com/dyes-and-pigments
- Many online Journals

ISSN Name of the Journal

1528 *Journal of Industrial Textiles*
0970 *Cotton Research Journal* (Journal of the Indian Society for Cotton Improvement)
0143 *Dyes and Pigments*
1229 *Fibers and Polymers*
0266 *Geo textiles and Geo-membranes*
0971 *Indian Journal of Fibre and Textile Research*
2250 *International Journal of Textile and Fashion Technology*
0972 *Journal of Cotton Research and Development*
1558 *Journal of Engineered Fibers and Fabrics*
1528 *Journal of Industrial Textiles*
1544 *Journal of Natural Fibers*
1388 *Journal of Nano particle Research*
1533 *Journal of Nano-science and Nanotechnology*
0163 *Journal of Natural Products*
0368 *Journal of the Textile Association*
0377 *Man Made Textile in India*
0369 *Pigment and Resin Technology*
0040 *Textile Research Journal*
0040 *The Journal of the Textile Institute*

I. Course Title : Colour Application in Textiles
II. Course Code : ATS 604
III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Colour theory and Dye Structure

Theory of colour science. Dyeing theories- physical, chemical, fibre complex, solid solution and pigment. Dye structure- size, shape and molecular weight of dye, state of the dye, electrical nature of dye molecule, chemical groups attached to dye and dyeing parameters.

Unit II: Colour measurement system

Colour measurement systems- Spectrophotometer- features, types and viewing systems; Software and hardware for colour measuring systems; Objective specification of colour- tristimulus values, colour strength, colour difference, shade sorting and various colour spaces; Assessment of whiteness, yellowness and brightness; Assessment of fastness of colour.

Unit III: Computer Colour Matching

Computer Colour Matching- Theory, Isomeric and metameric colour matching, accuracy of match prediction, measurement of reflectance, benefits; Pass Fail Systems.

V. Practicals

1-2. Identification of dye classes: primary and confirmatory tests- direct, basic, acid, sulphur, vat, and reactive dyes.
3-4. Handling colour spectrophotometer- familiarization of commands to use Software
5-6. Recording reflectance values of coloured samples, recording colour strength.
7. Assessment of colour fastness and recording the grey scale fastness grades
8. Colour assessment techniques for assessing dyed fibre, yarn and fabric.
9. Determination of relative dye strength in solution
10-13. Creation of data files and reproduce dyed samples with the match prediction
14. Management and interpretation of data generated
15. Exposure to Pass/ Fail system in industry
16. End-term assessment

VI. Suggested Reading

- Amutha K. 2016. *A Practical Guide to Textile Testing*.Woodhead Publishing, India.
- Booth JE. 2018.*Principles of Textile Testing*.CBS publishers and Distributors, New Delhi.
- Gulrajani ML. 2010. *Colour Measurement: Principles*, *Advances and Industrial Applications*. Woodhead Publishing Series in Textiles, UK.
- Janet. 2017. *Best Colour Design: Theories and Applications*. (The Textile Institute Book Series) 2nd Edition Woodhead Publishing, Cambridge, England.
- Padmanabhan AR. 1988. *A Practical Guide to Textile Testing*, SITRA, Coimbatore.
- Sule AD. 1997. *Computer Colour Analysis Textile Applications*. ATIRA Publication, Ahmadabad.
- Xin J. 2006. *Total Colour Management in Textiles*. Woodhead Publishing.
- https://www.elsevier.com/books/total-colour-management-in-textiles/xin/978-1-85573-923-9

I. Course Title : Functional Clothing

II. Course Code : ATS 605

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Introduction to functional clothing and other associated aspects

Clothing as a portable environment. Comfort in clothing - principles of heat transfer in apparels, thermal insulation, clothing systems for thermal protection, breathable teXtiles.

Unit II: Clothing design for special groups

Functional Design Process; Clothing design for special groups – eXpectant and lactating mothers, clothing design to accommodate differently abled. Geriatric clothing; Impact theory- designing impact-protective clothing

Unit III: Functional and protective clothing

Requirements and designing of functional and protective clothing – sports, farm, military, industrial workers, fire fighters, mines, space and marine. Fastening systems in clothing.

V. Practicals

1-2. Survey on selected functional clothing available in the market.
3. Functional designing process- Assessment of functional aspects
4. Designing clothing for eXpectant woman
5. Designing clothing for nursing mothers.
6. Designing garments for physically handicapped – disabled hands.
7. Designing garments for physically handicapped – disabled legs
8. Designing garments for physically handicapped – wheel chair incumbent
9. Designing protective clothing for pesticide applicators and analysis
10. Designing protective clothing for selected industrial workers and analysis
11. Designing protective clothing for fire fighters and analysis.
12. Designing impact clothing- use of different material and techniques of padding
13. Designing locale specific sports clothes and analysis.
14-15. Mini Project- Designing customized functional clothing
16. End-term assessment

VI. Suggested Reading

- Cooklin G. 2012. *Garment Technology for Fashion Designers*. Wiley-Blackwell, New Jersey
- Dwight Garner. 2018. *Bill Cunningham, Style Maven, Leaves Behind a Memoir and It's 'a Real Dilly'*. Patricia Wall. New York
- Gandhi Kim. 2019.*Woven Textiles Principles, Technologies and Applications*. Woodhead Publishing, UK.
- Karen L LaBat. *Clothing Fasteners*. http://fashion-history.lovetoknow.com/clothing-closures-embellishments/clothing-fasteners
- Kilgus R (Ed.). 1999. *Clothing Technology*. Europa Lehrmittel, TeXtile Institute, Manchester.
- K Amutha. 2016. *A Practical Guide to Textile Testing*.Woodhead Publishing India in TeXtiles, ý Cambridge.
- McCarthy J. 2011. *Textiles for Hygiene and Infection Control*. Woodhead Publishing Series in TeXtiles, UK
- Meinander Harriet and Varheen maa Minna. 2002. *Clothing and textiles for disabled and elderly people*. VTT Tiedotteita – Research Notes 2143. 57 p. + app. 4 p. www.http://www.inf.vtt.fi/pdf/
- Patricia Dolez. *2017. Advanced Characterization and Testing of Textiles*.Woodhead Publishing, California
- Susan M Watkins. 1995. *Clothing the Portable environment*. Iowa State University Press. Ames

- Anonymous Disability SA. 2008. *Dressing: aids and equipment* [www] Available from: http://www.sa.gov.au/upload/franchise/Community Support/Disability/Information sheets - Disability SA/Dressing - aids and equipment (PDF 185kb).pdf
- www.ijrdet.com (ISSN 2347-6435(Online) Volume 3, Issue 2, August 2014)
- http://www.sun-protection-and-products-guide.com/UV-protective-clothing.html
- http://www.sunprotection.net/sunprotectionclothing.html
  http://www.umanitoba.ca/

I. Course Title : Textile Conservation

II. Course Code : ATS 606

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Introduction to textile conservation

Importance of textile conservation; Important terminologies in conservation; Various methods for analysis of textiles - fibre content, yarn and fabric structure.

Unit II: Object examination and Assessment

Object examination; Damage causing agents – insects, pests, microorganisms, mildew, and environmental factors; Condition assessment, repair and stabilization of textiles and apparel in museum collections; Recording, handling and pre-preparations in conservation; Materials and methods used for conservation treatments.

Unit III: Support and Considerations in textile conservation

Support and Considerations in textile conservation; Reassembly and Finishing; Examination of storage and exhibition techniques; Transportation of artifacts/ historic textiles; Equipment and the workspace for textile conservation

Unit IV: Principles of cleaning fragile textiles

Principles of cleaning fragile textiles; Dry, aqueous and solvent cleaning; Conservation of Linen and Flags, historic costumes and feather work, lace, leather goods, tapestries and carpets; Proper conditions for storage and display of various textiles.

V. Practicals

1-2. Visit to a museum and study of various textile conservation methods
3-4. Analysis of aged textiles - fibre content, yarn and fabric structure
5-6. Assessment of damage
7-9. Repair and stabilization of textiles
15. Determination of colour strength
11-12. Exposure to cleaning techniques
13-15. Mini Project work
16. End-term assessment

VI. Suggested Reading

- Balazsy. 2012. Chemical Principles of Textile Conservation. Routledge, UK.
- Frances Lennard. 2012. *Textile Conservation: Advances in Practice.* A Butterworth-Heinemann, UK.
- Harris J. (Ed.). 2011. *Five Thousand Years of Textiles*. Smithsonian Books, UK.
- Leene JE. 1972. *Textile Conservation*. Butterworths, UK.
- Williams JC. 1977. *Preservation of Paper and Textiles of Historic and Artistic Value*. American Chemicals Society.
- https://en.wikipedia.org/wiki/Conservation_and_restoration_of_textiles#Display
- https://scindeks-clanci.ceon.rs/data/pdf/0351-9465/2017/0351-94651701094D.pdf
- https://www.researchgate.net/publication/318014663
- http://webspace.utexas.edu/ecb82/textile_care.doc

I. Course Title : Operations Management in Textiles and Apparel

II. Course Code : ATS 607

III. Credit Hours : 3 (3+0)

IV. Theory

Unit I: Scope of production and operations management in textiles and apparel

Scope of production and operations management in textiles and apparel, methods and measurement of capacity planning. Plant climatology-Plant building and its significance, considerations of building design, types of industrial building- plant lighting; need, types and factors governing. Importance of ventilation.

Plant location; factors governing, types of location; rural, sub-urban and urban, merits and demerits. Plant layout; objectives of scientific layout, principles of layout, types of material flow, factors governing the layout, types of layouts, merits and demerits.

Unit III: Material handling

Material handling- need, classification, handling costs, principles and types of material handling equipment; Maintenance management- need, types, organisation of maintenance department, maintenance audit, maintenance cost, maintenance indices.

Unit IV: Work study

Work study- need, objectives from apparel and textile industry point of view; Method study- steps in method study, tools of record. Time study-time and motion economy, steps, elements, allowances, work measurement and derivation for standard minute value (s m v or s a m) – calculations from apparel industry; Ergonomics- meaning, scope in apparel and textile industry, impact on working conditions and productivity, recommendations for better ergonomically conditions.

Unit V: Automation in Textile & Apparel Industries & Government Policies:

Mechatronics in Apparel & Textile Industries; Scope for Robotics and applications in Apparel & textile Industries; Policies of the government in export and import of materials and made-ups. Government initiatives for various sectors of textile and apparel industry.

V. Suggested Reading

- Aswathappa and Rao S. 2009. *Production and Operations Management*. Himalaya Publishing House, New Delhi.
- Chunnawala and Patel. 2007. *Production and Operations Management*. Himalaya Publishing House, New Delhi.
- Rao S. 2009. *Production Management*. Himalaya Publishing House, New Delhi.
- Vidyasagar P.V. 2010. *Encyclopedia of Textiles*. Vol 2 & 3. Mittal Publications, New Delhi
- http://www.fibre2fashion.com/industry-article/1579/agro-textiles-a-rising-wave?page=1
- http://www.bch.in/agro-textiles.html
- http://www.technicaltextile.net/agro-textiles/
- http://www.ijarse.com/images/fullpdf/1373424521_APPLICATION_OF_TEXTILE_IN_AGRICULTURE.pdf

I. Course Title : Technology of Nonwovens

II. Course Code : ATS 608

III. Credit Hours : 2(2+0)

IV. Theory

Unit I: Development of the nonwovens industry

Development of the non-woven industry. Types of Nonwovens- dry, wet and polymer-laid non-woven, web formation, bonding and raw materials.

Unit II: Types of web formation

Types of web formation, mixing and blending, card clothing, cross lapping. Developments, physical properties and practical applications of air laid fabrics. Wet-laid fabrics- raw materials, bonding systems, finishing and product application. Polymer- laid fabrics- raw materials, bonding techniques, spun-bond fabrics, characteristics, properties and other extrusion properties.

Unit III: Types of bonding

Types of bonding: Mechanical bonding- stitch, needle punching, hydro entanglements process technology and applications. Thermal bonding- raw materials, contact, thermal reaction/ infrared and ultrasonic bonding and applications. Chemical bonding- chemicals, binder polymers, mechanism, drying and applications.

Unit IV: Non-woven fabric finishing

Non-woven fabric finishing - wet, chemical, lamination, mechanical, surface and other developing technologies. Fabric inspection.

Unit V: Characterization of non-woven fabrics

Characterization of non-woven fabrics - weight, thickness, density and other structural parameters. General standards for testing non wovens- absorption, strength, bonder and optional properties.

V. Suggested Reading

- Amutha K. 2016. *A Practical Guide to Textile Testing*.Woodhead Publishing, UK.
- Chapman ARA. 2010. *Applications of Nonwovens in Technical Textiles*. Woodhead publishing limited, New Delhi.
- Dharmadhikary RK Gilmore TF Davis HA and Batra SK. 1995. *Thermal Bonding of Nonwoven Fabrics*. Textile Progress, Vol.26, No.2, Textile Institute Manchester, ISBN: 1870812786.
- Gohl. 2005. *Textile Science: An Explanation of Fibre Properties*. CBS Publishers & Distributors, New Delhi
- Jirsak O and Wadsworth LC. 2004. *Nonwoven Textiles*. Textile Institute, Manchester, 1999, ISBN: 0 89089 9788.
- Lewin M. 2006. *Handbook of Fiber Chemistry*. Taylor and Trancies e-books. Boca Raton
- Lunenschloss J Albrecht W and David S. 1985. *Nonwoven Bonded Fabrics*. Ellis Horwood Ltd., New York, ISBN: 0-85312-636-4.
- Mrstina V and Feigl F. 1990. *Needle Punching Textile Technology*. Elsevier, New York,
- Russel SJ. 2007. *Handbook of Nonwovens*. Woodheadpublishing limited, Cambridge, England.
- Vidyasagar PV. 2008. Handbook of Textiles. BS Publications, New Delhi, India
- Wilson J. 2001. *Hand book of Textile Science*. Woodhead Publishing, UK of Textile Design

I. Course Title : Research and Publication Ethics
II. Course Code : ATS 611
III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Philosophy and Ethics

Introduction to philosophy- definition, nature and scope, concept, branches; Ethics: definition, moral philosophy, nature of moral judgments and reactions

Unit II: Scientific Conduct

Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts- Falsification, Fabrication, and Plagiarism (FFP); Redundant publications; duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data

Unit III: Publication Ethics

Publication ethics- definition, introduction and importance; Best practices/ standards setting initiatives and guidelines- COPE, WAME, etc.; Conflicts of interest;
Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types; Violation of publication ethics, authorship and contributorship; Identification of publication misconduct, complaints and appeals; Predatory publishers and journals

V. Practicals

Unit IV: Open Access Publishing

Open access publications and initiatives; SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies; Software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestion tools, viz., JANE, Elsevier Journal Finder, Springer Journal Suggested, etc.

Unit V: Publication Misconduct

Group Discussions - Subject specific ethical issues, FFP, authorship; Conflicts of interest; Complaints and appeals: examples and fraud from India and abroad
Software tools- Use of plagiarism software like Tumitin, Urkund and other open source software tools

Unit VI: Databases and Research Metrics

Databases- Indexing databases; Citation databases: Web of Science, Scopus, etc. Research Metrics - Impact Factor of journal as per Journal Citation Report, SNIP, SIR, IPP, Cite Score; Metrics: h-index, g index, i10 index, altmetrics.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 6

Community Science
– Extension Education and Communication Management

Modifications Suggested in Courses in the Revised Curricula

M.Sc. Community Science (Extension Education & Communication Management)

Course Code	Course Title	Credit Hours	Remarks
	Major Courses		
EECM 501	Global Extension Systems	3 (3+0)	Content modified in view of emergence of innovative processes in extension systems
EECM 502	Development communication	3 (2+1)	Title changed and content modified to suit to developmental challenges
EECM 503*	ICT and New Media	4 (1+3)	Credits enhanced and content modified by focusing ICT in community education
EECM 504*	Technology Transfer and Management	3 (1+2)	New course to engage students for on-hands training by attaching to AICRP/KVKs
EECM 505*	Dynamic Communication skills	3 (1+2)	New course for development of holistic communication skills.
EECM 506	Participatory Programme Management	3 (1+2)	Content modified for practical orientation to application and analysis in different situations

Course Code	Course Title	Credit Hours	Remarks
EECM 507	Organizational Development and HRD	2 (1+1)	New course to orient students towards professional management of organizations.
EECM 508	Educational Technology	3 (2+1)	Content modified to achieve proficiency in teaching and learning.
EECM 509	Group Dynamics	2 (2+0)	Content modified, highlighting adoption of SHG for simulated learning
EECM 510	Community Development and Outreach	3 (2+1)	New course to stimulate strong connection with community and communication.
EECM 511*	Climate change management	2 (1+1)	New course to mold students as service providers in climate change management.
EECM 512	Gender Sensitization for Empowerment	2 (2+0)	Content modified to promote interest in national gender sensitive issues.
EECM 513	Special Project- Out sourcing for Media product development	2 (0+2)	New course for entrepreneurial skills.
	Minor Courses		
FN 505	Nutrition and Physical fitness	3(2+1)	Proposed minor courses from subjects closely related to a student's major subject.Apart from these courses a student can register any other course
FN 509	Food Safety and Standards	3(2+1)	
FN 513	Human Physiology	3(3+0)	
HDFS 503	Methods and Techniques of Assessment in Human Development	3(2+1)	
HDFS 506	Management of differently abled	3(2+1)	
ATS 512	Apparel and Textile Product Development	2(1+1)	
ATS 513	Laboratory Techniques in Textiles Research	2(0+2)	

Course Code	Course Title	Credit Hours	Remarks
RMCS 513	Environmental Resource Management	2(1+1)	offered by any other
RMCS 508	Product Design	3(1+2)	departments
RMCS 507	Consumer Issues and Legislations	2 (2+0)	
	Supporting Courses		
	Research methodology	3(2+1)	Course numbers
	Statistics	3(2+1)	will be assigned
	Total	**6(4+2)**	by the departments that offer these courses.
	Common Courses		
	Library and Information Services	1(0+1)	The common courses will be registered with the respective departments that offer these courses
	Technical Writing and Communication Skills	1(0+1)	
	Intellectual Property and its management in Agriculture	1(0+1)	
	Basic Concepts in Laboratory Techniques	1(0+1)	
	Agricultural Research, Research Ethics and Rural Development Programmes	1(0+1)	
		5(0+5)	
EECM591	Seminar	1(0+1)	
EECM599	Thesis/Research	30	
	Total	**70**	

*Compulsory core curses

Ph.D. Community Science (Extension Education and Communication Management)

Course Code	Course Title	Credit Hours	Remarks
	Major Courses		
EECM 601*	Managerial Skills for Extension Professionals	3 (2+1)	Content updated for delivery of specialized extension support in competitive environment

Course Code	Course Title	Credit Hours	Remarks
EECM 602	Impact Assessment of Development programmes	3 (1+2)	New title, by taking a part of content from HECM 606 , Monitoring, Evaluation and Impact Assessment. Content focuses on Case study method
EECM 603*	Scaling Techniques for Behaviour Research	3 (1+2)	New course, to provide eXpertise in development of scales.
EECM 604	Design and Development of e-EXtension Project	3 (0+3)	New course to provide comprehensive eXperience of EXtension-Research-Education through digital communication.
EECM 605	Sustainable Livelihood Systems	2 (1+1)	Content updated, highlighting sustenance processes to different conteXts and situations of uncertainty
EECM 606	EXtension Research Project Management	3 (1+2)	Title of HECM 604 Research project management is changed and content modified to focus on EXtension research
EECM 607	Media application and Product Promotion	4 (2+2)	Basics of media are covered at UG and M.Sc. level. Hence HECM 603 Advanced media management is

Course Code	Course Title	Credit Hours	Remarks
			modified for application skills in media product development
EECM 608	Advocacy and Behavior Change Management	3 (1+2)	New course to provide skills for logical thinking in planning behaviour change communication programme.
	Total	24 (9+15)	
	Minor Courses		
FN 604	Global Nutrition Problems	2(2+0)	Proposed minor courses from subjects closely related to a student's major subject.Apart from these courses a student can register any other course offered by any other departments
FN 608	Energy Metabolism	2(2+0)	
HDFS 608	Qualitative research methods	3(2+1)	
ATS 602	Technical Textiles	3(2+1)	
ATS605	Functional Clothing	3(2+1)	
ATS 607	Operational Management in Textiles and Apparel	2(2+0)	
RMCS 603	Globalization and Consumer Economics	3 (2+1)	
RMCS 606	Environmental Issues and Challenges	2 (2+0)	
RMCS 607	Family Dynamics and Women Power	3 (2+1)	

Supporting Courses

Student can choose any course relevant to the research from other faculties of the University or from Swayam portal or online courses.

EECM 691	Doctoral Seminar I Optional Field)	1 (1+0)
EECM 692	Doctoral Seminar II (Core Field)	1 (1+0)
EECM 699	Research	75
	Total	100 Credits

*Compulsory core curses

** Detail missing

Course Title with Credit Load M.Sc. (Community Science) in Extension

Education and Communication Management

Course Code	Course Title	Credit Hours	**Semester**
EECM 501	Global Extension Systems	3 (3+0)	
EECM 502	Development communication	3 (2+1)	
EECM 503*	ICT and New Media	4 (1+3)	
EECM 504*	Technology Transfer and Management	3 (1+2)	
EECM 505*	Dynamic Communication skills	3 (1+2)	
EECM 506	Participatory Programme Management	3 (1+2)	
EECM 507	Organizational Development and HRD	2 (1+1)	
EECM 508	Educational Technology	3 (2+1)	
EECM 509	Group Dynamics	2 (2+0)	
EECM 510	Community Development and Outreach	3 (2+1)	
EECM 511*	Climate change management	2 (1+1)	
EECM 512	Gender Sensitization for Empowerment	2 (2+0)	
EECM 513	Special Project- Out sourcing for Media product development	2 (0+2)	

Minor Courses**

FN 505	Nutrition and Physical fitness	3(2+1)
FN 509	Food Safety and Standards	3(2+1)
FN 513	Human Physiology	3(3+0)
HDFS 503	Methods and Techniques of Assessment in Human Development	3(2+1)
HDFS 506	Management of differently abled	3(2+1)
ATS 512	Apparel and Textile Product Development	2(1+1)
ATS 513	Laboratory Techniques in Textiles Research	2(0+2)
RMCS 513	Environmental Resource Management	2(1+1)
RMCS 508	Product Design	3(1+2)
RMCS 507	Consumer Issues and Legislations	2 (2+0)

Supporting Courses

Research methodology	3(2+1)
Statistics	3(2+1)
Total	6(4+2)

Common Courses

Library and Information Services	1(0+1)
Technical Writing and Communication Skills	1(0+1)
Intellectual Property and its management in Agricultur	1(0+1)
Basic Concepts in Laboratory Techniques	1(0+1)

	Agricultural Research, Research Ethics and Rural development of programmes	1(0+1)
	Total	**5(0+5)**
EECM591	Seminar	1(0+1)
EECM599	Thesis/Research	30
	Total	**70**

*Compulsory core curses

Course Contents
M.Sc. (Community Science) in Extension Education and Communication Management

I. Course Title : Global Extension Systems

II. Course Code : EECM 501

III. Credit Hours : 3 (3+0)

IV. Theory

Unit I: Orientation to extension systems

Early extension efforts; Indian extension systems - reforms, challenges of extension management in India; Paradigm shift in extension systems; Extension approaches in view of globalization and market liberalization; Privatization of extension services – introduction, scope, advantages, limitations and experiences; Decentralization of extension systems; Revolution in extension systems.

Unit II: Governance and extension systems

Indian governance and role of extension systems - retrospection on Indian governance; Role of extension system; Ministries - rural development, agriculture, science and technology, human resource development, health, industries, education and women and child development; NGO collaboration; Review of five year plans.

Unit III: ICAR extension system

History; Extension system; Organisational structure; Policy issues; Existing extension systems and challenges; National and regional institutions - vision, objectives, activities, innovations, programmes; Extension systems in SAUs - organisational structure, personnel, roles, innovations, SWOT analysis.

Unit IV: Extension management and training organisations and institutions

FAO, IFAD, IFRI, WFO, WHO, *Biodiversity international*, MANAGE, NIRD, National Institute of Agricultural Marketing (NIAM), NAARM, EEI, SAMETI, FTC.

Unit V: Comparative analysis of extension system

India with USA, UK, Israel, China, Pakistan, Bangladesh, Japan, Italy, South Africa, Island, Indonesia, Philippines and Brazil - history, approaches, organizational structure, methodology, services, problems and research linkages.

V. Suggested Reading

- Azadi H and Filson G. 2009. *Comparative Study of Agricultural Extension Systems-A Systemic View Outlook on Agriculture*. https://www.rug.nl/research/portal/publications.
- Sagar M. 2013. *Text Book of Agricultural Extension with Global Innovations*. Kalyani Publishers, Ludhiana, ISBN: 978-93-272-2877-9.
- Salahuddin A and Magor NP. 2005. *Innovations in Rural Extension: Case Studies from Bangladesh*. CABI Publishing, Wallingford, UK.
- Sangeet G and Mithilesh V. 2011. *Global Extension Systems: A Textbook*. New Academic Publications ISBN-10: 8186772464 ISBN-13: 978-8186772461.

- Singh KK *et al.* 2015. *Agricultural Extension Explorer*. Kalyani Publishers, Ludhiana.
- *Global Approaches to Extension Practice: A Journal of Agricultural Extension*
- *International Journal of Agricultural Extension*
- *Indian Research Journal of Extension Education* published by Society for EXtension Education Agra

I. Course Title : Development Communication

II. Course Code : EECM 502

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Over view of development communication- Hypothetical concepts and theories- Press theories

Normative - authoritarian, libertarian, social responsibility, democratic participant theory; Sociological - uses & gratification, agenda setting; two-step flow; Psychological; Bullet theory; Theories of persuasion and advocacy; Critical theory of frank furt school; Attitude change theories; Political economy theory; Critical cultural theory of birmingham school and framing theory.

Unit II: National and international perspectives of development communication

National and international perspectives; Evolution of development communication concept; Government and non-government initiatives; Government and non-government organisations - FAO, UNDP, WHO, UNICEF, CARE and strategies.

Unit III: Millennium development goals (MDGs) and sustainable development goals (SDGs)

Achievements of MDGs - analytical review and recommendations; SDGs - document, vision and objectives; Targets and strategies for implementation.

Unit IV: Research perspectives of development communication:

Emerging issues; Measurable and variables of development communication; EXisting research projects; Research lag and supporting organisations.

Unit V: Media initiatives for development communication:

Conventional and contemporary media technologies; Globalisation and media convergence; Ethical issues and media impact analysis.

V. Practical

1. Research review on hypothetical concepts and theories of Development communication
2. Presentation on hypothetical concepts and theories of Development communication
3. Critical analysis of Sustainable Development goals (SDGs)
4. Report writing and presentation on critical analysis of SDGs
5. Case study preparation focusing national and international organisation efforts for development communication.
6. Presentation of national and international organisation efforts
7. Critical review on ongoing Development Communication research projects in respective SAUs
8. Presentation on ongoing Development Communication research projects

9. Interaction with personnel and consumers of development communication projects and group discussion.
10. Interaction with personnel and consumers of development communication projects and group discussion.
11. Selection of contemporary media for development of communication issue, dissemination through existing channels of respective SAUs
12. Analysis of contemporary media for development of communication issue
13. Analysis of contemporary media for development of communication issue

14. Presentation of media analysis of the issue
15. End term assessment

VI. Suggested Reading

- Huesca R. 2003. Participatory Approaches to Communication for Development. In Mody B (Ed.) *International and Development Communication*: *A 21st Century Perspective*. Sage, California.
- Joshi Uma *Understanding Development Communication*. Dominant Publications, New Delhi.
- Karin G, Wilkins Thomas T and Rafael O. 2014. *The Handbook of Development Communication and Social Change*. Kindle Publication, ISBN: 9781118505311.
- Mefalopulos P. 2008. *Development Communication Sourcebook- Broadening the Boundaries of Communication*, The World Bank Publication.
- Mikkelsen and Britha. 2002. *Methods for Development Work and Research*. Sage Publications, New Delhi.
- Narula and Uma. 2007. *Development Communication Theory and Practice*. Har-Anand Publication, Ltd. New Dehli.
- Mefalopulos Paolo. 2008. *Development Communication Sourcebook Broadening the Boundaries of Communication Development Communication Sourcebook Broadening the Boundaries of Communication*. Washington DC ISBN 978-0-8213-7522-8.
- Servaes Jan. 2008. *Communication for Development and Social Change*. Sage Publications, New Delhi.
- *Journal of Development Communication*. Asian Institute for Development Communication
- Journal of Development and Communication Studies. Asian Journal of Communication

I. Course Title : ICT and New Media

II. Course Code : EECM 503

III. Credit Hours : 4 (1+3)

IV. Theory

Unit I: Information communication technology

Information communication technology - components of ICT, role of ICT in community education; IT enabled services - call centre, helpdesks, data warehouse; Current status of application; Government policy on ICT; Emerging research issues.

Unit II: Perspective of new media

Definitions, Soft and hardware components, Traditional media transition to new media; Knowledge management and archiving; Networks; Social Media - advantages and limitations.

Unit III: Multimedia - concept and evolution

Digital Audio - sound design and mixing, digital videography and photography, digital text writing.

Unit IV: Web and blog designing

Hosting; Introduction of HTML and basic tags and HTML document structure; Cascading style sheets; Text in CSS and working.

V. Practical

1. Multimedia and emerging technologies - Introduction to Video-on demand, internet - radio and web television
2. Introduction to Internet and the browsers
3. Introduction to Internet access and browsing
4. Introduction to Internet access and browsing extension related websites, blogs and data bases
5. Exposure to network
6. Compose e-mails, send and receive mails
7. Video on demand- different video formats
8. Creating a Basic Video Clips with Video Editing software.
9. Adding audio into developed videos
10. Editing of existing videos and audios
11. Video on demand-accessing downloads and editing of required video formats
12. Internet radio- Accessing different radio channels in online websites and browsing
13. Web Television- Exposure and accessing
14. Impact of new media on traditional media- listing of various traditional media and new media formats- collection of literature
15. Group discussion/debate on advantages and disadvantages of traditional media and new media
16. Writing on specialized area on the web
17. Writing for general interest web- script writing concepts, principles for web
18. Writing for online- script writing concepts, principles, styles for online
19. Writing for net newspapers and editions- script writing concepts, principles, styles for online
20. Writing for blogs and search engines- script writing concepts, principles, styles for online
21. Writing for video logs, citizen journalism- script writing concepts, principles, styles for online
22. Evaluation of e-journals- Exposure to electronic journals, browsing sites, accessing and down loading the journal articles

23. Evaluation of e-journals
24. Submission of reports
25. Unique features of web language-, open source softwares, viz., wordpress, joomla, moodle
26. Introduction and basics to Advanced HTML
27. Introduction of Cascading Style Sheets
28. Orientation – java script and HTML scripts
29. Designing web page- Home page(landing page), hyperlinks with using CSS
30. Practical exercise on designing a web page by using HTML5 and CSS3.
31. How to create responsive (Mobile friendly) Pages with Using HTML5 and CSS3.
32. Designing web page- Home page, hyperlinks - open source softwares, viz., Wordpress
33. Explanation of WordPress Dashboard and creating blog in Wordpress
34. Hosting a WordPress Blog online
35. Creating Google Analytics
36. Adding Google Analytics into HTML page and Wordpress Pages
37. Introduction to interactive web media- web animation
38. Understanding web animation- jquery, dream weaver and Photoshop
39. Exposure to animated graphics in the web
40. Introduction to designing interactive elements, sound addition
41. Introduction to web visual editor, creation and editing.
42. Acquiring a domain and webhosting to host the website/blog.
43. Familiarisation with FTP and Cpanel
44. Hosting website into Online
45. Updating/change the contents and images online Website after Hosting.
46. How to take the backups of the website after hosting a website.
47. Tracking Web Traffic from Analytics
48. End term assessment

VI. Suggested Reading

- Andleig PK and Thakrar K. 2003. *Multimedia Systems Design*. PHI: New Delhi.
- Chrisanthi Avgerou, Robin Mansell, Danny Quah and Roger Silverstone. 2009. *The Oxford Handbook of Information and Communication Technologies.* http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199548798.001.0001/oxfordhb-9780199548798.
- Earnshaw RA and Vince JA. 1995. *Multimedia Systems and Applications*. London: Academic Press.
- Grace Kite. 2012. *The Impact of Information Technology Outsourcing on Productivity and Output: New Evidence from India* Volume 1. Pages 239-48.
- ST Nandasara. 2009. *Information Communication Technology – Grade 11.* Educational Publications Department, Ministry of Education, Sri Lanka https://www.researchgate.net.
- Thatchinamoorthi J and C Meenambigai. 2018. *Textbook of Extension Communication & Information Technology*. ISBN-10: 9788183214681 ISBN-13: 978-8183214681.
  Vanaja and Rajasekar. 2016. *Information & Communication Technology* (*ICT*) *In Education*

  First Edition, Neelkamal ISBN- 0: 8183165192 ISBN-13: 978-8183165198.
- https://www.india.gov.in/topics/communication/information-and-technology
- Smart Villages Through Information Technology – Need of Emerging India https://www.researchgate.net/publication
- http://atcm.mathandtech.org/EP2009/papers_ full/2812009_17282.pdf
- https://www.emeraldinsight.com/doi/abs/10.1108/eb047157

I. Course Title : Technology Transfer and Management
II. Course Code : EECM 504
III. Credit Hours : 3 (1+2)

IV. Theory

Unit I: Introduction to technology transfer

Transfer of Technology - Definition and importance; Models of technology transfer - different models, qualitative technology transfer models, dimensions of technology transfer, features of technology package, routes of technology transfer; FLD, OFT, Minikits.

Unit II: Technology acquisition

Technology acquisition; Alternatives for acquiring new technologies; Reasons; Management of acquired technology; Measures of scale and mechanisms for acquiring technologies - economy of scale, levels of scale, measurement of scale, factors affecting the choice of scale.

Unit III: Introduction to technology management

Concept and meaning of technology management; Evolution and growth of technology management.

Unit IV: Role and significance of technology management

Impact of technology on society; Technology and competition; Key issues in managing technological innovation, Forms of technology - product and process technologies; Technology forecasting - methods and principles; Role of government in technology management.

Unit V: Technological change

Characteristics of technological change; Classification of technological change; Impact of technological change; Technology life cycle; Technology transformation; Technology policies and policy instruments.

Unit VI: Technology assessment

Technology choice; Technology assessment and refinement; Technology assessment process; Technology leadership and followership; Writing technology assessment report.

Unit VII: Invention, innovation and creativity

Meaning and differences; Innovation management; Intellectual property management.

Unit VIII: Technology adoption, diffusion, and absorption

Technology adoption diffusion and absorption; Role of technology absorption - benefits, constraints in technology absorption, technology package and technological dependence, Indian experience in technology absorption efforts, issues involved in the management of technology absorption and government initiatives.

Unit IX: Development of technology

Development process and steps; Technology development and competition; Managing research & development (R & D); Reforms in technology development.

Unit X: Social issues in technology management

Technological change and industrial relations; Implementation of rationalization and automation in India.

V. Practical

Note: Students may be attached to AICRP on Home Science/ Research project all through the semester for practical experience with either one of the departments, or for a stipulated duration with every department may be left to the discretion of course-in-charge. Students' report may consist the following information.

1. Enlisting of technologies already transferred under five disciplines/ research project.
2. Selection of technologies for observation of change attained and preparation of observation schedule
3. Field visit and interaction with clientele to collect data
4. Analysis of data and preparation of report
5. Presentation of report
6. Group discussion on technology refinement/ sustainability issues
7. Enlisting and description of technologies transferred by the concerned scientist/s during the semester
8. Description of invention, innovation and creativity of the selected technology
9. Description of transfer of technology model
10. Design and development of transfer of technology process
11. Presentation of technology transfer process
12. Preparation and finalisation of work plan for participation in technology transfer

13–25. Execution of work plan as per time line

26. Analysis of technology adoption and diffusion stages
28. Preparation of report on technology transfer
29. Presentation of report
30. End term assessment

VI. Suggested Reading

- A Inzelt and Jan Hilton. 1999. *Technology Transfer: From Invention to Innovation*. Springer Science and Business Media, Kluwer academic publishers.
- Albert E Muir. 1997. *The Technology Transfer System*: *Inventions: Marketing*, *Licensing*, *Patenting*, *Setting*, *Practice*, *Management*, *Policy*. Book News, Inc., Portland.
- Ali Hussein Saleh Zolai. 2012. *Knowledge and Technology Adoption*, *Diffusion*, *and Transfer*: *International Perspective*. University of Bahrain, Bahrain ISBN13: 9781466617520.
- Avid B, Audretsch Erik E, Lehmann Albert N, Link Alexander Starnecker. 2012. *Technology Transfer in a Global Economy*. Springer Science & Business Media, ISBN 146146102.
- Thomas J Allen. 1984. *Managing the Flow of Technology*. Edition III, Massachusetts Institute of Technology, ISBN 0262510278.
- *International Journal of Technology Transfer and Commercialisation*. Interscience Publishers, Genèva.

I. Course Title : Dynamic Communication Skills

II. Course Code : EECM 505

III. Credit Hours : 3 (1+2)

IV. Theory

Unit I: Need and importance of communication in present context

Types of communication skills - verbal, non-verbal and written communication; Types of corporate and business communication skills - oral presentations, group discussions, facing interviews, e-mail, memos, business letters, blogs, inter office memorandums, report writing; Hard and soft skills; difference between hard and soft skills.

Unit II: Scientific communication

Meaning; Need and importance; Fora of scientific writing - conference, seminar, symposium, workshop and colloquia; Writing for scientific journals; Thesis writing and writing articles for popular media; Farm journalism and its importance in agriculture and allied sectors; Science communication and formats for scientific writing; Writing for scientific journals and their ratings; NAAS rating; Impact factor and h-index; Oral and poster presentation; Reading and comprehension of - print and audio video media; General and technical articles.

Unit III: Introduction to public speaking

Types of speeches - persuasive, informative, and motivational or inspirational speech; Structuring the speech - introduction, body content and conclusion; Effective delivery - voice modulation, appearance during speeches and delivery; Platform performance - posture, gesture, eye contact, emphasis, pause, voice pitch, overcoming fear and anxiety of public speaking; Visuals in presentation - type of visuals for public speaking, tips for effective use, computer aided visual presentation, body language.

Unit IV: Importance of listening

Introduction; Listening styles - active & passive and direct & indirect listening, thinking & listening, adjusting listening style to that of speaker, social situations & listening; Listening improvement techniques.

V. Practical

1. Orientation to NAAS rated Journals related to respective discipline
2. Enlisting relevant national and international journals
3. Exercise on writing a review article on given topics
4. Presentation of the topic
5. Exercise on writing popular articles for Newspapers, Magazines and farm journals in English
6. Presentation and group discussion
7. Exercise on writing popular articles for Newspapers, Magazines and farm journals in vernacular language
8. Presentation and group discussion
9. Exercise on writing thesis in UAS format
10. Presentation and group discussion
11. Exercise on Numbers, Units, Abbreviations and nomenclature
12. Presentation and group discussion
13. Scientific style and use of English in research paper
14. Presentation and group discussion
15. Exercise on writing business letters, e mail, blogs, Internet etiquettes
16. Presentation and group discussion

17. Exercise on listening skills
18. Presentation and group discussion
19. Exercise on presentation skills
20. Presentation and group discussion
21. Exercise on writing for radio
22. Presentation and group discussion
23. Message preparation for SMS
24. Practice on modalities of SMS dissemination
25. Presentation and group discussion
26. Learning skills of indexing, footnote and bibliographic procedures
27. Presentation and group discussion
28. Tips for public speaking
29. Exercise on public speaking
30. Organising public speaking- Impromptu, Extemporaneous, Manuscript and Memorized
31. Evaluation of public speaking
32. End term assessment

VI. Suggested Reading

- D'Souza YK. 2000. *Encyclopedia of Advanced Journalism*. Vols. I-III. Anmol Publ.
- Khan PM. 2002. *Textbook of Extension Education*. Himanshu Publications, New Delhi.
- Lamerton J. 2001. *Everything You Need to Know Public Speaking*. Harper Collins Glasgow.
- Ravindran RK. 1999. *Hand Book of Reporting and Editing*. Anmol Publ.
- Ray GC. 1991. *Extension Communication & Management*. Kalyani Publishers, Ludhiana.

I. Course Title : Participatory Programme Management

II. Course Code : EECM 506

III. Credit Hours : 3 (1+2)

IV. Theory

Unit I: Overview to PPM

Concept; Meaning; Importance; Types of participation in development; Advantages and disadvantages of participation by different stakeholders; Role of government and non profit organizations in promoting participation; Conceptual framework of extension programme planning; Objectives; Principles and process.

Unit II: Participatory planning

Concept; Importance; Process; Techniques of participatory planning - RRA, PRA, PLA and their application in extension; Approaches of participatory planning - cooperative, democratic, bottom up and down.

Unit III: Project management techniques

Administration of the Project; Concept of Professional management - stakeholder analysis, force field analysis, SWOT analysis, logical framework analysis, PERT, CPM.

Unit IV: Monitoring and evaluation

Concept; Meaning and importance of monitoring and evaluation; Components of M&E - physical, financial, staff performance; Technical aspects - output, outcome & impact; Trends in people's participation in M & E; Contribution of right to information Act.

V. Practicals

1. Literature survey and research review on different perspectives of PPM
2. Presentation of review reports
3. Observation of PPM techniques in SHGs (female groups)
4. Observation of PPM techniques in SHG village federations
5. Observation of PPM techniques in SHG mandal/block level federations
6. Observation of PPM techniques in SHG district level federations
7. Observation of PPM techniques in SHGs (male groups)
8. Observation of PPM techniques in watershed management groups
9. Preparation of case study and presentation
10. Preparation of case study and presentation
11. Preparation of case study and presentation
12. Application of PRA methods – Critical analysis of different methods through research review- Mapping techniques
13. Application of PRA methods – Critical analysis of different methods through research review- Ranking techniques
14. Application of PRA methods – Critical analysis of different methods through research review- Transaction techniques
15. Application of PRA methods – Critical analysis of different methods through research review- Focus group discussion
16. Application of PRA methods – Critical analysis of different methods through research review- Problem analysis
17. Application of PRA methods – Critical analysis of different methods through research review- Institutional analysis
18. Preparation and implementation of home improvement work plans

19. Preparation and implementation of home improvement work plans
20. Critical evaluation of work plan
21. Critical evaluation of work plan
22. Application of project management techniques- PERT
23. Presentation of feedback on project management techniques- PERT
24. Application of project management techniques – CPM
25. Presentation of feedback on project management techniques – CPM
26. Application of project management techniques- SWOT
27. Presentation of feedback on project management techniques- SWOT
28. Application of project management techniques- Stake holder analysis
29. Presentation of feedback on project management techniques- stakeholder analysis
30. Application of project management techniques- Logical frame work analysis
31. Presentation of feedback on project management techniques- Logocal frame work analysis
32. End term assessment

VI. Suggested Reading

- Elizaphan N. 2015. P*roject Monitoring and Evaluation: Tools and Techniques*. Kindle Edition, Ekon Publishers. *J. Agril. Res. Innov. & Tech.* **3**(2): 72-78, December, 2013 http://www.ijarit.webs.com
- Koen K, Maartjede G and Louise B. 2016. *Participatory Planning, Monitoring and Evaluation of Multi-stakeholder Platforms in Integrated Landscape Initiatives*. (Working Paper). https://www.researchgate.net/publication/311100782.
- Nabhi. 2005. *Handbook for NGOs: An Encyclopaedia for Non-government Organisations and Voluntary. Agencies* Vol1. Nabhi Publications, New Delhi.
- Rory B. 2014. *Burke Publishing Project Mmanagement Techniques*. 2nd College Edition, http://www.burkepublishing.com/component/%20content/article.html?id=16
- Uddin MN and Anjuman N. 2013. *Participatory rural appraisal approaches: an overview and an exemplary application of focus group discussion in climate change adaptation and mitigation strategies*. ISSN: 2224-0616.
- *Team FME SWOT Analysis Strategy Skills* ISBN 978-1-62620-951
- http://www.free-management-ebooks.com/dldebk/dlst-swot.htm

I. Course Title : Organizational Development and Human Resource Development

II. Course Code : EECM 507

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Introduction to organization development

Definition; scope and importance; Relevance of organization development in community science; History of organizational development; Revolution in organizational development; Planned change - theories of planned change, models of planned change; General and specific.

Unit II: Designing interventions for organisational development

Types; Interpersonal and group process approaches - process consultation, third party evaluation; Organisation process approaches - organization confrontation meeting, intergroup relations interventions, large group interventions; Techno-structural interventions - engineering approach, motivational approach, socio-technical systems approach; Human resource management interventions performance management - goal setting performance appraisal and rewards systems.

Unit III: Introduction to human resource development

Concept; Relationship between human resource management and human resource development; HRD mechanisms - processes and outcomes; HRD matrix; HRD interventions; Roles and competencies of HRD professionals; Challenges in HRD.

Unit IV: HRD process

Assessing need for HRD; Designing and developing effective HRD programmes; Implementing HRD programmes; Evaluating effectiveness of HRD programmes; HRD audit; HRD culture and climate; Employee development activities - approaches, leadership development, action learning, assessment and development centres; Intellectual capital and HRD.

Unit V: HRD Trends

Coaching and mentoring; Career management and development; Employee counselling; Competency mapping (CM); People capability maturity model (PCMM); Balanced score card; Appreciative inquiry; Integrating HRD with technology and Employer branding and other emerging trends.

V. Practical

1. Visit to an organization to study the models of planned change and preparation
2. Presentation of report on models of planned change
3. Research review and presentation of organizational interventions in national context
4. Research review and presentation of organizational interventions in international context
5. Collection of data/information and preparation of case studies on organizational interventions in health
6. Collection of data/information and preparation of case studies on organizational interventions in education
7. Collection of data/information on organizational interventions in welfare and training organizations and preparation of case studies.
8. Presentation of case studies.
9. Study of existing HRD strategies of respective SAUs/Institutions

10. Analysis of existing HRD strategies of respective SAUs
11. Analysis of existing HRD strategies of respective Institutions
12. Presentation of reports with recommendations
13. Preparation of CM of the organization and planning for planned change
14. Preparation of PCM of the organization and planning for planned change
15. Presentation of reports
16. End term assessment

VI. Suggested Reading

- Brown D. 2010. *Experiential Approaches to Organization Development*. (8th Ed.), Prentice Hall, New Jersey.
- Cheung-Judge M and Holbeche L. 2015. *Organization Development: A Practitioner's Guide for OD and HR*. 2nd Ed., Kogan, London.
- Cummings TG and Worley CG. 2014. *Organization Development and Change*. 10th Edition, West Publishing Company, New York.
- David M. 2009. *Human Resource Development*. Oxford University Press, Delhi.
- Haldar UK. 2010. *Human Resource Development*, Oxford University Press India.
- Harris DM and Desimonerady L. 2001. *Human Resource Development*. The Dryden Press, Orlando.
- Harvey DF and Brown DR. *An Experimental Approach to Organization Development*. Prentice-Hall, Englewood Cliffs, N.J. Mankin D. *Human Resource Development*. Oxford University Press, India.
- Pace RW, Smith Philip and Mills GE. 1991. *Human Resource Development*. The Field, Prentice Hall, New Jersey.
- Traeger J and Warwick R. 2018. *Organization Development: A Bold Explorer's Guide*. Libri Publishing, Farringdon, England.
- International Journal of Human Resources Development and Management
- IOSR Journal of Humanities And Social Science
- European journal of work and organizational psychology
- Human Resource Development Quarterly (Online)
- Human Resource Development International
- International Journal of Human Resource Studies

I. Course Title : Educational Technology

II. Course Code : EECM 508

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Overview of educational technology

Meaning; Concepts and scope of educational technology; Curriculum design and development; Lesson planning; Concept and methodology; Modularised instruction - fundamentals, process, formulation of objectives, selection of media, field testing and evaluation of module.

Unit II: Teaching learning process

Meaning and characteristics of teaching and learning; Maxims of teaching - stages, forms and levels of teaching and learning; Motivation - concept, importance and techniques; Teaching styles - expert, formal authority, personal model, facilitator, delegator; Learning Styles - visual, aural, read/write, kinaesthetic (VARK).

Unit III: Teaching learning strategies

Microteaching; Programmed instruction; Simulation role-play; Team teaching; Experiential learning; Traditional media; ICT Applications in education; Multimedia based teaching and learning.

Unit IV: Current education

Genesis and trends; Management of formal and non formal education in India; Vocationalization of education; Distance education; Guidance and counselling; Innovative instructional aids - web instruction, e-learning, virtual laboratories.

Unit V: Educational technology for differently able

Visual impaired script - advances in braille; Hearing impaired - advances in Indian sign language; People with special needs - educational programmes and government policies.

Unit IV: Evaluation

Question bank; Introduction to evaluation - need and importance in education appraisal of teacher performance; Development of question bank; Evaluation of instructional effectiveness; Competency based question paper; Reliability and validity of question papers.

V. Practical

1. Identification of key terms in educational technology and preparation of directory
2. Critical analysis of UG and PG curriculum of Community Science in relation to course objectives
3. Research review on planning and implementation of lesson planning
4. Presentation of research review report
5. Preparation of lesson plan
6. Conducting class as per lesson plan and self and peer evaluation
7. Preparation of inventory for identification of teaching styles and execution
8. Preparation and presentation of report
9. Preparation of inventory for identification of learning styles and execution
10. Preparation and presentation of report
11. Construction of Objective questions- Multiple choice, fill in the blanks
12. Construction of competency based question paper- Matching, Technical terms
13. Construction of subjective questions- Short type
14. Construction of subjective questions- Essay type
15. Analysis of questions in terms competency evaluation- knowledge, memory,

application, analysis

16. End term assessment

VI. Suggested Reading

- Dahama OP and Bhatnagar OP. 2005. *Education and Communication for Development*. Oxford & IBH.
- Bhaviskar SG. 2006. *Modern Technology in Education*. Kalyani Publication, New Delhi.
- Suhaskumar and Ruprao P *Modern Trends in Curriculum Organization*. Kalyani Publication, New Delhi.
- Heidi HJ. 2010. *Curriculum Essential Education for a Changing World*.
- Kochhar SK. 1985. *Methods and Techniques of Teaching*. Sterling Publication.
- Ray GL. 2006. *Extension Communication and Management*. Kalyani Publication, New Delhi.
- Anita S *Encyclopaedia of Curriculum Reforms and New Teaching Methods* (*4 Vol. Set*). Dominant Publishers and distributors, New Delhi.
- The International Journal of Educational Technology in Higher Education
- *International Journal of Educational Technology* (ISSN 2476-0730)

I. Course Title : Group Dynamics
II. Course Code : EECM 509
III. Credit Hours : 2 (2+0)

IV. Theory

Unit I: Introduction to group and group dynamics

Meaning; Characteristics; Types and functions of groups; Stages and process of group formation; Group norms and structure; Values; Ethics; and Morals.

Unit II: Understanding group behaviour

Definitions; Theories - social comparison, cognitive dissonance, self presentation, drive, social impact, self attention, social cognition theories; Individual; Interpersonal and human behaviour and dimensions.

Unit III: Group dynamics

Cooperation; Competition; Communication; Group pressure; Group cohesiveness; Group leadership; Measurement of group dynamics - tools and techniques; Group break down - causes and solutions; Strengths; Weaknesses and myths; Crowds and the mob mentality; Diversity and difference; Group dynamic skills - training and development.

Unit IV: Managing group

Team building; Conflict management; Stress management; Active listening and feedback; Achieving cooperative group structure.

Unit V: Understanding collective action in groups

Collective action meaning; Theories and applications; Incentives for collective action; Research reviews on collective action for sustainable group dynamics.

V. Suggested Reading

- Ernest S and Sharon AR. 1985. *Effective Group Communication- How to Get Action by Working in Groups*. National TeXtbook Company, Lincolnwood.
- George RG. 2011. *Chapter on Theories of Group Behavior:* Commentary.
- Mary AG and Hennen. 2009. *Stages of Group Development*. Shared by EXtension Center for Community Vitality, 10-21-14.
- Mary S. 2010. *Book of Conflict Resolution Games Quick, Effective Activities to Improve Communication, Trust, and Collaboration*. ISBN: 978-0-07-174366-2.
- Smith GE. 2001. *Group Development: A Review of Literature and A Commentary on Future Research Directions. Group Facilitation.*
- Susan WA. 2005. *Facilitating Group Communication.* The Handbook of Group Research and Practice, Sage Publications, Inc, Thousand Oaks.
- Vanni F. 2014. *The Role of Collective Action.* Agriculture and Public Goods, 21. DOI 10.1007/ 978-94-007-7457-5_2, © Springer Science +Business Media Dordrecht.
- *Managing Stress*. 2010. MTD Training and Ventus publication Aps. ISBN-978-87-7681-658-2. https://www.mindtools.com/pages/article/newTMM_79.htm

I. Course Title : Community Development and Outreach

II. Course Code : EECM 510

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Community development

Definition; Issues and concepts; Historical perspective of community development in India and emerged changes since inception to current era.

Unit II: Approaches

Approaches - concept and characteristic features gandhian approach, community development approach, sectoral approach, target approach, area approach, minimum need approach, integrated or holistic approach, participatory development approach; Strategies - multipurpose strategy, growth oriented strategy and spatial planning strategy; The modernization theory; Human development model (components, HDI, ranking, gender related development index, HPI)

Unit III: Key principles of community development

Community participation - definition and scope; Inclusion; Equality; Collective action; Empowerment and community development process; Provision of information; Identification of felt needs and common issues; Consultation for Shared vision; Mobilisation for action; Reflection and evaluation.

Unit IV: Community development and governance in India

Community development policy in India; Community development perspectives in five year plans.

Unit V: Cross cutting edges of community development

Horizontal edges - education, health, women empowerment, skill development, agriculture and caste occupations; Vertical edges - adults, youth, adolescents, children, pregnant and lactating mothers, physically and mentally challenged.

Unit VI: Outreach of community development

General orientation to outreach models - precede model, evaluation and indicator metrics; Outreach of urban; Rural and tribal community development programmes; Impact - economic and social perspectives.

Unit VII: Globalisation impact on community development

Impact on social forms - individualism, enclavism and fatalism, transition between **gemeinschaft and gesellschaft, issues of migration and mitigation.**

V. Practical

Development of special project to study Community Development programme outreach in selected areaand execution Preparation of project report and presentation.

1. Selection of Community development programme and detailed description of the programme in terms of objectives, targets, inputs, expected outputs and outcome
2. Visit to programme operating area and interaction with stakeholders-implementing agency, personnel and beneficiaries
3. Visit to programme operating area and interaction with stakeholders-implementing agency, personnel and beneficiaries
4. Framing of special project for measurement of outreach – title, objectives, study area, research review and plan of work
5. Selection of Community development programme and detailed description of the programme in terms of objectives, targets, inputs, expected outputs and outcome

6. Visit to programme operating area and interaction with stakeholders-implementing agency, personnel and beneficiaries
7. Visit to programme operating area and interaction with stakeholders-implementing agency, personnel and beneficiaries
8. Framing of special project for measurement of outreach – title, objectives, study area, research review and plan of work
9. Finalisation of tools and techniques for eXecution of project
10. Finalisation of tools and techniques for eXecution of project
11. Preparation of tools for eXecution of project
12. Field testing and finalization

of tools9-12. EXecution of work plan

12. Data analysis and preparation of project report
13. Data analysis and preparation of project report
14. Presentation of report
15. End term assessment

VI. Suggested Reading

- Jerry WR and Gary P. 2014. *Introduction to Community Development*: *Theory*, *Practice*, *and Service-Learning*. 1st Edition, *ISBN*-13: 978-1412974622 ISBN-10: 1412974623
- Manohar P. 2014. *Social and Community Development Practice* http://dX.doi.org/10.4135/9789351507987
- Marianne R, Woodside and Tricia McClam. 2015. *An Introduction to Human Services*. 8th Edition, ISBN-13: 978-1285749907 ISBN-10: 1285749901
- Patil AR. 2013. *Community Organization and Development*: *An Indian Perspective*. PHI Learning Private Limited, Delhi 110092ISBN 978-81-203-4694-9
- Rhonda P and Robert P. 2015. *An Introduction to Community Development* (*Volume 1*) 2nd Edition, ISBN-13: 978-0415703550 ISBN-10: 0415703557
- *A Step by Step Guide to 'Turning Outward' in Your Community*. American Library Association. http://www.ala.org/tools/sites/ala.org.tools/files
- From Project to Branch Integration and Sustainability: Community-Led Work. http://publiclibrariesonline.org/2013/04/from-project-to-branch-integration-and-sustainability-community-led-work-at-halifaX-public-libraries

I. Course Title : Climate Change Management

II. Course Code : EECM 511

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Basics of climate and climate change

Introduction to climate and climate change - Definition and meaning; Climate change classification; Method of classification; General concept of environmental Science; Natural and manmade causes of climate change; Affects for climate change; Consequences risks and uncertainty of climate change; Climate system; Major predictions.

Unit II: Greenhouse gases and global warming

Major greenhouse gases and sources; Global warming effect and causes, Responses to global warming; Different views on greenhouse gases and global warming natural resource management; Solid waste management; Biodiversity; Alternative livelihood security; Drought prone technologies.

Unit III: Climate change Impacts

Impacts on biodiversity - wetland, forest, agriculture, transportation, coastal area, water resources; Global, National and regional impacts; Vulnerability assessment; Climate modelling.

Unit IV: Climate change policy

Introduction; Various policies in India; National action plan; Sector specific policies and policies instruments; Environment impact assessment; Environment planning and management; Climate resilient technology.

Unit V: Climate change communication

Introduction - definition, perspectives and importance; Engaging climate change communication; Audiences; Frames; Values and Norms.

Unit VI: Visual communication on climate impacts and solutions

Theories of visual perception; Classification and selection of visuals.

Unit VII: Advocacy and communicating global climate action

National international advocacy groups and organisations; Strategies and programmes.

Unit VIII: Role of stake holders

Media; Scientific Experts; Policymakers; and academic institutions on climate change communication.

V. Practical

1-4. Visit to Climate management organization to understand strategies and observe the impacts

5. Identification of climate management needs at home level and development of suitable technology- Apparel and textiles
6. Identification of climate management needs at home level and development of suitable technology- Food and Nutrition
7. Identification of climate management needs at home level and development of suitable technology- General health
8. Identification of climate management needs at home level and development of suitable technology- domestic appliances and arrangements
9. Identification of climate management needs and development of suitable

technology- Children and senior citizens.

10. Identification of climate management needs and development of suitable technology- differently able
11. Preparation of climate communication media – print
12. Preparation of climate communication media – radio
13. Preparation of climate communication media – video
14. Preparation of climate communication media – blog/web writing
15. Exhibition on climate change management
16. End term assessment

VI. Suggested Reading

- Gopal B. 2004. *Global Warming and Climate Changes: Transparency and Accountability*. 3 ISBN-10: 8182050782 ISBN-13: 978-8182050785
- Kandarp TP and Vaishnav. 2018. *Climate Change Solutions, Global Warming Solutions and Innovative Ideas for Construction of World Development*. Notion Press; 1 edition ISBN-10: 1643241818 ISBN-13: 978-1643241814
- Lenka S and Lenka NK. 2013. *Climate Change and Natural Resources Management*. New India Publishing Agency SBN-10: 9789381450673 ISBN-13: 978-9381450673
- Mark M. 2009. *Global Warming: A Very Short Introduction*. ISBN-10: 0199548242 ISBN-13: 978-0199548248
  http://envfor.nic.in/e-books
- *Climate Change: Impacts, Vulnerabilities and Adaptat.ion in Developing Countries*. https://unfccc.int/resource/docs/publications/impacts.pdf
- Mom L and Pin M. 2010. *Education Sector Responses to Climate Change Background Paper with International Examples*. UNESCO Bangkok Asia and Pacific Regional Bureau for Education, Bangkok, Thailand.
- *Journal of Climate Change* https://www.iospress.nl/journal/journal-of-climate-change

I. Course Title : Gender Sensitization For Empowerment

II. Course Code : EECM 512

III. Credit Hours : 2 (2+0)

IV. Theory

Unit I: Overview of gender

Concept; Meaning and related terms; Gender sensitization - concept, meaning and importance of gender sensitization; Gender and empowerment - meaning, definitions and need; Gender issues in home - community and organization.

Unit II: Gender issues

Gender issues and challenges in development; Understanding gender and subordination of women; Gender as a development tool; Policy approaches for women development; Gender perspectives in development of women - roles, responsibilities, access and control over resources, constraints and opportunities.

Unit III: Gender tool kit for assessment of gender empowerment

Gender budgeting and gender analysis framework - context, activities, resources and programme action profile; Concept of GDI, GEM, GSI; National and regional indicators.

Unit IV: Gender issues and development

National policy for empowerment of women since independence; Interventions to enhance women's empowerment at individual; Community and national level; Livelihood implications of gender - health and nutrition, agriculture, violence, governance, education, media and legal issues.

V. Practicals

1. Simulation role play to understand sex and gender, gender blind: gender aware: gender sensitive: gender equity.
2. Critical analysis of status of women in different sectors
3. Presentation of reports
4. Public speaking on Gender issues- Gender mainstreaming
5. Public speaking on Gender issues- Drudgery
6. Public speaking on Gender issues- Agriculture and allied sectors
7. Public speaking on Gender issues- Health and Nutrition
8. Public speaking on Gender issues- Business and Enterprise
9. Public speaking on Gender issues- Politics and Public administration
10. Preparation of case studies on selected issues/personalities
11. Gender sensitive interventions in SAUs and their objectives and frame work
12. Critical analysis of selected interventions and projects in operation
13. Preparation of report
14. Presentation of report
15. Critical review of Gender policy of GOI
16. End term assessment

VI. Suggested Reading

- Adriana DS. 2010. *Gender Issues and International Legal Standards: Contemporary Perspectives*. Publisher, Catania, Italy.
- Grover I and Grover D. 2002. *Empowerment of Women*. Agrotech Publ. Academy.
- Sahoo RK and Tripathy SN. 2006. *SHG and Women Empowerment*. Anmol Publ.
- Sinha K. 2000. *Empowerment of Women in South Asia*. Association of Management Development Institution in South Asia, Hyderabad.
- *Gender Budgeting Handbook for Government of India Ministries and Departments* (2007) Ministry of Women and Child Development, GOI http://wcd.nic.in/gender-budgeting.
- *Measuring Women's Empowerment:* An assessment of the Gender-related Development Index

and the Gender Empowerment Measure www.tandfonline.com
- *A Toolkit for Women's Empowerment and Leadership in Health and Welfare* http://www.who.int/kobe_centre/publications/womens_empowerment 2005.pdf
- *Indicators for Gender Equality and Women's Empowerment* – An Introduction http://www.oecd.org/development/gender-development/43041409.pdf
- Indian Journal of Gender Studies
- International Journal of Gender and Women's Studies

Course Title with Credit Load
Ph.D. (Community Science) in Extension Education and Communication Management

Course Code	Course Title	Credit Hours	Semester
EECM 601*	Managerial Skills for Extension Professionals	3 (2+1)	
EECM 602	Impact Assessment of Development programmes	3 (1+2)	
EECM 603*	Scaling Techniques for Behaviour Research	3 (1+2)	
EECM 604	Design and Development of e-Extension Project	3 (0+3)	
EECM 605	Sustainable Livelihood Systems	2 (1+1)	
EECM 606	Extension Research Project Management	3 (1+2)	
EECM 607	Media application and Product Promotion	4 (2+2)	
EECM 608	Advocacy and Behavior Change Management	3 (1+2)	
	Minor Courses**		
FN 604	Global Nutrition Problems	2(2+0)	
FN 608	Energy Metabolism	2(2+0)	
HDFS 608	Qualitative research methods	3(2+1)	
ATS 602	Technical Textiles	3(2+1)	
ATS605	Functional Clothing	3(2+1)	
ATS 607	Operational Management in Textiles and Apparel	2(2+0)	
RMCS 603	Globalization and Consumer Economics	3 (2+1)	
RMCS 606	Environmental Issues and Challenges	2 (2+0)	
RMCS 607	Family Dynamics and Women Power	3 (2+1)	
	Supporting Courses		
	Student can choose any course relevant to the research from other faculties of the University or from Swayam portal or online courses.		
EECM 691	Doctoral Seminar I (Optional Field)	1 (1+0)	
EECM 692	Doctoral Seminar II (Core Field)	1 (1+0)	
EECM 699	Research	75	
	Total	**100 Credits**	

*Compulsory core curses

Course Contents
Ph.D. (Community Science) in Extension Education and Communication Management

I. Course Title : Managerial Skills for Extension Professionals

II. Course Code : EECM 601

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Orientation to management

Concept; Process; Functions; Management problems in extension organizations; Managerial skil1 – definition, nature and importance; Skills for effective management of extension activities and organizations.

Unit II: Theories of management

Scientific theory; Administrative theory; Bureaucratic theory; Human relations theory; Systems theory y; X&Y theory.

Unit III: Strategic planning

Importance; Steps and techniques; Concept of management by objective (MOB) as applicable to extension organizations; Techniques of transactional analysis for improving interpersonal communication.

Unit IV: Contemporary professional management trends

Artificial intelligence (AI), Unified talent management (UTM); Self-directed micro learning (SDML); Personalisation; Design thinking; Augmented reality and virtual reality tools (AR&VR).

Unit V: Creative problem solving techniques

Stress management practices; Total quality management (TQM); Team building and management; Concept of learning organization; Time management practices; Management of information system; Self-management techniques.

Unit VI: Work motivation

Organizational climate; Resource management - concept and methods; Team building- process and strategies at organizational and village levels; Mobilization and empowerment skills; Concept and strategies in mobilization; Concretisation and empowerment of rural people.

V. Practicals

1. Identification of professional management skills required for extension organisation through literature survey
2. Finalisation of major and specific professional management skills
3. Preparation of case studies of professional extension management professionals and visual presentation
4. Preparation of inventories for identification of professional skills
5. Finalisation and presentation of inventories for identification of professional skills
6. Execution of inventories- interviews with extension professionals in Government organisations
7. Execution of inventories- interviews with extension professionals in Non-Government organisations
8. Compilation and analysis of data
9. Report writing and presentation of data with special reference input training for

professional skills

10. Hands-on-training for selected professional skills
11. End term assessment

VI. Suggested Reading

- Basford TE, Offermann and Lynn R. 2012. Beyond Leadership: The Impact of Coworker Relationships on Employee Motivation and Intent to Stay. *Journal of Management and Organization* Vol. 18, No. 6.
- Chitale AK, Rajendraprasad Nishith M and Dubey R. 2012. *Organizational Behaviour: Text and Cases*. Prentice Hall India Learning Private Limited SBN-10: 8120346963 ISBN-13: 978-8120346963.
- Craig C and Pinder. 2008. *Work Motivation in Organizational Behavior*. 2nd Edition Psychology Press. ISBN-13: 978-0805856040 ISBN-10: 0805856048.
- Kumar Sanjeev and Dash MK. 2011. Management education in India: Trends, issues and implications. *Research Journal of Internatýonal Studýes*. Issue 18 January, 2011.
- Prasad LM. 2015. *Principles and Practice of Management*. Sultan Chand & Sons-New Delhi ISBN-10: 9351610500 ISBN-13: 978-9351610502
- Rajan G. 2007. *Marketing Management: Concepts*, *Cases*, *Challenges and Trends*. 2nd Edition, Prentice Hall India Learning Private Limited, ISBN-10: 8120332598, ISBN-13: 978-8120332591.

I. Course Title : Impact Assessment of Development Programmes

II. Course Code : EECM 602

III. Credit Hours : 3 (1+2)

VI. Theory

Unit I: Orientation to development programme

Development issues and goals; National and International Perspectives - goals, strategies, structure and achievements.

Unit II: Analysis of contemporary national development programmes

Public Health; Nutrition; Education; Environment; Employment; Income generation; Welfare; Marketing; Human Resource Development - objectives, clients, salient features, inputs, deliverables, outputs and outcomes.

Unit III: Orientation to impact assessment

Sustainability impact; Social impact; Health impact; Environmental and institutional impact - frame works and element; Log frame analysis.

Unit IV: Impact identification and prediction

Identification techniques - checklist, matrices, networks, overlays, expert systems, professional judgements; Prediction methods - extrapolative-trend and scenario analysis, analogies; Intuitive forecasting from group consensus(Delphi technique); Normative methods - mathematical models, statistical models, field and laboratory experiment methods, physical models and expert judgement.

VII. Practical

1. Documentation of exiting national and international development programmes and their objectives
2. Presentation and group discussion on developmental issues of each programme
3. Research review on development policy of India and developed countries
4. Presentation of comparative analysis
5. Preparation and presentation of case study on impact of Public Health programmes
6. Preparation and presentation of case study on impact of Nutrition programmes
7. Preparation and presentation of case study on impact of Education programmes
8. Preparation and presentation of case study on impact of Environment programmes
9. Preparation and presentation of case study on impact of Employment programmes
10. Preparation and presentation of case studyon impact of Income generation programmes
11. Preparation and presentation of case study on impact of Welfare programmes
12. Preparation and presentation of case study on Marketing programmes
13. Consolidate report writing focusing on inputs, deliverables, outputs and outcome of every programmes and analysis of achievements and gaps.
14. Hands-on-experience on impact assessment – measurement of sustainability impact
15. Hands-on-experience on impact assessment – measurement of social impact
16. Hands-on-experience on impact assessment – Health impact
17. Hands-on-experience on impact assessment – Environment
18. Hands-on-experience on impact assessment – Long frame analysis
19. Hands-on-experience on impact assessment – Institutional impact
20. Hands-on-experience on impact identification techniques- Checklist
21. Hands-on-experience on impact identification techniques- Matrices
22. Hands-on-experience on impact identification techniques- Networks

23. Hands-on-experience on impact identification techniques- Overlays
24. Hands-on-experience on impact identification techniques- Expert systems
25. Hands-on-experience on impact identification and prediction techniques- Professional judgements
26. Hands-on-experience on impact prediction techniques- Trend and scenario analysis
27. Hands-on-experience on impact prediction techniques- Delphi technique
28. Hands-on-experience on impact prediction techniques- Statistical model
29. Hands-on-experience on impact prediction techniques-Field and laboratory experiment methods
30. Selection and planning for impact analysis development programme
31. Presentation and group discussion
32. End term assessment

VIII. Suggested Reading

- Anjaneyulu Y. 2010. *Environmental Impact Assessment Methodologies.* BS Publication.
- Arland T. 2012. *Knowledge and Beliefs about National Development and Developmental Hierarchies: the Viewpoints of Ordinary People in Thirteen Countries.* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3462366/
- Fateh Azzam. 2013. *The Right to Development and Implementation of the Millennium Development Goals.* http://www.academia.edu
- *E-Book of Ministry of Rural Development.* https://www.india.gov.in/download-e-book-ministry-rural-development
- Mc Donnell Ida *An International Perspective On Communication Strategies For The Millennium Development Goals.* http://www.oecd.org/development
- Lincoln CC *Nutrition in Developing Countries and the Role of International Agencies: In Search Of A Vision.* https://www.ncbi.nlm.nih.gov/books/NBK231298/
- Asian Development Bank (2018) *Health Impact Assessment,* Asian Bank Publication.
- *Impact Evaluation in Practice*. Second Edition. World Bank Group and the Inter-American Development Bank.

I. Course Title : Scaling Techniques for Behaviour Research

II. Course Code : EECM 603

III. Credit Hours : 3 (1+2)

IV. Theory

Unit I: Introduction

Definition - scaling techniques and behaviour research; Need and importance; Attitude, Knowledge and Practice measurement techniques and relevance to behaviour research.

Unit II: Structured techniques

Nominal; Ordinal; Interval; Ratio scales; Self rating scales- graphic rating scale; Itemized rating scales- likert scale, semantic differential scale, stapel's scale, multi-dimensional scaling, thurston scales, guttman scales/scalogram analysis and the q sort technique.

Unit III: Non structured techniques

Projective - association, completion, construction, expressive, problems and promises; Word association; Sentence completion; Story completion and pictorial; Advantages and limitations for adoption in behaviour research.

Unit IV: Knowledge and practice tests

Knowledge - objective multiple choice questions (MCQs); True/False Assertion - reason questions; Multiple response questions (MRQs); Text/Numerical matching ranking questions; Sequencing questions; Field simulation questions; Graphical hotspot questions; and Subjective tests; Practice - worksheets, performance metrics.

Unit V: Scalability of techniques

Measurement of Reliability and Validity of scales.

V. Practical

1. Presentation of research review on need and importance of scaling techniques in behavior research
2. Review and presentation of research articles on different scaling techniques Self rating scales- Graphic Rating Scale
3. Review and presentation of research articles on different scaling techniques Itemised rating scales-Likert Scale
4. Review and presentation of research articles on different scaling techniques-Semantic Differential Scale
5. Review and presentation of research articles on different scaling techniques-Stapel's Scale
6. Review and presentation of research articles on different scaling techniques-Multi-Dimensional Scale
7. Review and presentation of research articles on different scaling techniques-Thurston Scale
8. Review and presentation of research articles on different scaling techniques-Scalogram Analysis
9. Review and presentation of research articles on different scaling techniques-The Q Sort technique
10. Review and presentation of research articles on Projective techniques- association and sentence completion
11. Review and presentation of research articles on Projective techniques-Construction, and expressive

12. Review and presentation of research articles on Projective techniques- Problems and promises
13. Review and presentation of research articles on Projective techniques- Word association
14. Review and presentation of research articles on Projective techniques- Story completion and pictorial
15. Development of Self rating scales- Graphic Rating Scale
16. Execution and presentation of results
17. Development of Self rating scales- Likert Scale
18. Execution and presentation of results
19. Development of Self rating scales- Semantic Differential Scale
20. Execution and presentation of results
21. Development of Self rating scales- Stapel's Scale
22. Execution and presentation of results
23. Development of Self rating scales- Multi Dimensional Scale
24. Execution and presentation of results
25. Development of Self rating scales- Thurston Scale
26. Execution and presentation of results
27. Development of Self rating scales- Scalogram Analysis
28. Execution and presentation of results
29. Development of Self rating scales- Q sort technique
30. Execution and presentation of results
31. Hands-on-experience in writing research article on scale development
32. End term assessment

VI. Suggested Reading

- Colleen K. 2012. *Measurement in Health Behavior: Methods for Research and Evaluation*. 1st Edition. Jossey-Bass Publishers; ISBN-10: 9780787970970 ISBN-13: 978-0787970970
- Donnellan MB, Lucas RE and Fleeson W. 2009. *Introduction to personality and assessment at age 40: Reflections on the legacy of the person-situation debate and the future of person-situation integration. Journal of Research in Personality*. 43, 117-119.
- Eid M and Diene E. 2006. *Handbook of Multi Method Measurement in Psychology*. American Psychological Association, Washington, DC.
- Gaudry E Vagg P and Spielberger CD. 1975. *Validation of the state-trait distinction in anxiety research. Multivariate Behavioral Research*. 10, 331-341.
- Hampson SE and Goldberg LR. 2006. *A first large cohort study of personality trait stability over the 40 years between elementary school and midlife. J Pers Soc Psychol*. 91(4) 763-779.
- Jagadish R Raiyani. 2012. *Research Methodology: Theory and Teachniques*. New Century Publications ISBN: 9788177082944, 8177082949
- John A and Swets Signal. 2009. *Detection Theory and ROC Analysis in Psychology and Diagnostics*.Collected Papers www.questia.com/library
- Paul E, McNamara and Joyous S Tata. 2015. *Principles of Designing and Implementing Agricultural Extension Programs for Reducing Post-harvest Loss. Agriculture*. 5, 1035-1046; doi: 10.3390/agriculture 5041035
- Peter D, Gerald A, Susan and Shuqiang Z. 2004. *Scaling Method*. 2nd Edition. Lawrence Erlbaum Associates.
- Shuchi M. 2017. Scaling techniques of attitude measurement. *International Journal of Advanced Education and Research*. ISSN: 2455-5746, Impact Factor: RJIF 5.34 www.alleducationjournal.com Volume 2 Issue 2, March 2017; Page No. 41-50.
- Chapter 3: *Levels of Measurement and Scaling* http://www.fao.org/docrep/w3241e/w3241e04.htm

I. Course Title : Design and Development of E-extension Project

II. Course Code : EECM 604

III. Credit Hours : 3 (0+3)

VI. Practicals

1. Orientation to e-eXtension projects- Knowledge projects-moocs
2. Orientation to e-eXtension projects -Marketing projects- e choupla
3. Orientation to e-eXtension projects- Bulk SMS (TeXt and Voice) MMS
4. Orientation to e-eXtension projects- Video lessons
5. Orientation to e-eXtension projects-Virtual class rooms
6. Orientation to e-eXtension projects- Off line and Online Community Radio.
7. Interaction with personnel/professionals for understanding of media tools, hardware requirements of e-EXtension projects
8. Interaction with personnel/professionals for understanding of media tools software requirements of e-EXtension projects
9. Report writing and presentation
10. Identification of needs for skill development and proposal for skill training to undertake e-EXtension project- application of software, access to hardware, etc.
11. Orientation to eXisting e-EXtension projects of respective SAUs
12. Hands-on-eXperience in e- EXtension projects of SAUs - content development, management and analytics report
14. Selection of multimedia e-EXtension project and submission of proposal-knowledge management, product promotion, message alerting, analytical reports, etc. (EXample Digital literacy promotion, Audio/ Video streaming, Social media for product promotion)
15. Presentation of proposal
16. Content development and time lines for eXecution of project

17-23. EXecution of project and measurement of analytics as per time line

24. Report writing and presentation
25. Practical eXamination

VII. Suggested Reading

- Martin M. 2016. *Editorial – Extension education theory and research in India*. Pages 105-109 www.tandfonline.com
- Paul E McNamara and Joyous S. 2015. *Principles of Designing and Implementing Agricultural Extension Programs for Reducing Post-harvest Loss Agriculture 2015*, 5, 1035-1046; doi: 10.3390/agriculture5041035
- Richard F, Douglas A and Carolyn W. 2003 *National "e-Extension" Programs*: *Feasibility and Structure*, American Agricultural Economics Association Annual Meeting, Montreal, Canad.
- Ujjwal K, Abhay K and Thakur PK. 2012. *Status of Agricltural Development in Eastern India*. Chapter 7.1 Status and Constraints ofwww.researchgate.net on 'e- EXtension http://www.manage.gov.in/ftf-itt/prgReports/afgan.pdf
- Volker H, Maria GB, Anja C and Mamusha L. *Handbook: Rural Extension Volume 1 Basic Issues and Concepts*. Scientific books, Margraf Publishers, GmbH, Government of India Planning Commission Report of the Working Group on Agricultural EXtension for Agriculture and Allied Sectors for the Twelfth Five Year Plan(2012-17) http://planningcommission.gov.in
- ICT Applications in Agricultural EXtension Management. Report on USAID-INDIA-Afghanistan Feed The Future India Triangular Training (FTF ITT) Programme on 'e- EXtension http://www.manage.gov.in/ftf-itt/prgReports/afgan.pdf

I. Course Title : Sustainable Livelihood Systems

II. Course Code : EECM 605

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Orientation to livelihood system

Livelihood perspectives - definition, approaches and frame works; Livelihoods and life support systems; Designing livelihood interventions; Process; Tools and technique.

Unit II: Sustainable livelihood systems

Definition; Origin; Principles; Livelihoods - agriculture, horticulture, sericulture, forestry, animal husbandry, dairying, fisheries, non-farm activities; Urban livelihoods - linkage with food security, nutritional security, health security, livelihood security; Measuring sustainable livelihood systems.

Unit III: Critical understanding of livelihood interventions

Intervention of national and international organisations - agriculture based, forest based, non-farm based, market-led based; DFID sustainable livelihoods framework - elements, vulnerability context, policies, institutions and processes, coping and adaptive strategies.

- Unit IV: Sustainable development concepts and challenges

Sustainable development concepts and challenges; Ecological; Social and economic dimensions of sustainable development; Peoples participation and sustainability; Indicators of environmental sustainability; Sustainable livelihoods; Quality of life.

Unit V: Livelihood analysis tool kit

Operational model - tools, process; Gaps and challenges; Institutional issues; Participatory methods for analysis.

VIII. Suggested Reading

- Alan de B and Suryanarayana MH. 2015. Linkages between poverty, food security and undernutrition: evidence from China and India. *China Agricultural Economic Review*. Vol. 7 Issue: 4, pp.655-667
- Baumgartner R and Högger R. 2004. *In Search of Sustainable Livelihood*, *Managing Resources and Change*, Sage publications, New Delhi.
- Bijju MR. 2008. *Panchayati Raj System: Towards Sustainable Rural Livelihood and Development*. Kanishka Publishers, Distributors ISBN-10: 9788184570557
- Harishkumar HV. 2012. *Livelihood Security of Farm Households Under Different Farming Systems In Kolar District Of Karnataka – An Economic Analysis*. University of Agricultural Sciences, Bangalore. http://krishikosh.egranth.ac.in/bitstream/1/89107/1/Thesis.pdf
- Scoones Ian. 2015. *Sustainable Livelihoods and Rural Development*. Practical Action Publishing
- Nadel. 2007. *Working with a Sustainable Livelihoods Approach*. NADEL, Zurich, Bern: SDC. www.povertywellbeing.net
- Premchander S and R Menon. 2006. Engendering Development: Challenges and Opportunities for Mainstreaming Gender in Development Policy. In Premchander, S. & C. Mueller 2009 *Gender and Sustainable Development: Case Studies from the NCCR North-South. Perspectives of the Swiss NCCR North-South*, University of Bern. Vol. 2. Bern: Geographica Bernensia.
- *Livelihood Manual Integrated Watershed Management Programme* (*IWMP*). 2012. Commissionrate of Rural Development. www.ruraldev.gujarat.gov.in
- Food security: concepts and measurement. http://www.fao.org/docrep/005/y4671e/y4671e06.h

I. Course Title : Extension Research Project Management

II. Course Code : EECM 606

III. Credit Hours : 3 (1+2)

IV. Theory

Unit I: Overview to extension research

Definition; Concepts; Models- linear, advisory, facilitation; Types - advisory services, value chains, supply chains, incubation centres, knowledge management; Market led eXtension; Demand driven eXtension; Enterprise eXtension; Mainstreaming eXtension.

Unit II: Areas of extension research

Policy analysis; Gender issues; Public and private partnership; Product eXtension;

Process extension; Behaviour change - health security, nutritional security, food security; Impact analysis - technology, training; Funding agencies and project proposal formats.

Unit III: Research project management practices

Project charter and mission; Project life cycle; Project network diagram; Project progress/ performance measures; Project resource loading; Project SOW (statement of work); Project WBS (work breakdown structure) – budgeting, cost benefit analysis, resource management; Risk breakdown structure; SWOT.

Unit IV: Project management approaches and tools

Approaches - result oriented approach, constructivist approach, reflexive approach; Tools - PERT, CPM, GANNT.

V. Practical

1. Preparation and presentation of case study on linear model extension project
2. Preparation and presentation of case study on advisory model extension project
3. Preparation and presentation of case study on facilitation model extension project
4. Comparative analysis of different models of extension projects
5. Preparation and presentation of case study on advisory services
6. Preparation and presentation of case study on value chains
7. Preparation and presentation of case study on supply chains
8. Preparation and presentation of case study on incubation centers
9. Preparation and presentation of case study on knowledge management
10. Preparation and presentation of case study on market led extension
11. Preparation and presentation of case study on demand driven extension
12. Preparation and presentation of case study on enterprise extension
13. Preparation and presentation of case study on mainstreaming extension
14. Comparative analysis different extension projects
15. Identification of niche areas of extension research in Community Science discipline
16. Identification of organizations for extension research and presentation of organizational objectives
17. Critical analysis of formats for research project writing and presentation
18. Preparation of extension research project (2)
19. Revising the project as per suggestions
20. Presentation of case study on Project Life Cycle
21. Presentation of case study on Project Network Diagram
22. Presentation of case study on Performance Measures
23. Presentation of case study on Project Resource Loading
24. Presentation of case study on Project SOW (statement of work)
25. Presentation of case study on Project WBS (work breakdown structure)
26. Presentation of case study on cost benefit analysis,
27. Presentation of case study on Risk Breakdown Structure;
28. Visit to existing extension research projects of SAU for observation
29. Report writing
30. Presentation of report
31. End term assessment

VI. Suggested Reading

- Anandajayasekeram P, Puskur R, Sindu W and Hoekstra D. 2008. *Concepts and Practices in Agricultural Extension in Developing Countries*: *A Source Book*. IFPRI, Washington, DC,

USA.
- Annie SW and Merle F. 2014. *Background Paper: Research and Development and Extension Services in Agriculture and Food Security*. ADB Economics Working Paper Series, Asian Development Bank ISSN 1655-5252 Publication Stock No. WPS147021-3.
- Burton E Swanson and Riikka R. 2010. *Strengthening Agricultural Extension and Advisory Systems: Procedures for Assessing, Transforming, and Evaluating Extension Systems Agriculture and Rural Development*, Discussion Paper 45, The International Bank for Reconstruction and Development,The World Bank, NW Washington, DC.
- Dennis PM. 2010. *Building a Project Work Breakdown Structure: Visualizing Objectives, Deliverables, Activities, and Schedules*. ESI International Project Management Series, 1st Edition Auerbach Publications ISBN 9781420069693.
- Singh KM and Meena MS and Swanson BE. 2013. *Extension in India by Public Sector Institutions: An Overview*. ICAR-RCER, Zonal Project Directorate, Jodhpur, Patna, University of Illinois.
- Michelle JR, Jane MA, Anne-Maree S, Enly S and Helen T. 2009. *Can agricultural research and extension be used to challenge the processes of exclusion and marginalisation?* http://iari.res.in
- Ralf M and Jonas S. 2014. *Innovative Approaches in Project Management Research*. International Journal of Project Management. **33**(2) November 2014.
- Rodne JT, Martina H, Frank T Anbari and Christophe NB. 2010. *Perspectives on Projects*. Routledge Publishers, ISBN1135848831, 9781135848835.
- *Managing Projects with Openess Part 3*. Document No.16004, Version 1.5 https://idpasc.lip.pt

I. Course Title : Media Application and Product Promotion

II. Course Code : EECM 607

III. Credit Hours : (2+2)

IV. Theory

Unit I: Introduction to media applications

Internet media and globalization - concepts and theories; Technology and culture - debates, regulation, gatekeeping and ethics-case studies.

Unit II: Corporate online promotional strategies

Advertising and marketing; Public communication campaigns and global humanitarianism; Multiplatform journalism; Transnational citizen journalism; Grassroots activism and change.

Unit III: Media prospects of mass communication

Historical development and economic; Social and aesthetic impact on mass culture; Individual and mass consciousness.

Unit IV: Audience research

Definitions; Principles and features; Scope; BARC (Broad Cast Audience Research Council) India; Data management techniques and tools.

Unit V: Software access

Advanced new media; Design and edit software; Open and purchase sources; Application regulations; Ethics.

Unit VI: Product promotion

Search Engine Optimization; Social Media Marketing; E-mail marketing - creation, marketing campaign planning, development and execution; Research.

Unit VII: Social media platforms

Types; Optimization; Product page creation; Analytics.

Unit VIII: Social networking

SNS(Social Networking Sites) in India; Advantages and limitations; Critical analysis of role of SNS in mass communication.

Unit IX: Introduction to SEO

Targeting key words; Integrating search keywords; Search engines and directories; Page wise optimization process; Page title tags; META Description tag; META keywords Tag.

Unit X: Reports

Variables; Time line; Report access protocol; Documentation.

V. Practical

1. Identify and suggest the suitable keywords for a product
2. Adding keywords to website and blogs
3. Preparing Search Engine Optimization (SEO) friendly content for product website
4. Demonstration to get website listed among top Search in (SEO)
5. Demonstration on off page and on page in SEO
6. Identifying best practices for Social Media Marketing, including platform level best practices
7. Connecting product objectives to appropriate Social Media tactics
8. Creating strong content to engage target audience with marketing message
9. Creating events to manage content distribution
10. Creating Social Media policies that combine business objectives with appropriate

use of social media channels and content
11. Creating Fan Pages in Social media platforms
12. Hands-on-eXperience- learning targeting right audience
13. Hands-on-eXperience on process of running Facebook ads
14. Creating engaging post and creating brand for business
15. Creating channel on YouTube
16. Updating the profile on YouTube Channel
17. Understanding the Creator Studio of YouTube
18. Types of videos and different platforms of video creation
19. Creating videos- Hands-on-EXperience
20. Creating videos- Hands-on-EXperience
21. Uploading videos on YouTube
22. Practicing SEO of YouTube
23. Hands-on-eXperience on Page title tags
24. Hands-on-eXperience on META Description Tag
25. Hands-on-eXperience on META Keywords Tag
26. Promotion of videos
27. Promotion of product on YouTube
28. Online orientation to email marketing for product promotion.
29. Hands-on-eXperience on email marketing for product promotion.
30. Review of analytics of product promotion
31. Presentation of multimedia practice eXperience
32. End term assessment

VI. Suggested Reading

- Dave C and Smith. 2017. *Digital Marketing Excellence*. Taylor & Francis ISBN-10: 1138494232 ISBN-13: 978-1138494237.
- Godse and Godse. 2015. *Graphics and Multimedia for ANNA University*. (V-IT-2013 course) Technical Publications, Third edition ISBN-10: 9333202099 ISBN-13: 978-9333202091.
- Klara N and Ralf S. 2012. *Multimedia Applications*. Springer-verlag Gmbh ISBN: 9783642074103, 3642074103.
- Marshall S and Gohar Khan F. 2017. *Digital Analytics for Marketing*. Routledge Edition. ISBN-10: 1138190683 ISBN-13: 978-1138190689.
- Shajahan. 2010. *Strategic Marketing: Text and Cases Viva Books*. ISBN-10: 8130912694 ISBN-13: 978-8130912691.
- Simon K. 2010. *Digital Marketing Strategy: An Integrated Approach to Online Marketing*. ISBN-10: 0749484225 ISBN-13: 978-0749484224.
- *Convergence in Indian Media: a New Paradigm of ICT*
  www.researchgate.net/publication

I. Course Title : Advocacy and Behavior Change Management

II. Course Code : EECM 608

III. Credit Hours : 3 (1+2)

IV. Theory

Unit I: Advocacy

Meaning; Purpose and types of Advocacy; Tools; Techniques and approaches of advocacy; Elements of an advocacy strategy.

Unit II: Advocacy planning cycle

Planning advocacy campaigns for different stakeholders relationship between advocacy and development; Programme communication and social mobilization; Social marketing- models and approaches.

Unit III: Behaviour change communication

Concept; Approaches of BCC - functional approach, information processing approach, consistency approach, behaviour modification approach, health belief model and the bj fogg model of behavior change; Role of learning theories - social cognitive theory, theories of reasoned action and planned behaviour, trans theoretical model of behavior change.

Unit IV: Processes of behaviour change

Strategic issues and BCC (Health/ Environment/ Consumption); Analysis of BCC campaigns for social mobilization and policy change; BCC campaigns in core areas for stakeholders.

Unit V: Evidences of behaviour change

Global programs- evidences of WASH communication, HIV/AIDS communication, obesity communication, diabetic communication, concept of green marketing and cause marketing.

V. Practical

1. Interaction with Advocacy personnel to comprehend the advocacy approaches- working with HIV/AIDS patients
2. Interaction with Advocacy personnel- working with drug/alcohol addicts
3. Interaction with Advocacy personnel- Family/ Marriage issues
4. Interaction with Advocacy personnel- working with mentally challenged children
5. Preparation and presentation of report
6. Review of research on BCC approaches- Functional approach
7. Review of research on BCC approaches- Information processing approach
8. Review of research on BCC approaches- Consistency approach
9. Review of research on BCC approaches- Behavior modification approach
10. Review of research on BCC approaches- Health Belief model
11. Review of research on BCC approaches-BJ Fogg model of behavior change.
12. Report writing and presentation
13. Case study on Social marketing in India
14. Identification of Niche research in BCC
15. Presentation of researchable issues in BCC
16. End term assessment

VI. Suggested Reading

- Alan C. 2014. *An Introduction to Social Media Marketing*. Routledge Publishers, ISBN-10: 9780415856171 ISBN-13: 978-0415856171.
- Annette G and Claire B. 2013. *Advocacy and Policy Change Evaluation: Theory and Practice.*

1st Edition, ISBN-13: 978-0804792561 ISBN-10: 0804792569

- John AD. 2013. *Advocacy: Championing Ideas and Influencing Others*. 1st Edition, ISBN-13: 978-0300188134 ISBN-10: 0300188137.
- Nancy R Lee and Philip Kotler. 2011. *Social Marketing: Influencing Behaviors for Good*. Fourth Edition, ISBN-13: 978-1412981491 ISBN-10: 9781412981491.
- McKee Neill, Antje BB and Emily B. 2014. *Social and Behavior Change Communication*. https://doi.org/10.1002/9781118505328.ch17
- Kotler Philip. 2014. *Social Marketing –Strategies for Public Behaviour*. Routledge Publishers, ISBN-10: 9780415856171 ISBN-13: 978-0415856171.
- Sameer D and Nancy RL. 2014. *Social Marketing in India*. Sage Publications, SBN: 9788132113577.
- *Guidelines for Developing Behavioural Change Interventions in the Context of Avian Influenza Health Promotion and Education* (*HPE*). Department of Non-cummunicable Diseases and Mental Health World Health Organization, http://apps.searo.who.int
- *Strategic Communication - For Behaviour and Social Change In South Asia* (2005) The United Nations Children's Fund (UNICEF) Regional Office for South Asia.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 6

Community Science
– Food and Nutrition

Modifications Suggested in Courses in the Revised Curricula

M.Sc. (Community Science) in Food and Nutrition

Course Code	Course Title	Credit Hours	Remarks
	Major Courses (20 Credits)		
FN 501*	Macro and Micro Nutrients in Human Nutrition	3(3+0)	Content Modified
FN 502*	Public Health and Nutrition	3(2+1)	Content Modified
FN 503*	Techniques in Food Analysis	3(1+2)	Content Modified
FN 504*	Diet Therapy	3(2+1)	Content Modified
FN 505	Nutrition and Physical Fitness	3(2+1)	Content Modified
FN 506	Developments in Nutrition and Immunity	2(2+0)	Content Modified
FN 507	Clinical Nutrition	3(2+1)	Content Modified
FN 508	Nutrition Counselling	2(0+2)	New
FN 509	Food Safety and Standards	3(2+1)	
FN 510	Nutritional Challenges in Life Cycle	3(2+0)	Content Modified
FN 511	Food Science	3(2+1)	Content Modified
FN 512	Food Processing Technology	3(2+1)	Content Modified
FN 513	Human Physiology	3(3+0)	Content Modified
FN 514	Institutional Food Service Management	2(1+1)	Content Modified
	Minor Courses (08 Credits)		
	Food Science and Technology	3(2+1)	Course numbers will be assigned by the departments that offer the courses. Apart from these courses a student can register any other course offered by any other departments
	Food Biochemistry	3(2+1)	
	Nutritional Biochemistry	3(2+1)	
	Food Microbiology	3(2+1)	
EECM 504	Technology Transfer and Management	3 (1+2)	

Course Code	Course Title	Credit Hours	Remarks
EECM 505	Dynamic Communication Skills	3 (1+2)	
	Supporting Courses (06 Credits)		
	Research Methodology	3(2+1)	Course numbers will be assigned by the departments that offer the courses.
	Statistical methods and application		
	Common Courses (05 Credits)		
	Library and Information Services	1(0+1)	Common to all disciplines. The course numbers will be assigned by the departments that offer the courses
	Technical Writing and Communications Skills	1(0+1)	
	Intellectual Property and its management in Agriculture	1(0+1)	
	Basic Concepts in Laboratory Techniques	1(0+1)	
	Agricultural Research, Research Ethics and Rural Development Programmes	1(0+1)	
FN 591	Seminar	1(1+0)	
FN 599	Thesis/ Research	30	
	Total	**70 Credits**	

*Core courses/ compulsory courses

Ph.D. (Community Science) in Food and Nutrition

Course Code	Course Title	Credit Hours	Remarks
	Major Courses (12 Credits)**		
FN 601*	Macronutrient Metabolism	3(3+0)	Modified
FN 602*	Micronutrient Metabolism	2(2+0)	Modified
FN 603*	Nutrition and Agricultural Interface	3(3+0)	Modified
FN 604	Global Nutritional Problems	2(2+0)	
FN 605	Nutrition in Calamities	2(2+0)	Modified
FN 606	Maternal and Child Nutrition	2(2+0)	
FN 607	Hormones and Enzymes	2(2+0)	New
FN 608	Energy Metabolism	2(2+0)	Modified
FN 609	Application of Biotechnology in Food Science and Nutrition	3(3+0)	Modified
FN 610	Recent Trends in Food Science and Technology	3(3+0)	Modified
	Minor Courses (06 Credits)		
	Food Science and Technology	3(2+1)	Course numbers will be assigned
	Food Biochemistry	3(2+1)	

Course Code	Course Title	Credit Hours	Remarks
	Nutritional Biochemistry	2(2+0)	by the
	Food Microbiology	3(2+1)	departments that offer the courses. Apart from these courses a student can register any other course offered by any other departmentss
EECM 603	Scaling Techniques for Behaviour Research	3 (1+2)	
EECM 605	Sustainable Livelihood Systems	2 (1+1)	
Supporting Courses (05 Credits)			
A student can opt any course related to the topic of research offered by other faculties of agriculture university or SWAYAM portal or MOOCS or other online courses up to a maximum of 5 credits.			
FN 691	Doctoral Seminar I (Major Field)	1(1+0)	
FN 692	Doctoral Seminar II (Minor Field)	1(1+0)	
FN 699	Research	75	Increased credits for Research
	Total	**100 Credits**	

*Core courses/ compulsory courses.

**Practical sessions in Ph.D. Programme are not suggested by the experts in the field of Food and Nutrition on the grounds detailed below:

1. Sufficient hands-on exposures at UG/PG(M.Sc) level in areas of food & Nutrition covering aspects of nutrient analysis in normal and processed conditions. Such exposures ensure hand holding of related equipment/ instruments, chemicals and methods of analysis. Furthermore, nutritional assessment methods at community level provide ample opportunities to gather the expertise in survey research methods.

2. Exposure to Animal Experiments, however, is limited due to the prevailing ethical issues. If a particular field of research necessitates Animal Experiment, facilities available in established organisation could be linked through meaningful and prior arrangements.

3. In these courses, it is expected that the students take up live case studies with regard to the specificity of the course and report. Preliminary training in dealing with case studies may be imparted by a third party for which some funding may be given by ICAR. The University may offer a common training to students from all faculties through experts within the University set-up. The faculty should lead a thorough discussion of all the cases and a consolidated report may be submitted and sent for publication. In each course, the students spend one credit time during the semester for this exercise.

Course Title with Credit Load
M.Sc. (Community Science) in Food and Nutrition

Course Code	Course Title	Credit Hours
	Major Courses (20 Credits)	
FN 501*	Macro and Micro Nutrients in Human Nutrition	3(3+0)
FN 502*	Public Health and Nutrition	3(2+1)
FN 503*	Techniques in Food Analysis	3(1+2)
FN 504*	Diet Therapy	3(2+1)
FN 505	Nutrition and Physical Fitness	3(2+1)
FN 506	Developments in Nutrition and Immunity	2(2+0)
FN 507	Clinical Nutrition	3(2+1)
FN 508	Nutrition Counselling	2(0+2)
FN 509	Food Safety and Standards	3(2+1)
FN 510	Nutritional Challenges in Life Cycle	3(2+0)
FN 511	Food Science	3(2+1)
FN 512	Food Processing Technology	3(2+1)
FN 513	Human Physiology	3(3+0)
FN 514	Institutional Food Service Management	2(1+1)
	Minor Courses (08 Credits)	
	Food Science and Technology	3(2+1)
	Food Biochemistry	3(2+1)
	Nutritional Biochemistry	3(2+1)
	Food Microbiology	3(2+1)
EECM 504	Technology Transfer and Management	3 (1+2)
EECM 505	Dynamic Communication Skills	3 (1+2)
	Supporting Courses (06 Credits)	
	Research Methodology	3(2+1)
	Statistical methods and application	
	Common Courses (05 Credits)	
	Library and Information Services	1(0+1)
	Technical Writing and Communications Skills	1(0+1)
	Intellectual Property and its management in Agriculture	1(0+1)
	Basic Concepts in Laboratory Techniques	1(0+1)
	Agricultural Research, Research Ethics and	1(0+1)
	Rural Development Programmes	
FN 591	Seminar	1(1+0)
FN 599	Thesis/ Research	30
	Total	70 Credits

Course Contents
M.Sc. (Community Science) in Food and Nutrition

I. Course Title : Macro and Micro Nutrients in Human Nutrition

II. Course Code : FN 501

III. Credit Hours : 3(3+0)

IV. Theory

Unit I: Carbohydrates

Body composition; Functions, sources, requirements, digestion and absorption of carbohydrates. Composition, classification and functions of dietary fibre; Role of dietary fibre, resistant starch and fructo-oligosaccharides in various physiological disorders; Glycemic response to carbohydrates.

Unit II: Proteins

Classification, functions, sources, digestion and absorption of proteins; Synthesis of non-essential amino acids in the body; Urea cycle; Protein quality; Relationship between energy and protein requirements; Regulation of food intake; Nutrient adaptation to low intake of energy and protein.

Unit III: Fats

Classification, functions, sources, digestion, absorption and deficiency disorders of lipids and essential fatty acids; Role of omega-3 and omega 6 fatty acids in physiological disorders.

Unit IV: Vitamins, minerals and water

Functions, absorption, requirement, sources, deficiency and toXicity of fat-soluble vitamins - A, D, E and K and water-soluble vitamins- thiamine, riboflavin, niacin, pyridoXine, folate, B_{12}, ascorbic acid, pantothenic acid, biotin and amygdalin; Functions, absorption, requirement, sources, deficiency and toXicity of macro minerals – calcium and phosphorus and micro minerals – iron, zinc, sodium, copper, cobalt, selenium and chromium; Water and electrolyte balance, functions and distribution of water in body, Electrolyte composition of body fluids and electrolyte balance.

VIII. Suggested Reading

- Bamji MS, Rao NP and Reddy V. 2003. *Textbook of Human Nutrition*. 2nd Edition, OXford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Berdanier CD and Zempleni J. 2009. *Advanced Nutrition: Macronutrients, Micronutrients and Metabolism*. CRC Press, New York.
- Eastwood MA. 1997. *Principles of Human Nutrition*. London; Chapman & Hall.
- FAO. 2004. *Human Energy Requirements - Report of a Joint FAO/WHO/UNU Expert Consultation*. Technical Report Series 1. Food and Agriculture Organization, Geneva.
- FAO. 2007. *Protein and Amino Acid Requirements - Report of a Joint FAO/WHO/UNU Expert Consultation*. Technical Report Series 1. Food and Agriculture Organization, Rome.
- Groff JL and Gropper S. 2012. *Advanced Nutrition and Human Metabolism*. 7th Edition, Yolanda Cossio, New York.
- Ross AC, Caballero B, Cousins RJ, Tucker KL and Ziegler TR. 2012. *Modern Nutrition in Health and Disease*. 11thEdition, LWW, Philadelphia.
- Summathi S. 2017. *Food Chemistry and Nutrition*. BS Publication, Hyderabad.
- Whitney EN and Rolfels CR. 2019. *Understanding Nutrition*. 15th Ed., West Publishing Company, USA.
- Wildman REC and Medeiros DM. 2000. *Advanced Human Nutrition*. CRC Press, Boca Raton, Florida.

- Stipanuk MH and Caudill MA. 2013. *Biochemical, Physiological and Molecular Aspects of Human Nutrition*. 3rd Edition, Elsevier Pub.
- https://www.nutritionintl.org
- https://www.who.int
- https://www.hsph.harvard.edu/nutritionsource
- http://www.nin.res.in

I. Course Title : Public Health and Nutrition

II. Course Code : FN 502

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: Nutritional status assessment

Assessment of nutritional status at individual, household and institutional level: direct and indirect methods; Ecological, socio-cultural, economic and demographic correlations of malnutrition.

Unit II: Nutritional deficiencies and life style disorders

Prevalence, aetiology, biochemical and metabolic changes in protein energy malnutrition, vitamin A deficiency, iron deficiency anaemia, iodine deficiency disorders, diabetes mellitus, cancer, hypertension and other life style disorders.

Unit III: Present scenario of nutritional problems

Major nutritional problems of the state, nation and world; Nutrition intervention-definition, importance, methods of nutrition intervention, monitoring and evaluation; E-surveillance.

Unit IV: Nutritional programmes and polices

National nutritional programmes and policies and nutritional surveillance; National programmes and policies regarding food production and distribution.

V. Practicals

1-3. Techniques of assessment of nutritional status
4-5. Use of Screening Tools
6-7. Visit to the ongoing public health nutrition programme and report writing.
8-9. Study of existing diet and nutrition practices
10-12. Planning and conducting survey
13-14. Analysing data and writing report
15-16. Development, implementation and evaluation of community nutrition and health programmes

VI. Suggested Reading

- Bamji MS, Kamala K and Brhmam GNV. 2017. *Textbook of Human Nutrition*. 4th Edition, Oxford & IBH.
- Endres JB. 1990. *Community Nutrition Challenges and Opportunities*. Pearson Education Inc. London.
- Frank GC. 2008. *Nutrition: Applying Epidemiology to Contemporary Practice* . 2nd Edition, Jonts and Bartlett Publishers, Sadbury, MA.
- Gopaldas T and Seshadari S. 1987. *Nutrition Monitoring and Assessment*. Oxford University Press.
- Jeannette BE. 1990. *Community Nutrition: Challenges and Opportunities*. 1st Edition, Merrill.
- Jelliffe DB. 1966. *The Assessment of the Nutritional Status of the Community*. WHO, Geneva.
- Longwah T, Ananthan R, Bhaskarachary K and Venkalah K. 2017. *Indian Food Composition Tables*. National Institute of Nutrition, Hyderabad.
- Marie AB and David HH. 2012. *Community Nutrition in Action: An Entrepreneurial Approach*, Cengage Learning Inc. USA.
- McLaren DS. 1977. *Nutrition in the Community*. John Wiley & Sons.
- Park JE and Park K. 2007. *Park's Text Book of Preventive and Social Medicine*. 19th Edition, Banarsidas Bhanot Publishers, Jabalpur.

Park JE and Park K. 2017. *Park's Textbook of Preventive and Social Medicine*. Banarsidas Bhanot Publ.
- Prabha B. 2017. *Community Nutrition in India*. 1st Edition, Star Publications, Agra.
- Rosalind S Gibson. 2005. *Principles of Nutritional Assessment*. 2nd Edition, OXford University Press Inc.
- Salil S and Rita SR. 2007. *Textbook of Community Nutrition*. ICAR publication, New Delhi.
- Shukla PK. 1982. *Nutritional Problems of India*. Prentice Hall of India.
- Suryatapa Das. 2018. *Textbook of Community Nutrition*. 3rd Edn., Academic Publishers.
- https://www.india.gov.in/ agriculture
- https://mhrd.gov.in/mid-day-meal
- https://www.harvestplus.org
- https://www.icmr.nic.in/

I. Course Title : Techniques in Food Anaysis

II. Course Code : FN 503

III. Credit Hours : 3 (1+2)

- To equip the students with knowledge to ascertain quality of the tested food/ products.

IV. Theory

Unit I: Sampling techniques

Preparation of various standard solutions; Sample and sampling techniques; Introduction to standard analytical methods of FSSAI.

Unit II: Analytical techniques

Principle, techniques and applications of colorimeter, spectrophotometer and atomic absorption spectrophotometer, gel filtration and ultra-centrifugation.

Unit III: Photometric methods and electrophoresis

Principle, techniques and applications of fluorimetry, flame photometry and electrophoresis.

Unit IV: Chromatography

Principle, techniques and applications of paper, thin layer, gas liquid and high-pressure liquid chromatography, introduction to animal assay.

V. Practicals

1-2. Principles and operation of laboratory equipmen
3-6. Determination of moisture content and titratable acidity
7-8. Determination of ash- dry and wet ash
9-10. Determination of reducing sugars and total sugars
11-14. Analysis of protein- Kjeldhal method
15-16. Analysis of amino acids- HPLC
17-20. Analysis of fat - Soxhlet method, Cold extraction method
21-22. Determination of peroxide value and iodine value
23-24. Analysis of crude fibre. Analysis of minerals- sodium and potassium
25-26. Analysis of iron, copper, zinc and lead. Absorption spectrophotometry
27-28. Analysis of phosphorus- Colorimeter method
29-30. Analysis of vitamin C
31-32. Estimation of carotene. Experiments on gel electrophoresis

VI. Suggested Reading

- AOAC. 1995. *Association of Official Analytical Chemists*. Washington, DC. Gruenwedels DW and Whitakor JR. 1984. *FoodAnalysis: Principles and Techniques*. Vols. I-VIII. Marcel Dekker.
- AOAC International. 2016. *AOAC Official Methods of Analysis*. 20th Edition, Association of Official Analytical Chemists. Washington DC.
- Dennis D Miller. 1998. *Food Chemistry*: *A Laboratory Manual*. John Wiley and Sons Indianapolis.
- Joslyn MA. 1970. *Methods in Food Analysis: Physical, Chemical and Instrumental Methods of Analysis*. Academic Press.
- Kalia M. 2002. *Food Analysis and Quality Control*. Kalyani Publishers, New Delhi.
- Neilsen SS. 2010. *Food Analysis*. 4th Ed., ISBN 978-1-4419-1478-1 Springer Science+ Business Media, LLC, USA.
- Neilsen SS. 2002. *Introduction to Chemical Analysis of Foods*. 1st Ed., J S Offset Printers,

Delhi.
- Raghuramulu N, Mahavan and Kalyanasundaram SK. 2003. *A Manual of Laboratory Techniques*. 2nd Edition, NIN Press, Hyderabad.
- Sadasivam A and Manickam A. 2004. *Biochemical Methods*. 2nd Edition, New Age International Publishers, New Delhi.
- Sawhney SK and Singh R. 2000. *Introductory Practical Biochemistry*. Narosa Publishing House, New Delhi.
- Veerakumar L. 2006. *Bio-instrumentation*. MIP Publishers. Chennai.
- Pomeranz Y and Molean CE. 1977. *Food Analysis Theory and Practice*. AVI Publ.
- Wood R, Foster L, Damand A and Key P. 2004. *Analytical Methods for Food Additives*. CRC Press, London.
- https://www.fssai.gov.in
- http://www.fda.gov/food/default.htm

I. Course Title : Diet Therapy

II. Course Code : FN 504

III. Credit Hours : 3 (2+1)

VI. Theory

Unit I: Significance of diet therapy

Importance and scope of diet therapy; Role of dietician in a health care team in hospital and community.

Unit II: Dietary management of nutritional disorders

Newer concepts in dietary management of various nutritional disorders and disease conditions; fevers and infections.

Unit III: Dietary management of diseases

Dietary management during burns, allergy, gastrointestinal disorders, liver diseases, cardiovascular diseases, hypertension, renal disorders, obesity, diabetes, cancer and HIV; Nutrition in critical care.

Unit IV: Nutrigenomics and nutraceuticals

Nutrigenomics. Nutraceuticals. Health foods and supplements; Health foods and supplements; Dietary recommendations for blood donors; Nutrients and drug interaction.

VII. Practicals

1. Formulation of food exchanges
2. Therapeutic modifications of diet in terms of nutrients, consistency andcomposition
3. Planning and preparation of diet for diabetes

4-5. Planning and preparation of diet for cardiovascular diseases6-7.

Planning and preparation of diet for kidney disorders

8. Planning and preparation of diet for obesity
9. Planning and preparation of diet for cancer patients
10. Planning and preparation of diet for burns patients -first, second and third-degree burns

11-12. Planning and preparation of diet for gastrointestinal disorders

13. Planning of diet for critical care patients
14. Visits to hospital to see preparation of tube feeding diets15-

16. Presentation of case studies

X. Suggested Reading

- Cataldo CB, De Brayae LK and Whitney EN. 2012. *Nutrition and Diet Therapy*. 6th Edn.,Wadsworth/Thomson Learning Inc.
- Kathleen ML and JL Raymond. 2016. *Krause's Food and the Nutrition Care Process*. 14th Edition, Saunders, Philadelphia.
- Mazur EE and Litch NA. 2018. *Lutz's Nutrition and Diet Therapy*. 7th Edition, F.A. DavisCompany, Philadelphia.
- McIntosh SN. 2016. *Williams' Basic Nutrition and Diet Therapy*. 15th Edition, Mosby, Maryland.
- Schlenker E and Gilbert JA. 2014. *Williams' Essentials of Nutrition and Diet Therapy*. 11th edition, e- book.
- Srilakshmi B. 2019. *Dietetics*. 8th Edition, New Age Internatioanal Publisher.
- Skipper A. 2008. *Advanced Medical Nutrition Therapy Practice*. 1st Edition, Jones & Bartlett Learning, Burlington, Massachusetts.
- Ross AC, Caballero B, Cousins RJ, Tucker KL and Ziegler TR. 2012. *Modern Nutrition in Health and Disease*. 11th Edition, LWW, Philadelphia.
- Whitney E, DeBruyne LK, Pinna K and Rolfes SR. 2011. *Nutrition for Health and HealthCare*. 4th Edition.
- https://www.nutritionintl.org
- https://www.hsph.harvard.edu/nutritionsource
- https://www.nutrition.org.uk

I. Course Title : Nutrition and Physical Fitness

II. Course Code : FN 505

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Physical fitness and body composition

Overview of nutritional management vis-à-vis body composition and physical fitness; Techniques to assess physical fitness; Body composition in different physiological conditions and factors affecting it; Methods of measuring body composition.

Unit II: Energy balance

Energy metabolism; Factors influencing energy metabolism and physical fitness; Techniques to measure energy eXpenditure and energy intake.

Unit III: Sports nutrition

Requirement of nutrients for specific sports events; EXercise physiology and biochemistry; Nutrition support before, during and after sports event; Water and electrolyte requirement during eXercise and their role in performance; Ergogenic aids; Definition, types and dosage; Doping: Definition, types and consequences; Muscle physiology for performance and fitness; Biomechanics; Physiological testing for fitness and performance; Strength,respiratory fitness.

Unit IV: Nutrition and ageing

Role of nutraceuticals in fitness; Ageing theories; Physiology, mechanism and role of nutrients in arresting ageing process.

V. Practicals

1-4. Planning diets for general fitness
5-12. Planning and preparation of diets for different sports categories
13-14. Planning nutritional requirements for sports injuries
15. Visit to a sports academy
16. Visit to established fitness centres

VI. Suggested Reading

- Benardot D. 2005. *Advanced Sports Nutrition*. 2nd Edition, Human Kinetics Publishers, Champaign, IL.
- Baumgartner R. 2006. *Body Composition in Healthy Aging*. Annals of the New York Academy of Sciences.
- FAO. 2004. *Human Energy Requirements. -Report of a Joint FAO/WHO/UNU Expert Consultation*. Technical Report Series 1. Food and Agriculture Organization, Geneva.
- Geetanjali B and Subhadra M. 2018. *Nutritional Guidelines for Sportspersons*. Jaypee Health Books Publishers.
- Geissler C and Powers H. 2009. *Fundamentals of Human Nutrition*. Churchill Livingstone, London.
- Ross AC, Caballero B, Cousins RJ, Tucker KL and Ziegler TR. 2012. *Modern Nutrition in Health and Disease*. Eleventh Edition, LWW, Philadelphia.
- Srilakshmi B, Suganthi V and Kalaivani C Ashok. 2017. *Exercise Physiology Fitness and Sports Nutrition*. New Age International Publishers.
- https://www.who.int
- https://www.hsph.harvard.edu/nutritionsource
- http://www.nutritioncare.org

I. Course Title : Developments in Nutrition and Immunity

II. Course Code : FN 506

III. Credit Hours : 2 (2+0)

IV. Theory

Unit I: Immunity and macronutrients

Immunity: definition and history; Classification of immunity and immunological responses; Role of nutrients in immune functions- Carbohydrates, fat and protein; Effect of arginine, glutamine, sulphur amino acids and omega-3 fatty acids on immune system.

Unit II: Immunity and micronutrients

Effect of deficiency and eXcess of vitamins and minerals on immune cell functions; Effect of malnutrition on immunity; Infections and undernutrition – causes and consequences and role of immunization.

Unit III: Nutrition during infections

Age related immune depression; Role of nutraceuticals and functional foods in immune system; Nutrition, HIV/AIDS and Tuberculosis.

Unit IV: Immunity and chronic diseases

Nutritional immunity and chronic diseases; Probiotics, prebiotics, phytochemicals and immunity; Food allergy.

IX. Suggested Reading

- Calder P and Yaqoob P. 2013. *Diet, Immunity and Inflammation*. Woodhead Publishing Ltd. Cambridge.
- Gershwin ME, German JB and Keen CL. 2000. *Nutrition and Immunology – Principles and Practice*. Humana Press Inc. New York.
- Gershwin ME, Nestel P and Keen CL. 2004. *Handbook of Nutrition and Immunity*. Humana Press Inc. New York.
- Ivan M Roitt and Peter J Deves. 2004. *Essential Immunology*. Blackwell Science Ltd
- Pammi M, Vallejo JG and Abrams SA. 2016. *Nutrition-Infection Interactions and Impacts on Human Health*. CRC Press, Boca Raton, Florida.
- Philip C Calder and Anil D Kulkarni. 2017. *Nutrition, Immunity, and Infection*. CRC press, London
- Shetty PS. 2010. *Nutrition, Immunity and Infection*. CABI Publishers, OXfordshire, UK.
- https://www.nutritionintl.org
- https://nutrition.org
- https://www.icmr.nic.in

I. Course Title : Clinical Nutrition

II. Course Code : FN 507

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Macronutrients

Methods for estimating requirements and recommended allowances of energy, protein, minerals and vitamins for different age groups and physiological state; Growth studies; Depletion and repletion studies; Nutrient balance studies; Use of isotopically labelled nutrients: Nutrient turnover; Obligatory losses of nutrients; National and international recommendations on Nutrient Requirements; Recommendations for Indian by the Indian Council of Medical Research; FAO/ WHO expert committee recommendations; Nutrient interrelationship; therapeutic measures of protein energy malnutrition; Adaptation and chronic energy deficiency; Regulatory processes in chronic energy deficiency; Protein and amino acid turnover; Regulation of amino acid metabolism; Disposal of dietary amino acids and roles of specific organs.

Unit II: Micronutrients

Interrelationship, etiology and preventive measures of vitamin and mineral deficiencies toxicities; Adverse effects of Vitamins and minerals; Upper tolerable levels; Principles and interpretation of clinical laboratory methods with particular emphasis on their interpretation relative to nutritional status and disease; interaction between nutrients, infections and drugs; Functional tests of malnutrition; Nutritional assessment tools in clinical decision making.

Unit III: Nutritional support during disease

Nutritional support, enteral tube feeding, parenteral nutrition, drugs and enteral feeding; Special considerations with nutritional support; Nutrition in surgery and trauma; The stress response to trauma on metabolism; Nutrition support in critically ill patient; Guidelines for use of formula feeds and calculation.

Unit IV: Therapeutic nutrition

Nutrition in GI Diseases; Celiac disease, inflammatory bowel disease, Assessment of liver function - nutritional management in liver disease, acute and chronic pancreatitis, severity scores, nutritional aspects of disease affecting the skeleton, diagnostic imaging, biochemical assessment; Acute and chronic renal failure, nephrotic syndrome, transplantation; Diet and hypertension, stroke, peripheral vascular disease, and chronic heart failure; Wasting syndrome in cancer; Impact of radiation and chemotherapies; Nutritional support on clinical outcomes.

VII. Practicals

1-4. Visit to critical care wards in hospitals for familiarizing with enteral and parenteral feeding methods.
5. Handling and deciphering the medical case sheets.
6-9. Planning enteral feeding, critical care nutritional requirements for different clinical conditions
10-11. Calculating energy, protein, fat and micronutrients after nutritional assessment.
12-13. Presenting case studies of medical cases
14-15. Survey of various enteral feed formulations for different clinical conditions
16. Report writing

VIII. Suggested Reading

- Connie WB and Christine SR. 2016. *Handbook of Clinical Nutrition and Ageing.* Humana

Press.
- FAO. 2004. *Human Energy Requirements - Report of a Joint FAO/WHO/UNU Expert Consultation*. Technical Report Series 1. Food and Agriculture Organization, Geneva.
- Gibney MJ, Macdonald IA and Roche HM. 2011. *Nutrition and Metabolism*. Wiley-Blackwell Publishing Company, Boston.
- Gibney MJ, Elia M, Ljungqvist O and Dowsett J. 2013. *Clinical Nutrition*. Wiley-Blackwell Publishing Company, Boston.
- Heimburger DC and Ard JD (2006) *Hand Book of Clinical Nutrition*. Mosby Pub.
- Joshi YK. 2009. *Basics of Clinical Nutrition*. 2nd Edition, Jaypee Brothers Medical Publishers Private Limited, New Delhi.
- Macdonald IA and Michael J Gibney MJ. 2011. *Nutrition and Metabolism*. Wiley-Blackwell Publishing Company, Boston.
- Narasinga Rao BS and Sivakumar B. 2010. *Nutrient Requirements and Recommended Dietary Allowances*. 2nd Edition, National Institute of Nutrition, Hyderabad.
- Marian M and Susan R. 2009. *Clinical/Nutrition for Oncology Patients*. Jones and Bartlett Pub.
- Scott AS and George LB. 1997. *Nutrition Support-Theory and Therapeutics*. Chapman and Hall Series, International Thomson Publications.
- Sharon RR , Kathryn P and Whitney E. 2017. *Understanding Normal and Clinical Nutrition*. Cengage Learning.
- Width M and Reinhard T. 2017. *The Essential Pocket Guide for Clinical Nutrition*. LWW Pub.
- Wayne EB. 2005. *Clinical Nutrition Case Studies*. Cengage Learning.
- Vishwanath S. 2017. *Introduction to Clinical Nutrition*. CRC Press.
- http://www.nutritioncare.org
- https://nutrition.org
- http://www.nutritionlink.org/

I. Course Title : Nutrition Counselling

II. Course Code : FN 508

III. Credit Hours : 2 (0+2)

IV. Practicals

1-2. Development of resources and dietary guidelines for counselling
3-4. Procedures of nutritional counselling in clinical practice
5-12. Preparing nutritional and dietary care plans for individuals and groups
13-16. Records required for follow up study, group discussion and motivation as tools to bring attitudinal changes in food selection and preparation
17-18. Exercises on writing scientific facts in simple manner for the people
19-22. Diet campaigns, exhibitions, demonstrations and workshops
23-28. Setting up counselling unit. Counselling in outpatient wards in local hospitals
29-30. Simulation techniques for counselling in selected settings
31-32. Use of dietary apps for counselling and assessing food intake

V. Suggested Reading

- Aronson V. 1989. *The Dietetic Technician-Effective Nutrition Counselling*. John Wiley and Sons Florida.
- Betsy H and Judith BA. 2014. *Nutrition Counselling and Education Skills for Dietetics Professional*. 6th Edition, LWW, Philadelphia.
- Devito JA. 2015. *Human Communication: The Basic Course*. Pearson, New York.
- Gable J. 2016. *Counselling Skills for Dietitians*. John Wiley and Sons Florida.
- Kathleen DB, Doreen Land Carol AS. 2001. *Basic Nutrition Counselling Skill Development*. Brooks Cole Pub.
- Kathleen DB, Doreen L and Carol AS. 2014. *Nutrition Counselling and Education Skill Development*. CENGAGE Learning Custom Pub, USA.
- King K and Klawitter B. 2007. *Nutrition Therapy. Advanced Counselling Skills*. 3rd Edition, LWW, Philadelphia.
- Mahan LK and Escott S. 2016. *Krause's Food & Nutrition Therapy*. 14th Edition, Saunders, Philadelphia.
- Midwinter R and Dickson J. 2015. *Embedding Counselling and Communication Skills - A Relational Skills Model*. Routledge.
- Snetselaar L. 2009. *Nutrition Counselling Skills for the Nutrition Care Process*. 4th Edition Jones Bartlett Publishers, Sudbury, Massachusetts.
- https://nutrition.org
- http://www.nutritionlink.org
- http://www.fao.org/docrep/X2550E/X2550e04.htm

I. Course Title : Food Safety And Standards

II. Course Code : FN 509

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Xenobiotics

Toxicologically relevant principles of the cell and molecular biology; Dynamics and kinetics of xenobiotics; Environmental pollutants entering the food chain.

Unit II: Food poisoning

Introduction and significance of food toxicology; Food poisoning – types, causative factors, signs and symptoms and preventive measures; Naturally occurring food toxins, their harmful effects and methods of removal.

Unit III: Microbial and chemical toxins

Microbial toxins and food intoxication – source of contamination, effects on health, preventive measures and methods of inactivation and destruction; Chemical toxins – pesticides, insecticides, metallic and others and their residual effects, preventive measures and methods of removal.

Unit IV: Food safety laws and standards

Food packaging material – Potential contaminants from food packaging material; Food safety laws and standards: FSSAI, FPO, ISI, Agmark, Codex Alimentarius, ISO mark for vegetarian and non-vegetarian foods, eco-friendly products and others in operation.

V. Practicals

1-2. Basic chemical diagnostics of poisonings based on the samples from dead animal's organs and feed

3-7. Methods of identification and quantification of poisons isolation from biological materials

8-9. Principles of sampling and sending biological materials for toxicological analysis

10. Basis of intravital laboratory diagnostics of acute and chronic poisonings

11. Evaluation of toxic effects concerning the degree and the time of exposure to a xenobiotic

12-13. The determination of cholinesterase activity in the whole blood, in blood plasma and in red blood cells after the exposure to organophosphate and carbaminate insecticides

14. Evaluation of the effect of an antidote

15. Identification of nitrite and nitrate in water and in vegetables

16. Evaluation of nitrite and nitrate effect on haemoglobin.

VI. Suggested Reading

- Concon JM. 2000. *Food Toxicology- Principles and Concepts - Part A and B.* Marcel-Dekker Inc. New York.
- Helferich W and Winter CK. 2001. *Food Toxicology*. CRC Press, Boca Raton, Florida.
- Pussa T. 2013. *Principles of Food Toxicology*. CRC Press, Boca Raton, Florida.
- Timbrell J. 2001. *Introduction to Toxicology*. 3rd Edition, Informa, London.
- Vought JB and Henderson MK. 2000. *Principles of Sampling and Sending Biological Materials for Toxicological Analysis - Unit II Biomarkers Practical Aspects*. IARC publication, WHO, Geneva.
- https://www.fssai.gov.in
- http://www.fda.gov/food/default.htm

I. Course Title : Nutritional Challenges in Life Cycle

II. Course Code : FN 510

III. Credit Hours : 3 (3+0)

IV. Theory

Unit I: Importance of maternal nutrition

Nutritional needs during first 1000 days; Influence of maternal nutritional status on outcome of pregnancy: birth weight of infant and lactation performance.

Unit II: Human milk

Psycho-physiology of lactation; Milk synthesis and secretion; Maternal needs during lactation; Composition of colostrum and mature human milk; Milk of mothers of preterm babies; Milk of animal and formula feeds; Non-nutritional factors of human milk - immunological factors, enzymes and hormones; Human milk banking.

Unit III: Nutrition during childhood, adolescence and adulthood

Nutritional needs of the children and adolescents; Common childhood ailments and dietary considerations; Growth spurt and nutrition; Adolescent fads influencing nutrition, food preferences and nutritional problems; Nutritional requirements in adulthood; Malnutrition, mental development, learning abilities and behavior.

Unit IV: Geriatric nutrition

Overview of ageing process; Nutritional variables related to the ageing process; Physiology of aging; Biological markers of aging; Sociology of aging; Nutritional requirements and deficiencies in elderly; Medications and psychiatric problems in elderly; Immunopathological diseases and aging; Parkinson and Alzheimer syndrome; Care of the elderly; Care-givers and community services.

V. Suggested Reading

- Bales CW, Ritchie CS. 2013. *Handbook of Clinical Nutrition and Aging*. 2nd Edition, Springer Science & Business Media, Humana Press Inc. New York.
- Cataldo CB, De Brayae LK and Whitney EN. 2012. *Nutrition and Diet Therapy*. 6th Edn., Wadsworth/Thomson Learning Inc.
- Chernoff R. 2003. *Geriatric Nutrition: The Health Professional's Handbook*. 2nd Edition, Jones & Bartlett Learning, Burlington, Massachusetts.
- Kleinman RE. 2008. *Paediatric Nutrition Handbook*. 6th Edition, American Academy of Paediatrics Committee on Nutrition.
- Sachdev HPS and Choudhury P. 2004. *Nutrition in Children - Developing Country Concerns*. B I Publications.
- Schlenker E and Gilbert JA. 2014. Williams' *Essentials of Nutrition and Diet Therapy*. 11th Edition, e- book.
- Sharbaugh C and Brown JE. 2013. *Nutrition Through the Life Cycle*. 5th Edition, Wadsworth Co Inc. Belmont, CA.
- Srilakshmi B. 2019. *Dietetics*. 8th Edition, New Age Internatioanal Publisher.
- Whitney E, DeBruyne LK, Pinna K and Rolfes SR. 2011. *Nutrition for Health and Health Care*. 4th Edition.
- World Health Organization. 2005. *WHO Library Cataloguing-in-Publication Data. Nutrition in Adolescence –Issues and Challenges for the Health Sector*. WHO, Geneva.
- https://www.who.int
- http://www.nutritionlink.org
- https://www.icmr.nic.in

I. Course Title : Food Science
II. Course Code : FN 511
III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Evaluation of food

Colloidal chemistry as related to foods; Evaluation of food by subjective and objective methods.

Unit II: Characteristics of sugars and starches

Carbohydrates in foods sources; Characteristics of sugar; Starches - types, sources, uses and chemical characteristics; Factors effecting viscosity of starch paste; Characteristics of cellulose and pectin; Gums in foods; Effect of cooking and processing techniques on carbohydrates; Batters and dough- types, properties.

Unit III: Processing of cereals, legumes and animal foods

Preparation of gluten structure; Dough changes in baking; Protein in foods: Plant and animal protein; Chemical and physical properties related to protein foods; Effect of cooking and processing techniques on animal foods – meat, fish, poultry, eggs, milk and milk products; Effect of cooking and processing of plant foods – cereals, millets, legumes, nuts and oilseeds;

Unit IV: Processing of fruits and vegetables

Classification and importance of fruits and vegetables; Composition of fruits and vegetables. Effect of cooking and other processing methods on the nutritive value of fruits and vegetables; Food pigments; Browning reactions in fruits and vegetables; Classification and importance of beverages; Definition, classification, uses and legal aspects of food additives; Classification, nature and uses of leavening agents.

V. Practicals

1. Microscopic structure of different starch granules
2. Evaluation of food by subjective and objective methods

3-4. Changes in colour, texture and flavour of foods due to processing

5. Product preparation using leavening agents
6. Physicochemical evaluation of grains like length, breadth, L/B ratio, bulk density, cooking properties, 1000 grains weight
7. functional properties of grains - gelatinization, water absorption capacity, oil retention capacity and water retention capacity

8-9. Sugar cookery

10. Smoking temperature of fats and oils
11. Factors effecting absorption of fats
12. Deep fat fried food preparation
13. Changes in cookery- meat, fish, poultry
14. Coagulation of egg, poached egg, omelette, custard, cake
15. Emulsion - mayonnaise preparation
16. Soaking, germination and fermentation of pulses

X. Suggested Reading

- Belle Lowe. 2019. *Experimental Cookery from the Chemical and Physical Standpoint*. Facsimile Pub.
- Potter NN and Hotchkiss JH. 2007. *Food Science*. 5th Edition, CBS, New Delhi.
- Roday S. 2018. *Food Science and Nutrition*. 3rd Edition, Oxford University Press, UK.
- Sharma A. 2005. *Textbook of Food Science and Technology*. 3rd Edition, CBS, New Delhi.
- Stone H. 2004. *Sensory Evaluation Practices* (*Food Science and Technology*). 3rd Edition,

Academic Press, Cambridge.
- Subbalakshmi G and Udipi SA. 2006. *Food Processing and Preservation*. New Age International, New Delhi.
- Sofia Jan. 2013. *Elements of Food Science*. New India Publishing Agency,New Delhi ISBN: 979-93-81450-24-6.
- Vaclavik VA and Christian EW. 2014. *Essentials of Food Science*. 4th Edition, Springer-Verlag, New York.
- https://www.ift.org
- https://www.foodsciencematters
- https://www.ifst.org

I. Course Title : Food Processing Technology

II. Course Code : FN 512

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: Food processing techniques

Principles underlying food processing operations including thermal, radiation, refrigeration freezing and dehydration; Effect of processing on physiochemical characteristics; Principles underlying pressure modified processing (high hydrostatic pressure, hyperbaric processing, vacuum cooling, hypobaric storage).

Unit II: Processing technologies for plant foods

Processing technology for preservation and production of variety food products during storage, handling and processing of cereals/millets and legumes, oilseeds, fruits and vegetables; Food preservation by Hurdle technology and canning technology.

Unit III: Processing technologies for animal foods

Processing technology for milk and milk products, egg, meat, poultry and fish, convenience foods and processed foods; Technologies underlying mutual supplementation, enrichment and fortification, fermentation, malting and germination; Food additives commonly used in food industries for colour, flavour and as preservatives; Nanomaterials as food additives.

Unit IV: Quality control in food processing

Quality control in food industry - raw materials and finished products; Waste management and sanitation in food industries; Packaging - self-cooling self-heating packaging, micro packaging, antimicrobial packaging and water-soluble packaging.

V. Practicals

1. Effect of blanching on enzymatic activity and volume occupation
2. Effect of refrigeration and freezing on quality of fruits and vegetables
3. Dehydration of fruits and vegetables
4. Canning of fruits and vegetables

5-6. Preparation of fruit candy, squash, nectar, malt beverages and quality evaluation with respect to FPO

7. Clarification of juice using various methods (chemical, enzyme and fining agents)

8-9. Malting of green gram, moth bean- enzymatic activity determination

10. Preparation of *Paneer* and curd and its quality evaluation
11. Quality evaluation of egg and fish
12. Effect of chemical preservation on storage quality of food (bread, cake).
13. Storage of nuts and oil seeds under vacuum packaging
14. Packaging of fruits and vegetables for transportation distance market using corrugated fibre boxes
15. Transportation of fresh fruits and vegetables using cushioning system and fibre board
16. Visit to food processing unit

VI. Suggested Reading

- Brennan JG. 2006. *Food Processing Handbook*. Wiley-VCH
- Clark S, Jung S and Lamsal B. 2014. *Food Processing - Principles and Applications*. 2nd Edition, Wiley-Blackwell Publishing Company, Boston.
- Fellows PJ. 2000. *Food Processing Technology*. Woodhead Publishing Ltd.
- Fellows PJ. 2017. *Food Processing Technology, Principles and Practice*. 4th Edition, Woodhead

Publishing Ltd. Cambridge.
- Hartel R W and Heldman D. 2012. *Principles of Food Processing*. Aspen Publishers Inc. New York.
- Owens G. 2001. *Cereals Processing Technology*. Woodhead Publishing Ltd.
- Sivshankar B. 2002. *Food Processing and Preservation*. Prentice-Hall of India Pvt. Ltd. Delhi.
- Subbalakshmi. 2001. *Food Processing and Preservation*. New Age International Publishers, New Delhi.
- Vaclavik V. 2018. *Dimensions of Food*. CRC Press.
- https://www.ift.org
- https://www.foodsciencematters
- https://www.ifst.org

I. Course Title : Human Physiology
II. Course Code : FN 513
III. Credit Hours : 3 (3+0)

IV. Theory

Unit I: Circulatory system

Overview of anatomy and functions of human body; Reticuloendothelial system- functions, classification; Lymphatic system- functions, circulation; Circulatory system- blood and composition blood cells, development and function of blood cells, blood clotting, blood grouping and haemoglobin, Heart - anatomy, cardiac cycle, blood pressure and factors affecting blood pressure.

Unit II: Respiratory system

Respiratory system- anatomy, physiology and mechanism of respiration, regulation of respiration; Digestive system- anatomy of gastrointestinal tract and accessory organs, digestion and absorption of food, regulation of appetite.

Unit III: Excretory system

Excretory system- anatomy and functions of kidney, formation, composition and excretion of urine; Endocrine glands, mode of action of hormones.

Unit IV: Reproductive system

Reproductive system- structure and functions of male and female reproductive organs; Anatomy and functions of nervous and musculoskeletal system.

V. Suggested Reading

- Chaterjee CC. 2012. *Human Physiology Vol. I and Vol. II*. CBS Publications.
- David F, Stacia BM and Charles LS. 1993. *Human Physiology- Foundations and Frontiers*. 2nd Edn., Mosby Pub.
- Donnersberger AB and Scott AL. 2005. *Laboratory Textbook of Anatomy and Physiology*. 8th Edition, Jones and Bartlett Learning, Burlington, Massachusetts.
- Jain AK. 2009. *Human Physiology for BD*. 3rd Edition, Avichal Publishing Company, New Delhi.
- Hall JE. 2016. *Gayton and Hall Text Book of Medical Physiology*. 13th Edition, Elsevier India.
- Marieb EN. 2004. *Human Anatomy and Physiology 6th Edition*. Pearson Education, Inc. London.
- Waugh A and Grant A. 2014. *Ross and Wilson Anatomy and Physiology in Health and Illness*. 6th Edition, Elsevier Ltd. Churchill Livinstone, London.
- http://novella.mhhe.com/sites/0073525707/information_center_view0/custom_publishing_primis.html
- https://jsums.instructure.com/courses/2144344/pages/welcome-to-holes-human-anatomy-and-physiology-11-slash-e

I. Course Title : Institutional Food Service Management

II. Course Code : FN 514

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Food service management

Types of food services - organization and management. Tools of management; FSSAI and CODEX guidelines.

Unit II: Record keeping

Personnel management; Books, records and record keeping; Cost control in food services; Menu planning; HACCP.

Unit III: Quantity food production

Meal services management; Types of services; Quantity food production; Principles involved in development of recipes in large scale cooking; Standardization of recipes; Utilization of left-over foods.

Unit IV: Planning of food service unit

Types of kitchens; Planning of layout and equipment for food services; Sanitation and hygiene in handling foods; Personnel hygiene and its importance; Organisation of spaces.

V. Practicals

1-2. Standardization of basic recipes: planning and preparation
3. Modification in basic recipes
4. Use of left-over foods
5-6. Visit to different types of food service institutions and study the organization, physical plan and layout, food service equipment, sanitation and hygiene.
7-10. Practical experience in organization and management of a college cafeteria/ hotels
11-12. Setting of canteens with formal and informal table setting
13. Scale production of standardised recipes
14-15. Menu planning for snack bars, canteens, residential hostels and hospitals
16. Cost analysis

VI. Suggested Reading

- Arora RS. 2012. *Banquet and Catering Management*. Abhijeet Publications.
- Beckley JH, Herzog LJ and Foley MM. 2017. *Accelerating New Food Product Design and Development*. 2nd Edition, John Wiley and Sons Inc. Hoboken, New Jersey.
- Carpenter RP, Lyon DH and Hasdell TA. 2002. *Guidelines for Sensory Analysis in Food Product Development and Quality Control*. 2nd Edition, Aspen Publishers Inc. New York.
- Earle M and Earle RL. 2008. *Case Studies in Food Product Development*. Woodhead Publishing Limited and CRC Press, New York.
- Harish Bhat. 2008. *Hotel Management*. Crescent Publishing Corporation.
- Moskowitz HR, Straus T and Saguy S. 2009. *An Integrated Approach to New Food Product Development*. CRC Press, Boca Raton, Florida.
- Mudit Bhajwani. 2007. *Food Service Management: Principles and Practice*. Rajat publications, New Delhi.
- Nancy LS. 2007. *Catering Management*. John Wiley & Sons.
- Puckett RP. 2012. *Food Service Manual for Health Care Institutions*. 4th Edition, John Wiley and Sons Inc. Hoboken, New Jersey.
- Sethi M. 2018. *Catering Management- An Integral Approach*. 3rd Edition, New Age International, New Delhi.
- https://www.ferrerofoodservice.com
- https://www.foodservicedirector.com
- Vaclavik V (2018) *Dimensions of Food*. CRC Press.

Course Title with Credit Load
Ph.D. (Community Science) in Food and Nutrition

Course Code	Course Title	Credit Hours
	Major Courses (12 Credits)	
FN 601*	Macronutrient Metabolism	3(3+0)
FN 602*	Micronutrient Metabolism	2(2+0)
FN 603*	Nutrition and Agricultural Interface	3(3+0)
FN 604	Global Nutritional Problems	2(2+0)
FN 605	Nutrition in Calamities	2(2+0)
FN 606	Maternal and Child Nutrition	2(2+0)
FN 607	Hormones and Enzymes	2(2+0)
FN 608	Energy Metabolism	2(2+0)
FN 609	Application of Biotechnology in Food Science and Nutrition	3(3+0)
FN 610	Recent Trends in Food Science and Technology	3(3+0)
	Minor Courses (06 Credits)	
	Food Science and Technology	3(2+1)
	Food Biochemistry	3(2+1)
	Nutritional Biochemistry	2(2+0)
	Food Microbiology	3(2+1)
EECM 603	Scaling Techniques for Behaviour Research	3 (1+2)
EECM 605	Sustainable Livelihood Systems	2 (1+1)
	Supporting Courses (05 Credits)	
	A student can opt any course related to the topic of research offered by other faculties of agriculture university or SWAYAM portal or MOOCS or other online courses up to a maximum of 5 credits.	
FN 691	Doctoral Seminar I (Major Field)	1(1+0)
FN 692	Doctoral Seminar II (Minor Field)	1(1+0)
FN 699	Research	75
	Total	100 Credits

*Core courses/ compulsory courses

Course Contents
Ph.D. (Community Science) in Food and Nutrition

I. Course Title : Macronutrient Metabolism

II. Course Code : FN 601

III. Credit Hours : 3(3+0)

IV. Theory

Unit I: Macronutrients

Digestion, absorption and metabolism of carbohydrates, proteins and lipids; Inborn errors of metabolism; Degenerative diseases - diabetes, obesity, atherosclerosis, hyperlipidaemia and hypertension; Glucose homeostasis determined by insulin/ glycogen ratio; low carbohydrates diet and its metabolic consequences.

Unit II: Dietary fibre

Glycaemic Index and load; Dietary fibre and its impact in various physiological disorders; Hypoglycaemic action of foods.

Unit III: Proteins

Classification of protein, new discoveries in protein and their functions (protein in immune system, biological buffers and carriers); Evaluation of protein quality- *in vitro* and *in vivo* methods, animal and human bioassays; Amino acid pool, protein turnover in man with special reference to body size, age and various nutrition and pathological conditions; Novel food sources of protein; Role of hormones in protein metabolism; Effect of dietary protein on cardiovascular disease and cholesterol metabolism; Adaptation of body to low intake of energy and protein.

Unit IV.Lipids

Hypolipidemic action of MUFA, PUFA and oxidation products of cholesterol; Effect of saturated fatty acids and trans fatty acids in lipid metabolism, role of reversal diet in cardiovascular disorders; Causes, prevention and treatment of hyperlipidaemia.

V. Suggested Reading

- Akoh CC and Min DB. 2002. *Food Lipids - Chemistry, Nutrition and Biotechnology*. Marcel Dekker Inc. New York.
- Dickens F. 1981. *Carbohydrate Metabolism and its Disorders Vol. III*. Academic Press, Cambridge.
- FAO WHO/UNU ý(2004ý) *Human Energy Requirements: Report of a Joint FAO/WHO/UNU Expert Consultation*. Geneva: World Health Organization. FAO Food and Nutrition Technical Report Series 1.
- FAO WHO/UNU. ý2007. *Protein and Amino Acid Requirements in Human Nutrition: Report of a Joint FAO/WHO/UNU Expert Consultation, Geneva*. Word Health Organization. Technical Report Series 935. http://www.who.int/iris/handle/10665/43411.
- Nelson D L and Cox MM. 2017. *Lehninger Principles of Biochemistry*. 7th Edition. WH Freeman, New York.
- Stipanuk MH and Caudill MA. 2013. *Biochemical, Physiological and Molecular Aspects of Human Nutrition*. 3rd Edition. Elsevier Pub.
- https://www.who.int
- http://www.fao.org/home/en
- https://www.nutrition.org.uk

I. Course Title : Micronutrient Metabolism

II. Course Code : FN 602

III. Credit Hours : 2(2+0)

IV. Theory

Unit I: Vitamins

History, chemistry, distribution and functions of vitamins; Absorption, transportation, metabolism of vitamins; Nutritional requirements of vitamins; Deficiency manifestations of water soluble vitamins; Deficiency manifestations of fat soluble vitamins; Causes of vitamin deficiencies in India; Hypervitaminosis of water-soluble vitamins; Hypervitaminosis of fat-soluble vitamins; Vitamin fortification and supplementation; Methods of assay of vitamins; Interaction with other nutrients, antagonists and analogues of vitamins; Assessment of vitamin status of population.

Unit II: Minerals

Causes of macro and micro mineral deficiencies in India; Chronology, chemistry and distribution of minerals; Functions, absorption, transport and metabolism of minerals; Deficiency manifestations of minerals; Nutritional requirements of minerals; Methods of assay of minerals; Interactions of minerals with other nutrients, antagonists and analogues of minerals; Assessment of mineral status of population; Mineral fortification and supplementation; Metaloenzymes. Antioxidants and their relationship with aging, cancer and various non-communicable diseases.

Unit III: Heavy metal toxicity

Harmful effects of major mineral pollutants on health - mutagenicity, carcinogenicity and heavy metal toxicity; Heavy metal toxicity;

Unit IV: Trace elements

Trace minerals - their chronology, chemistry, distribution. Functions of trace minerals. Absorption and metabolism of trace minerals. Requirements of trace minerals. Deficiency manifestation and interaction of trace minerals. Use of mineral isotopes/ tracers in nutritional studies.

V. Suggested Reading

- FAO/WHO. 2004. *Vitamins and Minerals in Human Nutrition. A report of joint FAO/WHO Expert Consultation*. 2nd Edition, World Health Organization and Food and Agriculture Organization of the United Nations.
- Garland CF, Garland FC, Gorham ED, Lipkin M, Newmark H, Mohr SB and Holick MF. 2006. *The Role of Vitamin D in Cancer Prevention. American Journal of Public Health*. 96(2), 252–261.
- Groff JL and Gropper S. 2012. *Advanced Nutrition and Human Metabolism*. 7th Edition, Yolanda Cossio, New York.
- Guardia M and Garrigues S. 2015. *Hand Book of Mineral Elements in Foods*. John Wiley & Sons Inc. Hoboken, New Jersey.
- Rizvi S, Raza, ST, Ahmed F, Ahmad A, Abbas S and Mahdi F. 2014. *The Role of Vitamin E in Human Health and Some Diseases. Sultan Qaboos University Medical Journal*, 14(2), 157–165.
- Schwalfenberg GK. 2017. *Vitamins K1 and K2: the emerging group of vitamins required for human health. Journal of Nutrition and Metabolism*. https://doi.org/10.1155/2017/6254836.
- https://www.who.int
- https://nutrition.org
- https://www.gainhealth.org

I. Course Title : Nutrition and Agricultural Interface

II. Course Code : FN 603

III. Credit Hours : 3(3+0)

IV. Theory

V. Unit I: Food production and consumption

Food situation in India and in the world; Food production and consumption trends; Food balance sheets; Role of nutrition in agricultural planning and national development.

Unit II: Food distribution

Linkages between agricultural practices and food production, distribution and nutritional status; Factors affecting food distribution at macro and micro level; Per capita food availability and consumption; Food and Nutrition security at national and household level; Role of agriculture in enhancing food security; Food crop failure and malnutrition.

Unit III: Farming systems

Poverty and vicious cycle of low food production; Effect of food production and economic policies on food availability; Impact of physical resources, farming systems, cropping system, inputs and manipulation, agricultural marketing system, post-harvest processing of foods on food and nutrition situation; Implementation of nutrition policy.

Unit IV: Agricultural programmes

Sustainable food systems, nutritional impact of agricultural programmes, food price control and consumer subsidy; Contribution of National and International organization in agricultural development.

VI. Suggested Reading

- FAO. 2017. *The State of Food and Agriculture - Leveraging Food Systems for Inclusive Rural Transformation*. Food and Agriculture Organization, Rome.
- FAO. 2017. *The State of Food Security and Nutrition in the World*. Food and Agriculture Organization, Rome.
- GOI. 2016. *Agricultural Statistics at a Glance*. Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation and Farmers Welfare Directorate of Economics and Statistics, Government of India.
- GOI. 2017. *Agriculture - Statistical Year Book India*. Ministry of Statistics and Programme Implementation, Government of India.
- GOI. 2011. *Census of India*. Government of India.
- GOI. 2018. *A Reference Manualby Publication Division*. Ministry of Information about Broadcasting, Govt. of India.
- https://www.who.int
- http://www.fao.org/home/en
- https://www.india.gov.in/ agriculture
- https://mhrd.gov.in/mid-day-meal

I. Course Title : Global Nutritional Problems

II. Course Code : FN 604

III. Credit Hours : 2(2+0)

IV. Theory

Unit I: Food consumption

Food consumption pattern of underdeveloped, developing and developed countries.

Unit II: Nutritional deficiency diseases

An overview of world nutrition situation and assessment of problems of developing and developed countries in light of prevalence, aetiology, indicators and preventive measures.

Unit III: Health programmes

Nutrition and health programmes to alleviate malnutrition, role of national and international organizations.

Unit IV: Health care polices

Impact of health care polices and delivery systems; Micronutrients, food fortification and supplementation.

V. Suggested Reading

- Babu SC, Gajanan SN and Hallam JA. 2017. *Nutrition Economics-Principles and Policy Applications*. Science Direct. Elsevier.
- FAO. 2017. *Regional Overview of Food Security and Nutrition in Asia and the Pacific*. Food and Agriculture Organization, Rome.
- Park JE and Park K. 2007. *Text Book of Preventive and Social Medicine*. Barnasi Das Bhanot Publishers, Jabalpur.
- Semba RD and Bloem MW. 2008. *Nutrition and Health in Developing Countries*. 2nd Edition. Humana Press Inc. New York.
- Temple NJ and Steyn N. 2016. *Community Nutrition for Developing Countries*. AU Press, Athabasca University, Canada and UNISA Press, University of South Africa.
- https://www.who.int
- http://www.fao.org/home/en
- https://www.harvestplus.org
- https://www.hsph.harvard.edu/nutritionsource

I. Course Title : Nutrition in Calamities

II. Course Code : FN 605

III. Credit Hours : 2(2+0)

IV. Theory

Unit I: Calamities and undernutrition

Starvation in emergencies arising out of drought, floods, earth quakes, locust, war, wrong policies and poverty and climatic changes, conflict and global economic volatility, historical perspectives.

Unit II: Food needs during emergencies

Effect of inanition, short, medium and long- term emergencies on food and nutrient intake, precautions against food shortage; Population groups most vulnerable to under nutrition; Food needs at national level during normal emergencies.

Unit III: Nutritional deficiency diseases

Major nutritional deficiency diseases in emergencies, mobilization of local resources, general fund distribution, mass and supplementary feeding, therapeutic feeding, social funds; Nutritional Indices and reference standards; Preventing and handling donations in emergencies.

Unit IV: Hygiene and sanitation

Control of communicable diseases, public health and hygiene problems during emergencies.

V. Suggested Reading

- FAO. 2018. *Climate Change Challenge Badge*. 2nd edition. Food and Agriculture Organization of United Nations, Rome.
- Gibney MJ. 2004. *Public Health Nutrition*. Blackwell Science, Oxford.
- Park K. 2007. *Text book of preventive and Social Medicine* 19th Edition. Banarsidas Bhanot Publishers, Jabalpur, India.
- Spark A. 2007. *Nutrition in Public Health: Principles, Policies and Practice*. CRC Press, New York.
- WHO. 2000. *The Management of Nutrition in Major Emergencies*. World Health Organization, Geneva.
- https://www.who.int
- http://www.fao.org/home/en
- https://ndma.gov.in

I. Course Title : Maternal and Child Nutrition

II. Course Code : FN 606

III. Credit Hours : 2(2+0)

IV. Theory

Unit I: Nutrition and reproduction

Nutrition challenges, physiological changes, teenage pregnancy and gestational diabetes, nutrient needs, factors affecting nutrition of the women and children.

Unit II: Nutritional deficiencies

Needs and problems of lactating women, fetal malnutrition and low birth weight, nutrition and parasites, children with special needs, Protein energy malnutrition, vitamin A, iron, vitamin D, calcium and other common deficiencies, significance of stem cell and cord blood.

Unit III: Feeding practices

Formula feeding and supplements, lactation and breast feeding in the community, HIV and breast feeding; drug abuse and breast feeding. Human milk banks, IYCF guidelines, WHO breast feeding recommendations

Unit IV: Overnutrition and undernutrition

International programs regarding child and maternal health initiative to prevent overnutrition and undernutrition.

Suggested Reading

- Brown JE. 2016. *Nutrition through the Life Cycle*. 6th Edition. Cengage Learning, Boston.
- Ehiri J. 2009. *Maternal and Child Health - Global Challenges, Programs and Policies*. Springer Nature, Switzerland.
- Gluckman P, Hanson M, Seng CY and Bardsley A. 2015. *Nutrition and Lifestyle for Pregnancy and Breastfeeding*. OXford University Press, UK.
- Morgan JB and Dickeson JWT. 2003. *Nutrition in Early Life*. John Wiley and Sons Ltd. Chichester.
- https://www.unicef.org
- https://www.india.gov.in/ agriculture
- https://mhrd.gov.in/mid-day-meal

I. Course Title : Hormones and Enzymes

II. Course Code : FN 607

III. Credit Hours : 2(2+0)

IV. Theory

Unit I: Hormones

History, chemistry, endocrine and exocrine secretion of hormones, organs of secretion, metabolism, mechanism of action, regulation and sites of action, biological effects and interaction.

Unit II: Enzymes

Enzyme pathways in normal functions of the heart, pancreas, gastrointestinal and hepatic functions and kidneys.

Unit III: Metabolic disorders

Altered hormone and enzymatic pathways in obesity, reproductive functions, renal disorders, gastrointestinal disorders.

Unit IV: Degenerative diseases

Altered hormone and enzymatic pathways in hypertension, cardiovascular diseases, diabetes and cancer.

V. Suggested Reading

- Berg JM. 2007. *Biochemistry*. 6thEdition. W. H. Freeman and Company, New York.
- Henry HL and Norman AW. 2014. *Hormones*. 3rd Edition. Academic Press, Cambridge.
- Kleine B and Rossmanith WG. 2016. *Hormones and the Endocrine System*. Springer Nature, Switzerland.
- Palmer T and Bonner PL. 2007. *Enzymes*. 2nd Edition. Woodhead Publishing, Cambridge.
- Nelson DL and Cox MM. 2017. *Lehninger Principles of Biochemistry*. 7th Edition. W.H. Freeman Company, New York.
- https://www.nutrition.org.uk
- http://www.nutritioncare.org
- https://nutrition.org

I. Course Title : Energy Metabolism

II. Course Code : FN 608

III. Credit Hours : 2(2+0)

IV. Theory

Unit I: Bioenergetics

Scope and application of bioenergetics for human nutrition; Energy stores in man; Components of energy; Basal metabolism, energy cost of various activities; Factors affecting energy eXpenditure.

Unit II: Energy expenditure

Direct and indirect methods of assessing energy eXpenditure; Factors affecting energy requirements; Assessment of energy requirements.

Unit III: Regulation of metabolism

Thermogenesis, metabolic regulation; Weight control and obesity-role of adipose tissues; Effect of hormones on energy metabolism.

Unit IV: Hunger

Mechanism of hunger; Psychological and physiological factors associated with adiposity.

V. Suggested Reading

- Donohoue PA. 2010. *Energy Metabolism and Obesity*. Humana Press Inc. New York.
- Driskell JA and Wolinsky I. 2007. *Sports Nutrition: Energy Metabolism and Exercise*. 2nd Edition. CRC Press, New York.
- Korbonits M. 2008. *Obesity and Metabolism*. Karger Publishers, London.
- Rathore AK. 2015. *Bioenergetics*, *Physiology and Biostatistics*. Discovery Publishing House, New Delhi.
- Scott B. 2008. *A Primer for the Exercise and Nutrition Sciences*: *Thermodynamics*, *Bioenergetics*, *Metabolism*. Humana Press Inc. New York.
- http://www.nutritionlink.org
- https://www.icmr.nic.in
- http://www.nin.res.in

I. Course Title : Application of Biotechnology in Food Science and **Nutrition**

II. Course Code : FN 609

III. Credit Hours : 3 (3+0)

IV. Theory

Unit I: Food science and biotechnology

History, processes and products of biotechnology, application of biotechnology in production of nutritious foods.

Unit II: Product development

Role of biotechnology in enzymology and product development, fermentation process, fruit juice extraction, genetic improvement of food grade microorganisms.

Unit III: Nutraceuticals

Nutritional significance of food products developed by biotechnological techniques.

Unit IV: Constraints in food biotechnology

Scientific, technological and resource constraints in biotechnology; important factors affecting development in biotechnology.

V. Suggested Reading

- Nestle M. 2003. *Safe Food: Bacteria, Biotechnology and Bioterrorism*. University of California Press Ltd., London.
- Panesar PS and Marwaha. 2014. *Biotechnology in Agriculture and Food Processing: Opportunities and Challenges*. CRC Press, Boca Raton, Florida.
- Shetty K, Paliyath G, Pometto A and Levin RE. 2011. *Food Biotechnology*. 2nd Edition, CRC Press, New York.
- Ravishankar Rai V. 2015. *Advances in Food Biotechnology*. Wiley-Blackwell Publishing Company, Boston.
- https://www.bio.org

I. Course Title : Recent Trends in Food Science and Technology

II. Course Code : FN 610

III. Credit Hours : 3(3+0)

IV. Theory

Unit I: Macro and micronutrients

Recent advances in the field of carbohydrates, lipids, proteins, vitamins and minerals in relation to food science; Nutrigenomics, incorporating genetics into dietary guidance.

Unit II: Food analysis

Recent advances in the field of food analysis and food fortification.

Unit III: Advanced techniques

Membrane technology: micro-filtration, ultra-filtration, nano-filtration, reverse osmosis and their applications in food industry; Supercritical fluid extraction- concept and extraction methods; Microwave and radio frequency processing- mechanism and application in food processing; Hurdle technology- concept and its applications.

Unit IV: Foods of future

Food processing and product development; regulating; food processing and preservation through Total Quality Management (TQM) and Hazard Analysis and Critical Control Points (HACCP); Genetically Modified Foods (GM) foods and their health implications, functional foods and organic foods.

V. Suggested Reading

- Clark S, Jung S and Lamsal B. 2014. *Food Processing - Principles and Applications*. 2nd Edition, Wiley-Blackwell Publishing Company, Boston.
- deMan JM, Finley JW, Hurst WJ and Lee CY. 2018. *Principles of Food Chemistry*. 4th Edition, Springer International Publishing, New York.
- Fellows PJ. 2017. *Food Processing Technology*. 4th Edition, Woodhead Publishing Ltd. Cambridge.
- Hartel RW and Heldman D. 2012. *Principles of Food Processing*. Aspen Publishers Inc. New York.
- Ward JD and Ward LT. 2012. *Principles of Food Science*. Goodheart-Willcox Publisher, Illinois.
- https://www.gainhealth.org
- https://foodprocessingindia.co.in
- http://agronfoodprocessing.com

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 6

Community Science
– Human Development and Family Studies

Modifications Suggested in Courses in the Revised Curricula

M.Sc. (Community Science) in Human Development and Family Studies

Course Code	Course Title	Credit Hours	Remarks
	Major Courses (20 Credits)		
*HDFS 501	Theories of Human Development	3 (3+0)	Course content modified
*HDFS 502	Dynamics of Human Development	3 (3+0)	Contents modified and change in title
*HDFS 503	Methods and Techniques of Assessment in Human Development	3 (2+1)	Contents modified and change in title
*HDFS 504	Innovative Programmes in Early Childhood Development and Education	3 (2+1)	Contents modified
HDFS 505	Gender Issues in Human Development and Relationships	3 (2+1)	Contents modified and change in title
HDFS 506	Adult Development	2 (2+0)	New Course added
HDFS 507	Management of Differently Abled	3 (2+1)	Contents modified and change in title
HDFS 508	Adolescent Development and Challenges	3 (2+1)	Contents modified and change in title
HDFS 509	Guidance and Counselling	3 (2+1)	Contents modified
HDFS 510	Interventions for Differently Abled Children	2(1+1)	New course added
HDFS 511	Family Ecology	2 (2+0)	New Course added
HDFS 512	Family and Cultural Diversities	2(2+0)	New course added
HDFS 513	Family Therapy	3 (2+1)	Contents modified

Course Code	Course Title	Credit Hours	Remarks
	Minor Courses (08 Credits)		
FN 502	Public Health and Nutrition	3(2+1)	Proposed minor courses from subjects closely related to a student's major subject.
FN 505	Nutrition and Physical Fitness	3(2+1)	
FN 510	Nutritional Challenges in Life Cycle	3(2+0)	Apart from these courses a student can register any other course offered by any other departments
FN 513	Human Physiology	3(3+0)	
EECM 501	Global Extension Systems	2 (2+0)	
EECM 502	Development Communication	3 (2+1)	
EECM 508	Educational Technology	3 (2+1)	
EECM 509	Group Dynamics	2 (2+0)	
EECM 512	Gender Sensitization for Empowerment		2 (2+0)
	Supporting Courses (06 Credits)		
	Research Methodology	3 (2+1)	Course numbers will be assigned by the departments that offer these courses
	Statistical Methods and Application	3 (2+1	
	Common Courses (05 Credits)		
	Library and Information Services	1(0+1)	Common to all disciplines. The course numbers will be assigned by the departments that offer these courses
	Technical Writing and Communications Skills	1(0+1)	
	Intellectual Property and its management in Agriculture	1(0+1)	
	Basic Concepts in Laboratory Techniques	1(0+1)	
	Agricultural Research, Research Ethics and Rural Development Programmes	1(0+1)	
HDFS 591	Master's Seminar	1 (0+1)	
HDFS 599	Research	30	Increased credits for research
	Total	**70 Credits**	

*Core courses/ compulsory courses

Ph.D. (Community Science) in Human Development and Family Studies

Course Code	Course Title	Credit Hours	Remarks
	Major Courses (12 Credits)		
*HDFS 601	Advanced Human Development	3(3+0)	Contents and title modified
*HDFS 602	Ecology and Human Development	3(3+0)	Contents and title modified
*HDFS 603	Programme Development for Vulnerable Families	3(2+1)	Contents modified
HDFS 604	Strategic Developmental Intervention	3(2+1)	Contents modified
*HDFS 605	Family Studies	3(3+0)	Contents and title modified
HDFS 606	Adulthood and ageing	3(3+0)	Contents and title modified
HDFS 607	Mental Health	3(3+0)	New course
HDFS 608	Qualitative Research Methods	2(1+1)	Contents modified
	Minor Courses (06 Credits)		
CS/PGS 601	Research and Publication Ethics	2(1+1)	Proposed minor courses from subjects closely related to a student's major subject. Apart from these courses a student can register any other course offered by any other departments
EECM 602	Impact Assessment of Development Programmes	3(1+2)	
EECM 603	Scaling Techniques for Behavioural Research	3(1+2)	
EECM 608	Advocacy and Behavior Change Management	3 (1+2)	
FN 606	Maternal and Child Nutrition	2(2+0)	
FN 604	Global Nutritional Problems	2(2+0)	
FN 605	Nutrition in Calamities	2(2+0)	

Supporting Courses (05 Credits)

A student can opt any course related to the topic of research offered by other faculties of agriculture university or SWAYAM portal or other online courses up to a maximum of 5 credits.

HDFS 691	Doctoral Seminar I	1 (0+1)	
HDFS 692	Doctoral Seminar II	1 (0+1)	
HDFS 699	**Doctoral Research**	**75**	Increased credits for Research
	Total	**100 Credits**	

*Core courses/ compulsory courses

Course Title with Credit Load
M.Sc. in Human Development and Family Studies

Course Code	Course Title	Credit Hours	Semester
	Major Courses (20 Credits)		
*HDFS 501	Theories of Human Development	3 (3+0)	
*HDFS 502	Dynamics of Human Development	3 (3+0)	
*HDFS 503	Methods and Techniques of Assessment in Human Development	3 (2+1)	
*HDFS 504	Innovative Programmes in Early Childhood and Education Development	3 (2+1)	
HDFS 505	Gender Issues in Human Development and Relationships	3 (2+1)	
HDFS 506	Adult Development	2 (2+0)	
HDFS 507	Management of Differently Abled	3 (2+1)	
HDFS 508	Adolescent Development and Challenges	3 (2+1)	
HDFS 509	Guidance and Counselling	3 (2+1)	
HDFS 510	Interventions for Differently Abled Children	2(1+1)	
HDFS 511	Family Ecology	2 (2+0)	
HDFS 512	Family and Cultural Diversities	2(2+0)	
HDFS 513	Family Therapy	3 (2+1)	
	Minor Courses (08 Credits)		
FN 502	Public Health and Nutrition	3(2+1)	
FN 505	Nutrition and Physical Fitness	3(2+1)	
FN 510	Nutritional Challenges in Life Cycle	3(2+0)	
FN 513	Human Physiology	3(3+0)	
EECM 501	Global Extension Systems	2 (2+0)	
EECM 502	Development Communication	3 (2+1)	
EECM 508	Educational Technology	3 (2+1)	
EECM 509	Group Dynamics	2 (2+0)	
EECM 512	Gender Sensitization for Empowerment	2 (2+0)	
	Supporting Courses (06 Credits)		
	Research Methodology	3 (2+1)	
	Statistical Methods and Application	3 (2+1)	
	Common Courses (05 Credits)		

Course Code	Course Title	Credit Hours	Semest
	Basic Concepts in Laboratory Techniques	1(0+1)	
	Agricultural Research, Research Ethics and Rural Development Programmes	1(0+1)	
HDFS 591	Master's Seminar	1 (0+1)	
HDFS 599	Research	30	
	Total	**70 Credits**	

*Core courses/ compulsory courses

Course Contents
M.Sc. in Human Development and Family Studies

I. Course Title : Theories of Human Development

II. Course Code : HDFS 501

III. Credit Hours : 3 (3+0)

IV. Theory

Unit I: Psycho-dynamic theories

Meaning, types and functions of developmental theories. Theoretical perspectives and approaches- Psycho-dynamic theories- Psycho-analytic theory of Sigmund Freud – life history of Sigmund Freud, key concepts of psycho analytic theory, laws of psychological energy, three components of personality and their operational principles. Structural model of personality. Psycho-sexual stages and their impact on process of personality development. Contribution and criticism of Freudian theory. Neo-Freudians. Psycho-social theory of Erik Erikson – concept of development and basis of development, psycho-social stages of life.

Unit II: Maturation and cognitive theories

Maturational and biological approach- Arnold Gessell's theory of maturation. Cognitive Development theory of Jean Piaget – concepts, cognitive mechanism, cognitive structure, different stages of cognitive development, thought process and implications of the theory. Piaget's contribution to field of education. Neo-Piagetians- Fischer, Robert Case, Robert Sieglar and Bruner. Socio-cultural theory of Lev Vygotsky. Information processing theories.

Unit III: Behavioural and ecological systems theories

Behavioural approach of Watson. Stimulus Response theory by Sears, Skinner and Pavlov. Social- Learning and Social Cognition theory by Albert Bandura and its application in human development. Ecological Systems theory of Urie Bronfrenbrenner - concepts, systems and implications in understanding human development. Contribution of ecological systems theory in guiding families and teachers. Language development theory of Naom Chomsky.

Unit IV: Attachment, self and moral theories

Attachment theories by John Bowlby and Ainsworth. Maslow's Need Hierarchy model. Self Theories- Models of Morris Rosenberg and Cooppersmith. Moral development theories of Lawrence Kohlberg and Jean Piaget. Comparative analysis of theories and their application. Integrated approach to theory building.

V. Suggested Reading

- Baldwin AL. 1980. *Theories of Child Development*. John Wiley & Sons, New Jersey.
- Craig. 1985. *Theories of Human Development*. 2nd Ed., John Wiley & Sons, New Jersey.
- Grain WC. 1980. *Theories of Development: Concepts and Application*. Englewood Cliffs, Bergon, New Jersey.
- Hall CS. 1998. *Theories of Personality*. 4th Ed., John Wiley, New Jersey.
- Miller PH. 2016. *Theories of Developmental Psychology*. Worth Publishers, New York.
- Newman B and Newman R. 2007. *Theories of Human Development*. Rutledge, New Jersey.
- Sailkind NJ. 2004. *An Introduction to Theories of Human Development*. Sage Publications, New Delhi.

I. Course Title : Dynamics of Human Development

II. Course Code : HDFS 502

III. Credit Hours : 3 (3+0)

IV. Theory

Unit I: Nature vs. Nurture

Human development – basic concepts and issues. Genetic foundation, genetic code, chromosomal abnormalities. Role of epigenesis and canalization in growth and development. Interface between heredity and environment. Genetic research and its influence on child's development. Current research findings on pre-natal development and neo-natal stages – developmental sequence, prenatal environmental influences, developmental threats and DNA methylation.

Unit II: Cognitive development

Brain development- key concepts and process of development. Models of intelligence. Cognitive development during early years - perceptual capacities, attention, memory, imitation, early learning, conditioning and assessment. Role of early deprivation and enrichment in cognition. Information processing. Social cognition, emotional intelligence, metacognition and self regulation and their contribution to human mind and behavior. Gardner's Model of Multiple Intelligence.

Unit III: Psycho-social Issues

Language development and its components - pre-linguistic development, phonology, semantics and bilingualism. Socialization practices and influencing factors. Cultural influence on child outcomes. Exposure to media and technology and role of parents and institutions. Impact of socio-emotional deprivation on different stages of development. Vulnerability and resilience, risk and protective factors. Personality changes and self perceptions through different stages of development. Integrated view of human development.

Unit IV: Current and classic research trends in human development

Seminal work of Sigmund Freud, Erikson, Piaget, Uri Bronfenbrenner and Margaret Mead. Design and field work of "Six cultures project". Current research trends in physical, intellectual, psycho- social and moral development of children from birth to adolescence.

V. Suggested Reading

- Berk EL. 2017. *Development Through the Life Span*. 7th Ed., Pearson Education, Atlantic.
- Bronfenbrenner V. 1979. *The Ecology of Human Development*. Cambridge, Harvard.
- Feldman RS. 2017. *Development Across the Life Span*. Pearson, London, England.
- Garbarino J. 1982. *Children and Families in the Social Environment*. Aldine, New York.
- Kail R and Cavaraugh JC. 2016. *Human Development - A Life Span View*. Cenage Learning, Boston.
- Papalia DE and Olds SW. 2008. *Human development*. 11th Ed., McGraw Hill, New York
- Santrock JW. 2006. Life Span Development. Mc Graw Hill, New York.

I. Course Title : **Methods and Techniques of Assessment in Human Development**

II. Course Code : **HDFS 503**

III. Credit Hours : **3(2+1)**

IV. Theory

Unit I: Developmental assessment, methods and techniques.

Assessment –Concept, functions, characteristics, steps and rationale of assessment. History of tests and measurements. Different methods of child study/ developmental assessment. Techniques of measurement and their significance in measuring different aspects of human development. Role of assessment in intervention.

Unit II: Types of measures & methods

Scientific methods-definition, importance, goals and steps. Essential criteria of Scientific methods -reliability, validity control, item analysis. Use of objective measures and methods. Types of tests – individual and group tests. Projective techniques. Psychometrics, Sociometry. Types of scales –nominal, ordinal, interval and ratio scale

Unit III: Development of tests/ scales

Developmental Assessment from birth to early childhood. Tests for infants and children. APGAR scoring of new borns. Physical growth assessment. Anthropometric evaluation of nutritional status. Measurement of intelligence. Assessment of personality, aptitude, attitude and environment. Development of test/scale, steps, guidelines and standardization procedure – various methods of calculation of validity and reliability. Variables- extraneous, confounding, researcher variables and participant variables affecting internal validity. Threats to internal validity.

Unit IV: Ethical issues and barriers

Ethical issues in the assessment of human development. Special consideration in assessing young children. Ethical issues and barriers in assessment of infants and young children. Assessment of children with special needs. Interpretation and use of assessment information. Trends and challenges in assessment of human behavior.

V. Practical

1. Visit to neonatal unit to observe the neonates and to observe their assessment of APGAR score by pediatricians.
2. Physical Growth assessment and nutritional status of children of different age groups.
3. Review of available developmental screening and diagnostic tests for infants, toddlers and pre-school children.
4. Review of available screening and diagnostic tests for school age children and adolescents.
5. Developmental assessment of infants by using Bayley's Scale of Infant Development (BSID)
6. Interpretation of results and report writing
7. Administration of psychological tests for measuring cognitive abilities and intelligence.
8. Administration of psychological tests for assessment of socio-emotional development of children and adolescents.
9. Administration of psychological tests for personality assessment.
10. Administration of psychological tests for assessment of language development of children.
11. Assessment of home environment using HOME (Home Observation and

Measurement of Environment) inventory for different age groups of children/ Indian Home Inventory/ Family Environment Scale.

12. Interpretation of results and report writing on home environment
13. Development of scale or check lists on selected areas of development.
14. Standardization of the developed test, scoring and interpretation of results.
15. End term assessment

IX. Suggested Reading

- Anastasi A. 1988. *Psychological Testing*. 6th Ed., McMillan Publishing Company, New York.
- Bailey DB and Worley M. 2003. *Assessing Infants and Preschoolers with Handicaps*. Merrill Publishing Company, Delhi.
- Gregory RJ. 2004. *Psychological Testing - History, Principles and Applications*. 4th Ed., Pearson Education, Atlantic.
- Gumbiner J. 2003. *Adolescent Assessment*. John Wiley & Sons, New Jersey.
- Kumar R. 2014. *Research Methodology - A Step by Step Guide for Beginners*, 4th Ed., Sage Publications, New Delhi.
- Miller LA, Macintire SA and Lovler RL. 2012. *Foundations of Psychological Testing - A Practical Approach*. 4th Ed., Sage Publications, New Delhi.
- Shaughnessy JJ and Zechmeister EB. 2014. *Research Methods in Psychology*. 10th Ed., McGraw - Hill Publishing Company, New York.

I. Course Title : **Innovative Programmes in Early Childhood Development and Education**

II. Course Code : **HDFS 504**

III. Credit Hours : **3 (2+1)**

IV. Theory

Unit I: Innovative programmes in early childhood development and education

Need and scope for innovative programmes for early childhood development and education (ECDE). Innovative pedagogical approaches in early childhood development and education. Developmental patterns of children in early years. Current innovative programmes at State, National and International level. Innovative learning settings in classrooms of early child development and education centres. Usage of virtual and digital classrooms in Child Development and Education Centres

Unit II: Innovative programmes for child development

Methods and principles of designing, execution, monitoring and evaluation of programmes and activities in early childhood care and education centres. Innovative programmes for fostering physical, motor, cognitive, speech and language, creativity, socio- emotional and moral development of children.

Unit III: Stimulatory learning environment

Stimulatory learning environments at home and early childhood child care and education centres and at centres for children with special needs. Current and conventional practices of stimulatory learning. Innovative ideas for planning and execution of customized programmes/ activities for gifted children and differently able children.

Unit IV: Social support network systems

Innovative programmes for involving families in early childhood development and education centres. Challenges of family involvement. Development of social support network systems for inclusion of differently able children

V. Practical

1. Visits to observe early childhood care, education and development centers using varied pedagogical approaches in urban/ rural settings and study their programme and activities.
   i. Creche/ day care centre and Urban Nursery school
   ii. Visit to Aanganwadi centre and rural nursery school
2. Critical analysis and report presentation
3. Class room discussions on different types of virtual and digital classrooms
4. Designing innovative activities for young children - Physical and motor development
5. Designing innovative activities for young children - Cognitive and language development
6. Designing innovative activities for young children - Social, emotional and moral development
7. Execution of designed innovative activities.
8. Evaluation of the designed innovative activities as per their effectiveness and implementation potential
9. Conducting survey to assess parental needs on knowledge of innovative activities.
10. Designing need based parent education programmes

11. Organization of parent education programme
12. Conducting need assessment study to find out the training needs of ECCE staff
13. Planning of workshop/training for ECCE personnel
14. Conducting workshop/training for ECCE personnel
15. End term assessment

VI. Suggested Reading

- Deiner PL. 2006. *Inclusive Early Childhood Education*. Cengage Learning Press.
- Jaipaul I Roopnarian and James EJ. 2008. *Approaches to Early Childhood Education*. Pearson Education, Atlantic.
- Kaul V. 1997. *Early Childhood Education Programmes*. NCERT, Delhi.
- Saraswathi TS. 1988. *Issues in Child Development - Curriculum and Other Training and Employmen*t. Spmaiya.
- Shiradhonkar K and Patnam V. 2019. *Understanding and Developing Creativity*. New Academic Publications, New Delhi.
- Sinclair H. 2004. *Standards for Early Childhood Programmes in Centre based Child Care*. Govt. of New Found Land and Labrador. Dept. of Health and Community Services.
- Soni R. 2015. Theme Based Early Childhood Care And Education Programme - A Resource Book. NCERT, New Delhi.
- Wiltshire M. 2010. *Understanding the High Scope Approach, Early Years Education in Practice*. Taylor and Francis.

I. Course Title : **Gender Issues In Human Development and Relationships**

II. Course Code : **HDFS 505**

III. Credit Hours : **3 (2+1)**

IV. Theory

Unit I: Gender perspectives and theories

Concept of gender- biological and socio-cultural connotations. Historical perspectives. Gender differences in human development. Gender theories- Gender Orientation theory of Sandra Bem. Gender Schema theory, theory of Ego Development and Gender. Gender Stratification theory by Blumberg. Gender Identity Formation theory.

Unit II: Gender discrimination, gap and parity

Gender equality and development. Gender inequalities in human development– dimensions, causes and consequences. Gender discrimination indicators- global gender gaps. Gender Development Index, Global Gender Gap Index and Gender Parity Index. Demographic challenges to family ecology- gender role socialization.

Unit III: Gender violence and empowerment

Gender violence- dowry harassment and deaths, suicides, prostitution, sexual harassment and exploitation and prevention. Family violence, amniocentesis, female feticide, infanticide, eve teasing. Gender empowerment strategies- working towards family solidarity and social well-being. Gender main streaming- concept, policy of United Nations, objectives, requirements and principles. Empowering lives of women

by controlling – patriarchy system, women'svisibility. seXuality, fertility, labour, lack of Gender budgeting.

Unit IV: Changing trends in status of women

Status of women in India. Various plans and policies designed for achieving gender equality. Changing trends in gender role orientation- early civilization, pre-independence, post independent India, contemporary times, socio economic impact on the family and society, cultural impact on the family. Gender role portrayal in mass media. Gender stereotyping in schools. Gender issues at workplace.

V. Practical

1. Gender analysis of mass media: Print media and E-media
2. Report writing
3. Study of adopted socialization practices for children of both genders
4. Report writing
5. Case studies of three generations on dynamics of gender orientation
6. Report presentation and discussion
7. Case studies of three generations on dynamics of Gender roles and responsibilities.
8. Report presentation and discussion
9. Views of adolescents on their gender role orientation- designing questions .
10. Survey through questionnaire
11. Report presentation and discussion
12. Case studies on changing trends of roles and responsibilities of women and men
13. Report writing
14. Visits to women welfare Govt. organizations/ agencies/ NGOs
15. Presentation of report and class discussion.
16. End term assessment

VI. Suggested Reading

- Banddarage A. 1997. *Women Population and Global Crisis - A Political and Economical Analysis*. Zed books, London.
- Barnett RC, Biner L and Baruch GK. 1987. *Gender Stress*. The Free Press, New York.
- Chanana K. 1989. *Gender and the Household Domain*. Sage Publications, New Delhi.
- Kapadia S and Gala J. 2015. *Gender Across Cultures: Sex and Socialization in Childhood*. Sage Publications, New Delhi.
- Kumar CS. 2017. *Gender Socialization and The Making of Gender in The Indian Context*. Sage Publications. New Delhi.
- Menon L. 1997. *Gender Issues and Social Dynamics*. Kanishka Publishers and Distributors, New Delhi.
- Sudha DK. 2000. *Gender Roles*. A.P.H. Publishing Corporation, New Delhi.

I. Course Title : Adult Development

II. Course Code : HDFS 506

III. Credit Hours : 2 (2+0)

IV. Theory

Unit I: Theoretical and ecological perspectives of adult development

Adulthood- transition to adulthood, stages of adulthood. Psychosocial theories of ageing - Erikson's Psychosocial theory, Identity Process Theory, Activity Theory, Socio-emotional Selectivity Theory. Theoretical perspectives in adult development - Bio-psychosocial perspective, Ecological perspective, Life Course perspective. Klaus Riegel's Dimensions of Development Theory. Four principles of adult development and aging.

Unit II: Models and stereotypes in adulthood

Models of development- biological model of aging, psychological models of adulthood development, socio-cultural models of development, nature and nurture in adulthood-individual and environment interactions. Reciprocity in development. Themes and issues in adult development and aging. Ageism and stereotyping the elderly.

Unit III: Developmental changes during adulthood

Developmental changes in adulthood – biological changes, cognitive changes, sensory changes, psychological and social interactional changes associated with aging. ageing and health. Factors affecting health. Lifestyle and health. Key concepts in health and prevention of chronic diseases, physical and neuro-cognitive disorders and others. Risk factors and preventive measures, supportive services.

Unit IV: Adulthood Adjustment

Demographics of an ageing population. Gender differences in aging. Menopause and its effects on women. Cessation of sexual prowess and its effect on men. Issues and adjustments related to occupation, self and family. Retirement, leisure and adjustment. Causes of morbidity and mortality across the life cycle. Human longevity - the influence of genetic and environmental factors. Death, dying and bereavement. Attitude towards death, grief and bereavement.

V. Suggested Reading

- Dacey JS and Travers JF. 2002. *Human Development - Across the Lifespan*. McGraw Hill, Boston.
- Dandekar K. 1996. *The Elderly in India*. Sage Publications, New Delhi.
- Hayslip B and Panek P. 1989. *Adult Development and Aging*. Harper & Row.
- Hurlock EB. 2003. *Developmental Psychology - A Life Span Approach*. Tata McGraw Hill, New Delhi.
- Kail RV and Cavanaugh JC. 2004. *Human Development - A Life-Span View*. Thomson Wadsworth, United States.
- Kimmel DC. 1990. *Adulthood and Aging*. John Wiley & Sons, New York.
- Leme BH. 1995. *Development in Adulthood*. Allyn & Bacon.
- Newman BM and Newman PR. 2003. *Development Through Life: A Psycho Social Approach*. Cengage Learning, Boston.
- Sigelman CK. 1999. *Life Span Human Development*. 3rd Ed., Brooks/Cole Publishing Company, London.

I. Course Title : Management of Differently Abled

II. Course Code : HDFS 507

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Classification and statistics of differently abled

Concept and classification of differently abled individuals. Their current statistics. It's implications on the quality of life. Social, emotional, and economic aspects of exceptionality for both children and families. Multi disciplinary view of differently abled individuals.

Unit II: Characteristics, etiology and issues of differently abled

Different abilities- mental deficiency, learning disabilities, visual impairment, hearing impairment, communication disorders, neurological disorders - definition, types, characteristics, etiology, prevalence in India for all above different abilities. Associated psychological and behavioural problems, educational provisions, management considerations and remedial programmes for different types of special needs.

Unit III: Educational & vocational interventions for differently abled

Physical impairment or loco-motor disabilities (Orthopedic and neurological impairment)- definition, classification, assessment and etiology. Psychological and behavioural characteristics of physically challenged children. Educational and vocational interventions. Remedial programmes for physically challenged. Psycho-social disturbances and social maladjustment - definition, classification, types, characteristics and etiology of emotionally disturbed and socially maladjusted. Management considerations and remedial programmes for psycho-socially disturbed and socially maladjusted. Gifted children - definition, types, characteristics, assessment and prevalence in India. Inclusive education and special programmes for the gifted.

Unit IV: Government support services

Preventive measures. Assistive technologies for different developmental challenges. Inclusive education policies and programmes for differently abled persons. Government provisions, concessions, facilities, rights and legislations for differently abled. Community based rehabilitation. Rehabilitation Council of India. National and International agencies for differently abled individuals.

V. Practical

- Case studies of differently abled persons- etiology, characteristics, assessment of their different Abilities
  - Mentally subnormal children
  - Visually impaired children
  - Hearing impaired children
  - Speech impaired children
  - Orthopedically handicapped
  - Learning disabled children
  - Gifted children

2. Collaborative work with professionals in development of intervention packages for differently abled children (for any one category)
3. Conducting home based interventions
4. Conducting center based interventions at schools/ child clinics/ pediatric wards/ special schools and so on.

5. Report writing and presentation
6. Collaborative work with professionals in development of intervention packages for differently abled children (for any second category)
7. Conducting home based interventions
8. Conducting center based interventions at schools/ clinics/ pediatric wards/ special schools, etc.
9. Report writing and class presentation
10. End term assessment

VI. Suggested Reading

- Achenbach TM. 1982. *Developmental Psychopathology*. 2nd Ed., John Wiley, New York.
- Berdine WH and Blackhurst AE. 1985. *An Introduction to Special Education*. 2nd Ed., Harper Collins, LeXington.
- Hallahan DP and Kauffman JM. 1991. *Introduction to Exceptional Children*. Allyn and Bacon, Boston.
- Hegarty S. 2002. *Education and Children with Special Needs*. Sage Publications, New Delhi.
- Kar C. 1996. *Exceptional Children - Their Psychology and Education*. Sterling Publication, New York.
- Kirk SA. 1972. *Educating Exceptional Children*. Houghton Mifflin Company, Boston.
- NIMH. 1999. *School Readiness for Children with Special Needs*. National Institute for the Mentally Challenged Children, Secunderabad.
- Prasad J and Prakash R (1996). *Eduaction of Handicapped Children, Problems and Solution*. Kanishka Publications. New Delhi.
- Saini S and Vig D (2008). *Special Children - Behaviour, Needs and Management*. Swami Printers, Ludhiana.

I. Course Title : Adolescent Development and Challenges

II. Course Code : HDFS 508

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Theoretical perspectives of adolescents

Adolescence – definition, significance of the stage. Theoretical perspectives on adolescence – biological, psycho-analytical, psycho-social, social-cognitive and cultural. Physical and sexual development in adolescence - physical transition from child to adult, adolescent growth spurt, puberty causes and changes, psychological impact of puberty, early and late maturation and its psychological implications, adolescent sexuality, causes and correlates of physical development.

Unit II: Cognitive and communication development during adolescence

Cognitive and intellectual development during adolescence- the formal-operational stage, hypothetico-deductive reasoning, thinking like a scientist, complexities of adolescent thoughts, information-processing view of adolescent cognitive development, gender differences in mental abilities. Language development during adolescence- later syntactic development, semantics and meta-linguistic awareness, development of communication skills, learning in school and vocational development.

Unit III: Psycho-social and personality development

Psychosocial development during adolescence- emotional changes, problems, emotional regulation and stability, self-understanding. Role of family, peers, school in psychosocial development. Work, career, heterosexual relationships in adolescence. Personality development- Erikson's theory, identity crisis, identity diffusion, identity foreclosure, identity moratorium, self-concept, gender-role stereotyping. Moral development during adolescence and value orientation. Environmental learning, interactional and cultural context in moral development.

Unit IV: Different challenges of adolescence

Vocational preferences. Transition to adulthood- conflicts with special reference to contemporary socio-cultural changes. Challenges of adolescence- sexuality, aggression, delinquency, AIDS, substance abuse, alcoholism, personality disorders, depression, suicide, eating disorders, health problems, psychological problems, social problems- dating and relationships. Integration of self and psycho-sexual resolution. Resolving identity crisis- reorganization of social life relationship with peers and parents, heterosexual relationships. Risk and resilience during adolescence. Risk and protective factors. Challenges in adolescent's life in the 21st century. Challenges and opportunities for adolescent research. Programs and policies.

V. Practicals

1. Case studies- interviewing early and late adolescents on issues, problems, pubertal changes, friendships, career aspirations, self and social awareness, mass media references
   - Development of case study format
   - Conducting case study of early adolescent girl and early adolescent boy
   - Conducting case study of late adolescent girl and late adolescent boy
2. Report writing and presentation of case studies
3. Assessment of intellectual abilities of adolescents and class room discussion.
4. Assessment of psycho-social development patterns of adolescents and class room discussion.
5. Depiction of adolescents in mass media: Content analysis of media-
   - Feature films

- Television serials
- Literature-magazines, newspapers, advertisements.

6. Report writing and presentation
7. Survey in rural/ semi-urban/ urban communities on challenges faced by adolescents and their Parents.
8. Survey in rural/ semi-urban/ urban communities on challenges faced by teachers of Adolescents
9. Analysis of survey results for adolescent challenges and their need assessment.
10. Planning intervention education programmes for adolescents.
11. Organising intervention education programmes for adolescents about their developmental changes, needs and coping up strategies.
12. End term assessment

VI. Suggested Reading

- Berk LE and Meyers AB. 2010. *Infants, Children, and Adolescents*. 7th Ed., Prentice Hall, PTR.
- Conger JJ. 1977. *Adolescence and Youth: Psychological Development in a Changing World*. Harper & Row, New York.
- Hazen EP, Goldstein MA and Goldstein MC. 2011. *Mental Health Disorders in Adolescents: A Guide for Parents, Teachers, and Professionals*. Rutgers University Press: New Brunswick, NJ.
- Hurrelmann K and Hamilton SF. 1996. *Social Problems and Social Contexts in Adolescence*. Aldine De Gruyter: New York.
- Seifert KL, Hoffnung RJ and Zack IZ. 1999. *Child and Adolescent Development*. Cengage Learning, Belmont, CA, USA.
- Shaffer DR and Kipp K. 2010. *Developmental Psychology: Childhood and Adolescence*. Wadsworth, Cengage Learning, Belmont, CA, USA.
- Spielhagen FR and Schwartz PD. 2013. *Adolescence in the 21st Century: Constants and Challenges*. Information Age Publishing, Amazon Kindle.

I. Course Title : Guidance and Counselling

II. Course Code : HDFS 509

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Areas and types of guidance and counselling

Guidance and Counselling – Meaning, history, goals, levels and techniques. Areas of guidance and Counselling. Types of guidance and counseling services - educational, vocational, personal, marriage and family, leisure time. Assessment and diagnostics in counselling.

Unit II: Contemporary trends and ethical issues

Counselling and therapy relationships. Counselling children - goals, child-counsellor relationships. History about counselling children. Contemporary issues. Play therapy. Integrated counselling for children. Guidance and counselling in schools and colleges. Group guidance. Couple, pre-marital, marriage and family counselling. Current trends in counselling, computerized therapy programs. Research trends in guidance and counseling in India and abroad.

Unit III: Essentials of conducting guidance and counselling sessions

Competencies and role of guidance and counselling professionals. Modes and methods of counselling. Essentials of conducting guidance and counselling session. Understanding the process of guidance and counseling. Ethical issues in guidance and counselling. Knowledge and skills to handle assessment tools. Effective communication and documentation skills. Networking with allied professionals and institutions. Counselling with special concerns, Children with developmental challenges, ambivalent and oppositional type, crisis counselling, guidance in adolescence, counselling elderly.

Unit IV: Approaches and theories of counselling

Approaches and theories of counselling: Affective Counselling theory- concept, key principles. Humanistic approaches- Roger's Client centered approach, Gestalt approach. Psychoanalytic -Psychodynamic approaches by Sigmund Freud, Carl Jung, Alfred Adler and Melanie Klien. Skinner's Behaviouristic approach, Bandura's Behaviour Modification approach. Rational emotive behaviour therapy. Reality therapy. Beck's Cognitive –Behaviour approach.

V. Practicals

1. Compiling research reviews on various aspects of guidance and counselling.
2. Preparing a checklist to observe and analyze guidance and counselling centers – their organizational structure, objectives, types of services provided, available facilities, staff competencies and problems experienced by them, etc.
3. Survey of guidance and counselling centers by using prepared observation check list.
4. Visit to observe and conduct interviews to get information about the counselling services provided by these institutions such as-Women welfare & child development
5. Family court
6. Women cell, etc.
7. Preparation and presentation of report
8. Visit to observe career guidance centers
9. Feed back of the clients towards the services, financial management/budget, support of other professionals/agencies to different types of centers.
10. Simulation exercises of guidance and counselling children and parents.

11. Content analysis of problems addressed by the leading counselling centers.
12. Content analysis of prevailing psychosocial problems reported in print and electronic media.
13. Identification of characteristics and skills of the counsellors by watching recorded videos on child and adolescent counselling.
14. Understanding techniques used by counsellors by watching recorded videos on child and parent guidance, child counselling, adolescent counselling, couple counselling.
15. Writing reports on films and videos related to the course and its presentation.
16. End term assessment

VI. Suggested Reading

- Anthony DJ. 2006. *Mental Disorders Encountered in Counselling*. Anuragha Publications, Chennai.
- Barker M, Vossler A and Langdridge D. 2010. *Understanding Counselling and Psychotherapy*. Sage Publications, New Delhi.
- Cooper S. 2005. *Counselling, Inception, Implementation & Evaluation*. Infinity Books, New Delhi.
- Gunner J. 1984. *Counselling and Therapy for Children*. The Free Press, New York.
- Hough M. 2014. *Counselling Skills and Theory*. Hodder Education, Oxon, UK.
- Ivey AE, Ivey MB and Downing LS. 1987. *Counseling and Psychotherapy - Interpreting, Skills Theory and Practice*. Prentice Hall.
- Timulak L (2011). *Developing your Counselling and Psychotherapy Skills and Practice*, 1st Ed., Sage publications, New Delhi.
- Welfel E R and Patterson L E (2004). *The Counseling Process - A Multitheoretical Integrative Approach*. Thomson Brooks/Cole, Australia.

I. Course Title : Interventions for Diffrerently Abled Children

II. Course Code : HDFS 510

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Significance and types of intervention services

Intervention services- concept, need and significance. Prevention of avoidable health problems. Early intervention –concept, need and significance. Therapies and services- types and contents. Family centred, Child focused intervention, supportive and structured intervention. Speech therapy, occupational therapy, play based intervention.

Guidelines for intervention programmes for differently abled. Problems and strategies. Process and steps of intervention- identification, assessment and diagnosis of differently abled and at-risk children, planning and designing intervention, implementation and evaluation. Curriculum planning for differently abled children.

Unit III: Development of intervention programme

Developing need based intervention programmes and strategies for different categories of developmentally challenged children and their parents. Understanding key elements for successful interventions- tailoring for individual needs, providing normality and integration, provision of optimal environment for developmental progress, environmental compatibility and remedial services.

Unit IV: Executing intervention and multi disciplinary approach

Executing child and parent focused interventions and evaluating its effectiveness. Multi disciplinary approach-significance, strategies to include parents and community and overcoming barriers. Planning interventions for inclusion. Involving parents and community.

V. Practicals

1. Identification of families having children with specific disability
2. Based on selected families, developing need assessment checklist of differently abled children and their families.
3. Need assessment of differently abled children and their families, report presentation and enlisting the needs of family and differently abled child care & development.
4. Designing and developing intervention modules/ programme based on needs of differently abled children and their families.
5. Presentation of intervention modules/ programme, its evaluation and enhancement.
6. Intervention programme: Material selection from department and market survey of required Material/ toys/ tools/ books, etc.
7. Presentation of student's ideas for development of educational and development oriented material/ tools for intervention, discussion on it and finalizing the intervention material and tools.
8. Understanding and experiencing purchase procedure for required material- Seeking permissions of the authorities for purchases, drawing advances (Money indent), submission of vouchers and entry of material in registers.
9. Preparation and up gradation of intervention activities, material and tools.
10. Part-1: Implementation and monitoring of intervention programme in families of differently abled child
11. Part-II: Implementation and monitoring of intervention programme in families of differently abled child.

12. Part-III: Implementation and monitoring of intervention programme in families of differently abled child.
13. Part-IV: Implementation and monitoring of intervention programme in families of differently abled child.
14. Evaluation of effectiveness of intervention programme in catering the identified needs of families and their differently abled children.
15. Conducting parents/ community workshops for publicity of benefits of need based intervention programmes for creating awareness and motivation in families for the welfare of differently abled children.
16. End term assessment.

VI. Suggested Reading

- Chadha A. 2001. *A Guide to Educating Children with Learning Disabilities*. Vikas Publishing House, New Delhi.
- Chadha A. 2005. *Teaching Visually Impaired Children – Module 1*. Unistar Books, Chandigarh.
- Gutpa R K. 2005. *Disability In Indian Context - A Teacher's Role*. Unistar Books, Chandigarh.
- Khatib J and Khadi P. 2011. *Emotional Behaviouir of Mentally Challenged Children Attending Special Schools: Parental Educational Intervention*. UAS, Dharwad.
- Manga SK. 2009. *Educating Exceptional Children - An Introduction to Special Education*. PHI Learning, New Delhi.
- Panda KC. 1997. *Education of Exceptional Children*. Vikas Publishing House. New Delhi.
- Sahu BK. 2002. *Education of the Exceptional Children*. Kalyani Publishers, New Delhi.

I. Course Title : Family Ecology

II. Course Code : HDFS 511

III. Credit Hours : 2 (2+0)

IV. Theory

Unit I: Family relationships

Family as a social system. Socialization within the family. Models of parenting. Parent child relationships- functional and dysfunctional dyads. Family cohesion, conflict and family disorganization –impact on parenting. Children as family agents. Children and marital life. Child abuse. Bidirectionality in parent child relations. Family interactions and delinquency. Improving family communication and interpersonal relations.

Unit II: Family under transition

Family transitions. Change and continuity over life cycle. Needs and problems of families at different developmental stages. Impact of social change on family and changing family patterns in India. Religion and family. Family social class and ethnic variations in child rearing.

Unit III: Family stressors and resilience

Family as an institution under stress. Family crisis. Poverty and children. Stressors and family relations - with special reference to family disruption, sickness, divorce, substance abuse and disability. Stress Process Model. Family's adaptation to stress. Family resilience and protective factors for promotion of family resilience. Family environment and social support as a source of risk and resilience for vulnerable children/youth. Intergenerational family dynamics in management of family conflicts and negative patterns.

Unit IV: Impact of consumerism, emigration and multiculturalism on families

Impact of consumerism on rural and urban families. Impact of emigration and multiculturalism on families. Two culture children and their psycho-social dilemmas. Contemporary issues related to family.

V. Suggested Reading

- Carson DK, Carson CK, Chowdhury A. 2007. *Indian Families at the Crossroads*. Gyan Publishing House, New Delhi.
- Daly KJ. 2007. *Qualitative Methods for Family Studies & Human Development*. Sage Publications, New Delhi.
- Falcov CJ. 1991. *Family Transitions*. Gulford Press, California.
- Garbarino J, Eckenrode J and Barry F D. 1997. *Understanding Abusive Families: An Ecological Approach to Theory and Practice*. Jossey-Bass, New York.
- Grigorenko EL and Stenberg RJ. 2001. *Family Environment and Intellectual Functioning: A Life-Span Perspective*. Lawrence Erlbaum Associates Publishers, London.
- Karim AB. 2014. *Family Interactions: Concepts, Mechanism & Methods to Improve the Family Communication & Interpersonal Relationships*. Successful Family Upbringing Series, Refman.
- Kuczynski L. 2003. *Handbook of Dynamics in Parent-Child Relations*. Sage Publications, New Delhi.
- McCubbin H and Figley CR. 1991. *Stress And The Family: Coping with Normative Transitions Routledge*. Taylor and Francis Group, New York.

I. Course Title : Family and Cultural Diversities

II. Course Code : HDFS 512

III. Credit Hours : 2(2+0)

IV. Theory

Unit I: Culture and family

Culture- definition, components and characteristics of culture. Agents of cultural influences- school, family, community and other social groups. Cultural factors and impact on families. Western versus Eastern family culture. Cultural diversities in India. Elements of India's diverse culture – religion, philosophy, cuisine, language, fine arts, dance, music.

Unit II: Families in India and abroad

Families in India and abroad - communal, nuclear, joint, extended, polyamorous, polyandrous, polygynous, single parent families, unrelated families. Indian family culture-values and issues concerning families and its stability. Factors determining social status of families. Families in rural and tribal agrarian community – status of women, children, elderly and men in the families.

Unit III: Cross-cultural variations in family functioning

Cross-cultural variations in different aspects of family functioning across different West and East countries/ cultures *vis-à-vis* – marriage, parenthood, relationships, care of elderly and status of women. Cross cultural variations in family functioning, roles and responsibilities, cohesion, interpersonal communication patterns, conflict resolution. Parenting across cultures – child rearing, socialization and socialization practices. Family crisis and adaptations across cultures. Unique family experiences across cultures, some classic examples like Kibbutz in Israel.

Unit IV: Diversities in family life and challenges

Diversities in family life – ethnic, linguistic, regional, etc. Effect of urbanization, secularization, westernization, technological advancement, globalization and other such developments on families in general and agrarian in particular. Challenges before families across cultures. Legal provisions – emerging cultural trends. Research trends in cross-cultural family studies, methodological issues.

V. Suggested Reading

- Ballard SM and Taylor AC. 2012. *Family Life Education with Diverse Populations*. Sage Publications, Los Angeles.
- Brislin RW. 1990. *Applied Cross Cultural Psychology*. Sage Publications, New Delhi.
- Carson DK, Carson CK and Chowdhury A. 2007. *Indian Families at the Crossroads*. Gyan Publishing House, New Delhi.
- Ratra A, Kaur P, Chhikara S, Varma T and Chawla P. 2006. *Marriage and Family- In Diverse and Changing Scenario*. Deep & Deep Publications Pvt. Ltd, New Delhi.
- Saraswathi TS. 2003. *Cross Cultural Perspectives In Human Development*, Sage Publications, New Delhi.
- Selin H. 2014. *Parenting Across Cultures: Childrearing, Motherhood and Fatherhood in Non-Western Cultures*. Springer, Dordecht.
- Trask BS and Hamon RR. 2013. *Cultural Diversity and Families: Expanding Perspectives*. Sage Publications, New Delhi.

I. Course Title : Family Therapy

II. Course Code : HDFS 513

III. Credit Hours : 3 (2+1)

IV. Theory

Unit I: Family therapy - orientation and theoretical perspectives

Family Therapy – concept, need, significance, areas, scope, goals and application of marriage and family therapies. Evolution of family therapy. Early models and basic techniques of family therapy- group process and communications analysis. Theoretical developments in marital and family therapy. Approaches in family therapy - Social Learning approach, Psychoanalytic, Behavioural, Systems approach. Social Constructionism theory. Attachment theory.

Unit II: Types of family therapy

Classic schools of family therapy- Bowenian Family Systems therapy, Strategic, Structured, Communication and Experiential therapies, Psychodynamic Therapy, Cognitive- Behaviour family therapy and integrated family therapy. Contemporary marital therapies. Family therapy in the 21st century and its application to multicultural, single parent and disorganized families, solution focused therapy, narrative therapy and integrative models. Application of family therapy in depression, substance abuse, schizophrenia and eating disorders.

Unit III: Concerns for family therapy

Signs and symptoms of family in need of therapies- psychosomatic symptoms, psychiatric disorders, marital distress, alcoholism, drug dependence, juvenile offences, problems of adolescence, conduct problems, work and school phobias.

Unit IV: Prospects of family therapy

Qualities of marriage and family therapists. Techniques of marriage and family therapy. Advances in clinical assessment, preventive and enrichment programmes. Future direction for marriage and family therapy- bridging research, theory and practices.

V. Practical

1. Observational visits and screening families in need of therapy (in various settings) andpreparation of format for it. Visiting and screening of urban families in need of therapy
2. Visiting and screening of slum families in need of therapy
3. Visiting and screening of rural families in need of therapy
4. Report presentation and discussion
5. Case studies of different areas of marriage and family therapy (alcoholism, drug, dependence, juvenile offences, problems of adolescence).
6. Preparation of format. Case study of alcoholic de-addiction.
7. Case study of drug dependence and de-addiction.
8. Case study of juvenile offences and rehabilitation.
9. Case study of socio-emotional problems of adolescents.
10. Report presentation and discussion.
11. Case studies of different methods and techniques of marriage and family Therapy (one from each).
12. Visit to marriage and family therapy centre
13. Observation of sessions for knowing the methods and techniques used in marriage and family therapy (actual).
14. Observation of sessions for knowing the methods and techniques used in marriage and family therapy (recorded ones).

15. Report presentation and discussion.
16. End term assessment.

VI. Suggested Reading

- Carr A. 2008. *Family Therapy – Concepts, Process and Practice*. 2nd Ed., John Wiley & Sons Ltd, Chichester.
- Carson DK, Carson CK, Chowdhury A. 2007. *Indian Families at The Crossroads*. Gyan Publishing House, New Delhi.
- Doherty W, Boss P, Larossa R, Schumm W and Steinmets S. 1993. *Family Theories and Methods: A Contextual Approach*. Mac Millan & Company.
- Lowe R. 2004. *Family Therapy a Constructive Framework*. Sage Publications, New Delhi.
- Mark R. 2003. *Family Therapy in Focus*. Sage Publications, London.
- Roger L. 2004. *Family Therapy - A Constructive Framework*. Sage Publications London.

Course Title with Credit Load
Ph.D. in Human Development and Family Studies

Course Code	Course Title	Credit Hours	Semester
	Major Courses (12 Credits)		
*HDFS 601	Advanced Human Development	3(3+0)	
*HDFS 602	Ecology and Human Development	3(3+0)	
*HDFS 603	Programme Development for Vulnerable Families	3(2+1)	
HDFS 604	Strategic Developmental Intervention	3(2+1)	
HDFS 605	Family Studies	3(3+0)	
HDFS 606	Adulthood and ageing	3(3+0)	
HDFS 607	Mental Health	3(3+0)	
HDFS 608	Qualitative Research Methods	2(1+1)	
	Minor Courses (06 Credits)		
CS/PGS 601	Research and Publication Ethics	2(1+1)	
EECM 602	Impact Assessment of Development Programmes	3(1+2)	
EECM 603	Scaling Techniques for Behavioural Research	3(1+2)	
EECM 608	Advocacy and Behavior Change Management	3(1+2)	
FN 606	Maternal and Child Nutrition	2(2+0)	
FN 604	Global Nutritional Problems	2(2+0)	
FN 605	Nutrition in Calamities	2(2+0)	
	Supporting Courses (05 Credits) **		
HDFS 691	Doctoral Seminar I	1+0	
HDFS 692	Doctoral Seminar II	1+0	
HDFS 699	Research	75	
	Total	**100 Credits**	

*Core courses/ compulsory courses

Course Contents
Ph.D. in Human Development and Family Studies

I. Course Title : Advanced Human Development

II. Course Code : HDFS 601

III. Credit Hours : 3(3+0)

IV. Theory

Unit I: Human development – a science and a process

Classical and contemporary theoretical orientation to human development. Relational developmental systems and developmental science. Developmental psychology to developmental science from deficit to diversity in development. Regulation of development and differentiation. Constructing general model for development – developmental behaviour genetics. Multilevel nature and analysis of developmental processes.

Unit II: Developmental diversity and regularity

Concept of Consistency vs. change in development. Developmental diversity and regularity. Developmental diversity and consequences for Human Development.

Dynamics of stability and variability in development – role of experience in development, Optimal Experience theory. Human action perspective to developmental diversity and regularity. Abnormal behaviour vs. individual differences. Intentional personal development and personal control over development.

Unit III: Development through life span

Life span theory in development, five levels of analysis – Life cause theory, basicconcepts, life transitions and historical change. Continuity vs. discontinuity in different developments across stages of life. Cognitive and emotional development- development of children's thinking and emotions. Dynamic development of thinking, feeling and acting-infancy through adulthood. Emotional development and consciousness. Dynamic structure in cognitive and emotional development - growth cycle and brain activity. Unravelling the processes underlying social, emotional and personality development.

Unit IV: Psycho-social perspective

Dialectical models of socialization. Development of self-regulation and morality. Pro-social behaviour development-development across lifespan and correlates. Religious and spiritual development through life span – positive and negative correlates. Issues concerning children in difficult circumstances. Multilevel perspective on child maltreatment. Resilience in the face of adversities. Socio- emotional development in diverse family contexts. Gendered development. Future directions for life course and behaviour genetics.

V. Suggested Reading

- Ausubel D and Sullivan EV. 1980. *Theory and Problems of Child Development*. 3rd Ed., Grune & Stratton, New York.
- Berk LE. 2013. *Child Development*. Pearson, New Delhi.
- Damon W and Lerner R. 1998 & 2006. *Handbooks of Child Psychology*. Vol. I to Vol. IV. John Wiley & Sons.
- Lerner RM and Newell KM. 2014. *Handbook of Developmental Systems Theory and Methodology*. Pp. 19-65. The Guilford Press, New York.
- Rogoff B. 2005. *The Cultural Nature of Human Development*. Oxford University Press, New York.
- Saraswathi TS and Kaur B. 1993. *Human Development and Family Studies in India*. Sage Publications, New Delhi.
- Sharma N and Chaudhary N. 2009. Human development: Context and Processes. In G. Misra (Ed.), *Psychology in India* (*Vol.I*) *Basic Psychological Processes and Human Development*. Pp. 69-109. Pearson, New Delhi.
- https://en.wikipedia.org/wiki/Capability_approach
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5830131/

I. Course Title : Ecology and Human Development

II. Course Code : HDFS 602

III. Credit Hours : Credits: 3(3+0)

IV. Theory

Unit I: Ecological modelling in human development

Human ecology – concept and relevance in understanding human development. Ecological modelling, ecology of developmental processes, bio-ecological model of Bronfenbrenner. Developmental ecology through space and time. The Process–Person–Context–Time (PPCT) Model . An Integrated model of individual development based on PPCT Model. Life course development through ecological perspective.

Unit II: Physical ecology and human development

Developmental tasks through lifespan – role of ecology, social roles and structural role of ecology. Behavioural development – role of physical ecological factors, terrain, climatic changes, demographics and their effect on human development. Children's physical environment, housing, overcrowding, neighborhood and development. Economic factors and their impact on human development.

Unit III: Socio-cultural ecology and human development

Building blocks in the environment. Interpersonal structures as context of human development. Dyads- types, nature and function of joint and molar activities, affective relations, balance of power. Race, class, ethnicity and development. Socio-cultural and sub-cultural context of human ecology and development- differences in child's ecological systems and their impact on parenting and development. Socio-cultural imbalances and their impact on human development. Contemporary child rearing and implications for human development. Impact of time factor and cultural history on development.

Unit IV: Role of systems and policies

Children's institutions, day care and preschools as context of human development. Children in war and disaster. Socio-political, legal systems and policies and human development. Religion, caste, minority and deprived states and their effects. Community support and its value for human development. Impact of media, technology and social networking. Policies, programmes based on ecological factors impacting human development. Research and assessment of human development based on ecological perspective.

V. Suggested Reading

- Begon M, Harper JL and Townsend CR. 1990. *Ecology: Individuals, Populations and Communities*. Blackwell, Cambridge.
- Bronfenbrenner U. 1977. *Toward An Experimental Ecology of Human Development. American Psychologist.* 2, pp. 513-531.
- Bronfenbrenner U. 1979. *The Ecology of Human Development: Experiments by Nature and Design*. Harvard University Press, Cambridge.
- Hames R. 2001. *Human Behavioral Ecology. International Encyclopedia of the Social and Behavioral Sciences*. Elsevier Science Ltd.
- Ingold T. 1986. *Evolution and Social Life*. Cambridge University Press, Cambridge.
- Klein RG. 1989. *The Human Career: Human Biological and Cultural Origins*. University of Chicago Press, Chicago.
- Lerner RM. 2015. *Handbook of Child Psychology* (Ed.), Vol. 1 to 7. John Wiley & Sons, Harvard.
- Smith EA and Winterhalter B. 1992. *Evolutionary Ecology and Human Behavior*. Aldine, New York.
- https://en.wikipedia.org/wiki/Human_behavioral_ecology

I. Course Title : Programme Development for Vulnerable Families

II. Course Code : HDFS 603

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: Family Vulnerabilities

Vulnerable families- meaning, categories, forms of vulnerability, characteristics. Family vulnerability factors - poverty, alcohol and drug abuse, AIDS, prostitution, delinquency, social disadvantages, mental disorders, chronic serious health issues, destitute women and children, street children, abused children, women and senior citizens. Impact of family vulnerabilities on children and families.

Unit II: Programmes for vulnerable families

Developmental programmes for vulnerable families – concept, history and five year plans. Types of programmes and projects for vulnerable families. Different approaches to develop programmes for families. Inter disciplinary approach to research project management. National and international research projects for vulnerable families. National and International programmes and policies for vulnerable children and families. UNICEF framework for protection, care and support of orphans and vulnerable children. National Plan of Action for protection and care of children.

Unit III: Programme development – elements and process

Need assessment of vulnerable families. Developing need based multiple programmes for vulnerable families and children - project proposal, principles of project design, steps, guidelines, process involved, aspects of appraisal, basic considerations, risks and returns in project proposal development. Elements of effective programmes for families. Project sustainability- factors, components and action plan. Scientific values and professional ethics in development of programmes for vulnerable population. Donors and funding agencies- types, National and International donors funding projects. Role of public and private donors in funding projects.

Unit IV: Working with vulnerable families

Working with vulnerable families- need, goals and significance. Developing strategies to support vulnerable children and their families. Strategies for increasing participation and retention. Ethics in working with vulnerable families. Working with children in vulnerable families- need, goals, strategies. Family resilience in the face of adversities- concept, risk and protective factors. Strengthening family relations. Including fathers in work with vulnerable families. Implementing the stimulating management techniques- Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM), Line of Balance (LOB), Gantt Chart and SWOT analysis.

V. Practicals

1. Review of the national international projects and programmes for vulnerable families.
2. Discussion on programmes and research projects
3. Developing need assessment performa
4. Learning to use selected PRA techniques –
   - Focus group discussions/ interviews
   - Transit walk, social mapping and time line
5. Interviewing families with need assessment
6. Developing need based programme for vulnerable families
7. Class discussion on developed programme and enhancement

8. Programme implementation – Working with families and eXecution of developed programmes- home based approach
9. Working with families and eXecution of developed programmes- child centred approach
10. Programme Evaluation by using- Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM)
11. SWOT analysis
12. Developing concept note for research project on vulnerable families
13. Developing Multiple Programs for promoting family health with vulnerable Children
14. Dissemination/ publishing of success stories, popular articles.
15. End term assessment

VI. Suggested Reading

- Chandra P. 1995. *Project Planning, Analysis, Selection, Implementation and Review*. Tata McGraw, New Delhi.
- Chaudhary DP. 1992. *Women Welfare and Development*. NIPPCD, New Delhi.
- Dunst C, Trivette C and Angela D. 1998. *Enabling and Empowering Families: Principles and guidelines for families*. Brookline Books, Inc. Newton.
- Golden O, Lopres P and Mills G. 2012. *Economic Security for Extremely Vulnerable Families: Themes and Options for Work-force Development and Asset Strategies*. Urban Institute, University of New Hampshire, New Hampshire.
- Resource and Development Unit. 2012. *Supporting Vulnerable Families: Self-guided learning package*. Community Child Care Unit, Victoria.
- Mynarska M, Riederer B and Jaschinski I. 2015. *Vulnerability of families with children: Major risks, future challenges and policy recommendations*. Wittgenstein Centre for Demography and Global Human Capital, stockhom.
- https://www.dcya.gov.ie/documents/publications/A_Guide_to_what_Works_in_Family_Support_Serviecs_for_Vunerable_Families.pdf
- https://www.who.int/maternal_child_adolescent/documents/pdfs/lancet_child_dev_series_paper3.pdf
- https://www.unicef.org/aids/files/Framework_English.pdf
- https://www.cambridge.org/working-with-vulnerable-families/children-in-the-midst-of-family-and-domestic-violence

I. Course Title : Strategic Developmental Intervention

II. Course Code : HDFS 604

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: Developmental intervention – concept and significance

Intervention – definition, need and importance. Early intervention for promoting children's development - principles, assumptions, eligibility and success criteria, theory and practice, biosocial developmental contextualism. Current orientation towards developmental intervention for children from birth to early school years. Children with developmental vulnerablilities and their characteristics. Sources of developmental vulnerabilities and resources. Risk - biological, other personal and contextual risks, impact of social inequality. Protective factors - influences on children's development. Neurological basis for developmental intervention needs- importance of early years, sensitive periods and factors influencing brain development.

Need assessment for intervention, Contemporary issues and current trends in intervention. Intervention principles strategies and process. Theoretical frameworks in early intervention. Intervention models. Multi-disciplinary approaches to early intervention and programmes for motor, cognitive, language and social development. Characteristics of effective Intervention strategies. Framework for developing and implementing programs for children with developmental delays.

Unit III: Intervention procedural guidelines

Early intervention therapy program- guidelines, purpose, program goals and objectives, program description, service delivery and role of other supportive team members. Types of early intervention therapies. Service delivery models in early intervention- child centred, parent centred, family centred, home based, center/ school based. Role of personnel in intervention – role of physiotherapist, speech pathologist, audiologist, occupational therapist, behaviour therapist and developmental therapist. Developing network with other agencies. Resource Generation. Role of family and community in implementation of intervention programmes. Family as developmental context.

Unit IV: Strategic planning and implementation

Planning and implementation of intervention programme. Utilisation of other local level services offered to children and families – screening, referral, assessment, family education and support. Arranging services and family support, collaboration and teamwork with families and professionals. Collaboration and interdisciplinary practices. Professional and ethical behavior. Early intervention - operational standards, accountability and quality assurance, accreditation, program resources and service delivery. Evaluation of developmental intervention programmes – basic concepts, effectiveness, efficiency and economics. Government policies and provisions. Early intervention policies – an international perspective.

V. Practical

Week	Topics
1	Compilation of research reviews on various developmental Interventions for young children.
2	Observational visits to intervention unit to understand the organizational structure, objective, types of services provided, facilities available, frequency, duration & cost of the Intervention, etc.
3	Observational visit to Paediatric Intervention unit to understand the process/ steps followed in Intervention programme
4	Observational visits to any National Institute offering Intervention programmes for children with developmental delays
5	Observational visits to any NGO offering intervention programmes for children with developmental delays

6	Identification of groups for intervention and Developmental assessment
7	Conducting need based assessment to identify target groups in need of intervention using Developmental Screening test/ appropriate psychological tests
8	Preparing developmentally appropriate intervention package for the selected group
9	Involving parents in the intervention programme, offering home based parent education programmes for managing children with developmental delays.
10	Field testing the developed intervention package at–
	– Day care centers/ pediatric wards
11	– Clinics/ special schools

Week	Topics
12	Conducting home based intervention programme for children with developmental delays
13	Conducting center-based interventions at – Day care centers/ pediatric wards/ Clinics/ special schools
14	Developing a checklist for assessing the quality & effectiveness of the intervention packages.
15	Evaluation of developed intervention programmes
16	End term assessment

VI. Suggested Reading

- Berk LE. 1996. *Child Development*. Prentice Hall.
- Chandra P. 1995. *Project Planning, Analysis, Selection, Implementation and Review*. Tata McGraw, New Delhi.
- Choudhary DP. 1992. *Women Welfare and Development*. NIPCCD, New Delhi.
- Guralnick MJ. 2017. Early intervention for young children with developmental delays. In H Sukkar CJ, Dunst & J Kirkby (Eds.), *Early Childhood Intervention* (pp. 17-35). Oxon, UK: Routledge.
- Hetherington EM and Parke RD. 1993. *Child Psychology: A Contemporary View Point*. Mc Graw Hill.
- Saraswathi TS and Kaur P. 1999. *Human development and Family Studies in India*. Sage Publications, New Delhi.
- Sukkar H, Dunst CJ and Kirkby. 1999. *Early Childhood Intervention*. Routledge, Oxon.

I. Course Title : Family Studies

II. Course Code : HDFS 605

III. Credit Hours : 3 (3+0)

IV. Theory

Unit I: Theoretical frameworks and perspectives

Different frameworks to understand families-conceptual framework, institutional, developmemtal and interactional framework. Family theories- Family Systems theory, human ecology theory, life course perspectives, social-cognitive-behavioral theory, biosocial theory and family communication theories. Family perspectives- Parson's sociological perspective, Marxist perspective, feminist perspectives, modern perspective.

Unit II: Family assessment

Different approaches to Family research- demographic, psychological, psychiatric, ethnographic and inter disciplinary approach. Measurement of family roles and relationships. Ethics in family research. Current issues for research in Indian families in different communities- rural and urban.

Unit III: Family under transition

Indian family system and changing patterns. Fatherhood- changing role of parents. Global migration- demographics, nature, contemporary migration patterns and effects. Cultural identity, family change and transnational mothering. Influence of globalization on children, youth, aged and families. Work and family interface - changing nature of work, feminization of the labour force and changing nature of family life and family roles. Diverse families -single parent families, female headed households, dual career families, one child family, adoptive families. Marital distress, family disorganisation.

Unit IV: Family therapy

Evolution of family therapy. Early models and basic techniques of family therapy-group process and communications analysis. Classic schools of family therapy-Bowenian family systems therapy, strategic, structured and eXperiential therapies, solution focused therapy, narrative therapy, psychodynamic therapy and integrative models. Cognitive behaviour family therapy. Application of family therapy in mental disorders. Family resilience- concept, developmental systems perspective, advances and challenges in family resilience research.

V. Suggested Reading

- Bernardes J. 1997. *Family Studies: An Introduction*. Routledge, New York.
- Bharat S. 1996. *Family Measurement in India*. Sage Publlications, New Delhi.
- Boss P, Doherty WJ, LaRossa R, Schumm WR and Steinmetz SK. 1993. *Sourcebook of Family Theories and Methods: A Contextual Approach*. Plenum Press, New York.
- Le Poire and Beth A. 2005. *Family Communication: Nurturing and Control in a Changing World*. Sage Publications, New Delhi.
- Nichols P and Schwartz R. 2006. *Family Therapy - Concepts and Methods* (7th Ed.). Pearson Education, Inc. USA.
- Roger L. 2004. *Family Therapy - A Constructive Framework*. Sage Publications, New Delhi.
- Trask B. 2010. Globalization and Families: Accelerated Systemic Social Change.
- White JM and Klein DM. 2007. *Family Theories*. Sage Publications, New Delhi.
- http://www.Springer.com.

I. Course Title : Adulthood and Aging

II. Course Code : HDFS 606

III. Credit Hours : 3 (3+0)

IV. Theory

Unit I: Ageing perspectives and developmental changes

Socio demographic profile of the aged in Indian context. Biological theories of aging, programmed ageing theories, random damage theories. Stochastic theories, evolutionary theories . The Ageing body - physical, sensory, cardiovascular, brain and central nervous system changes. Changes in bodily systems - muscular and skeletal system, respiratory system, immune system. Cognition during adulthood-fluid and crystallized intelligence, decline/ stability in intelligence, dialectic operations, memory, multidimensional changes. Cognitive neuroscience and aging. Healthy aging.

Unit II: Ageing personality

Personality changes during late adulthood. Personality types among the elderly. The Five-factor Model of dispositional traits by Tupes and Christal. Neugarten's Personality Styles. Levinson's theory of Social development, Carl Jung's theories-personality, psyche & dreams. Peck's theory of personality adjustment in late adulthood. Erikson's theory. Disengagement theory. Information-processing in old age- attention, memory, pathological changes in memory. Cognitive disorders-dementia, Parkinson's disease and Alzheimer's disease. Ageing and sexuality, illness and sexuality.

Unit III: Ageing in the family context

Aged in the family milieu- family relationships, problems, prospects and support systems. Attachment and relationships in late adulthood. Ageing and mental health, Mental health risks and disorders. Loneliness, depression and sociability in old age. Indicators of successful and positive aging. Ageing and financial status. Elderly abuse. Stress among the aged and coping strategies. Grief and bereavement- patterns of bereavement and stages of grief. Dying with dignity.

Unit IV: Ageing in the current scenario

Contemporary socio-cultural changes and aging. Ageing in the current scenario-impact of urbanisation, globalisation and migration. Dual career families and aging, stress among caretakers and sandwich generation. International scenario of the aged. Critical issues around global aging. Reconceptualising aging. Researchable issues related on aging. Welfare of the aged- policies and programmes. Research trends in gerontology and methodological issues.

V. Suggested Reading

- Baron RA. 2008. *Psychology*. *Pearson*, Prentice Hall, New Delhi.
- Bigner JJ. 1994. *Individual and Family Development. A Life-Span Interdisciplinary Approach*. Prentice Hall, Englewood Cliffs, New Jersey.
- Brophy JE and Willis SL. 1981. *Human Development and Behaviour*. St. Martin's Press, New York.
- Dandekar K. 1996. *The Elderly in India*. Sage Publications, New Delhi.
- Hayslip B and Panek P. 1989. *Adult Development and Aging*. Harper & Row.
- Leme BH. 1995. *Development in Adulthood*. Pearson, Chicago.
- Richardson B and Barusch A. 2005. *Gerontological Practice for the 21st Century*. Columbia University Press.
- Sheets D, Bradley DB and Hendricks J. 2005. *Enduring Questions in Gerontology*. Springer Publishing Co., New York.

I. Course Title : Mental Health

II. Course Code : HDFS 607

III. Credit Hours : 3(3+0)

IV. Theory

Unit I: Mental health - Issues and theories

Mental health – concept, biological and psychological basis, historical perspectives. Concept, criteria and measurement of normality and abnormality. Cognitive functions - normal and pathological. Theories of mental health - behavioural, biological, humanistic, existential, psychoanalytical and related theories. Family and mental health. Gender and mental health. Sociology of mental health. Culture and mental health.

Unit II: Mental health disorders

Types, etiology and behavioural symptoms of various mental health disorders and maladjustments- psychosomatic problems, anxiety disorders, mood disorders, schizophrenia and multiple-personality disorders. Clinical manifestation and effects/ consequences of mental disorders- cognitive disturbances, affective disturbances, functional impairments, addictions, alcoholism, substance abuse, gambling, other addictions and social networking.

Unit III: Behaviour assessment and modification

Identification and assessment of mental disorders – approaches to diagnosis of mental disorders, techniques, steps in mental health assessment. Diagnostic and Statistical Manual of Mental Disorders (DSM) IV and DSM V. Psychological assessment - Role of mental health professionals. Strategies for behaviour modification - behaviour therapy, cognitive therapy, psycho therapy and family therapy.

Unit IV: Mental health programme and policy

Status of mental health in vulnerable population – children, adolescents, women and senior citizens in India and abroad. Contemporary intervention techniques. Mental Health Policy – legislations, programmes and policies for the promotion of mental health in India.

V. Suggested Reading

- Herrman H, Saxena S and Moodie R (Eds). 2005. *Promoting Mental Health*. World Health Organization.
- Kapur M. 1995. *Mental Health of Indian children*. Sage Publications, New Delhi.
- Paul S A. 2011. *Reference guide on Mental Health Evidence*. The National Academic Press, New York.
- Sreevani R. 2016. *A Guide to Mental Health and Psychiatric Nursing*. 4th Ed., Jaypee Publishers, New Delhi.
- Witte R and Howard GS. 2016. *Mental Health Practices in Today's Schools- Issues and Interventions*. Springer Publishing Company.
- https://www.who.int/mental_health/media/investing_mnh.pdf

I. Course Title : Qualitative Research Methods

II. Course Code : HDFS 608

III. Credit Hours : 2 (1+1)

IV. Theory

Unit I: Introduction to qualitative research

Qualitative research design- concept, need and scope of qualitative research methods. Types, contribution, overview and practical applications of qualitative research methods.

Unit II: Qualitative research methods

Case studies, naturalistic design, historical methods, content analysis, ethnography, single cases eXperimental design, grounded theory, phenomenology.

Unit III: Qualitative data analysis and interpretation

Coding procedures, analysis and interpretation of qualitative data. Report writing. Evaluation of qualitative research.

Unit IV: Issues in qualitative research

Trends, challenges, limitations and constraints of various qualitative research methods. Ethical issues in conduct of research.

V. Practical

Week	Topics
1	Critical review of research papers using qualitative methods
2	Critical analysis of research papers using qualitative methods
3	EXtensive review of the empirical research works using qualitative method
4	Preparing any one review paper using qualitative methods
5	Identifying researchable issues that can be researched for qualitative methods
6	Designing qualitative research, site selection, sampling. Data collection by using qualitative methods- i) Conducting in-depth interviews ii) Focused group interviews iii) Naturalistic design iv) Historical method v) Ethnography vi) Single cases eXperimental design vii) Grounded theory
13	Coding procedures, data analysis
Week	Topics
14	Report writing and presentation
15	Ethical issues in qualitative methods
16	End term assessment

VI. Suggested Reading

- Barbour R. 2008. *Introducing Qualitative Research*. Sage Publications, New Delhi.
- Corbin J and Strauss A. 2008. *Basics of Qualitative Research*. Sage Publications, New Delhi.
- Denzin N and Lincon Y. 2008. *Collecting and Interpreting Qualitative Materials*. Sage Publications, New Delhi.
- Hennink M, Hatter I and Bailay A. 2003. *Qualitative Research Methods*. Sage Publications, New Delhi.
- Ritchie J and Lewis J. 2003. *Qualitative Research Practices*. Sage Publications, New Delhi.
- Sharan BM. 2002. *Qualitative Research in Practice for Discussion and Analysis*. Jossey-Bass, Georgia.

Restructured and Revised
Syllabi of Post-graduate Programmes

Vol. 6

Community Science

– Resource Management and Consumer Science

Modifications Suggested in Courses in the Revised Curricula

M.Sc. (Community Science) in Resource Management and Consumer Science

Course Code	Course Title	Credit Hours	Remarks
	Major Courses		
RMCS 501*	Resource Management: Principles and Practices	3 (3+0)	Changed the title and modified the content to provide knowledge on features and methods of contemporary management practices.
RMCS 502*	Human Factors and Ergonomics	3 (2+1)	Changed the title and included content on human physiology and interactions among humans and other elements of system.
RMCS 503*	Interior Space Planning	3(1+2)	Changed the title and upgraded the content as per the requirements of contemporary interior design profession.
RMCS 504*	Consumer Economics	3 (2+1)	Upgraded the content in light of changing consumer behaviours.
RMCS 505	Work and Work Station Design	3(1+2)	Upgraded the content integrating the human factor into workplace design.

Course Code	Course Title	Credit Hours	Remarks
RMCS 506	Colour and Lighting in Interiors	3 (2+1)	Modified the content taking onto consideration the changing trends in interior colour and lighting developments.
RMCS 507	Consumer Issues and Legislations	2 (2+0)	Three existing consumer courses are merged and modified the content in light of modifications in consumer legislations.
RMCS 508	Product Design	3(1+2)	New course is added with a focus on generating and developing new product ideas. The concept of outsourced product development was introduced.
RMCS 509	Ergonomic Research Techniques	3(1+2)	New course is added to expose students to the developments in ergonomic research methodologies.
RMCS 510	Housing and Energy Efficient Building Design	3 (2+1)	Two courses are merged and modified the content.
RMCS 511	Technical Drawings	3(1+2)	New course is added to enhance the architectural drawing skills of students.
RMCS 512	Interior Design Business Management	3(1+2)	Increased the practical credits and decreased the theory credits.

Course Code	Course Title	Credit Hours	Remarks
RMCS 513	Environmental Resource Management	2(1+1)	New course is added to expose students to emerging scientific and policy issues.
RMCS 514	Special Project	2(0+2)	
	Minor Courses		
FN 505	Nutrition and Physical fitness	3(2+1)	Proposed minor courses from subjects closely related to a student's major subject. Apart from these courses a student can register any other course offered by any other departments.
FN 509	Food Safety and Standards	3(2+1)	
FN 513	Human Physiology	3(3+0)	
EECM 502	Development communication	3(2+1)	
EECM 505	Dynamic communication skills	2(0+2)	
EECM 507	Organisational development and HRD	2(1+1)	
EECM511	Climate Change Management	2(1+1)	
HDFS 503	Methods and Techniques of Assessment in Human Development	3(2+1)	
HDFS 506	Management of differently abled	3(2+1)	
ATS 512	Apparel and Textile Product Development	2(1+1)	
ATS 513	Laboratory Techniques in Textiles Research	2(0+2)	
	Supporting Courses		
	Research methodology	3(2+1)	Course numbers will be assigned by the departments that offer these courses.
	Statistics	3(2+1)	
	Common Courses		
	Library and Information Services	1(0+1)	Common to all disciplines. The course numbers will be assigned by the departments that offer these courses.
	Technical Writing and Communication Skills	1(0+1)	
	Intellectual Property and its management in Agriculture	1(0+1)	
	Basic Concepts in Laboratory Techniques	1(0+1)	
	Agricultural Research, Research Ethics and Rural Development Programmes	1(0+1)	
	Total	**5(0+5)**	
RMCS 591	Seminar	1(0+1)	
RMCS 599	Thesis/ Reseach	30	
	Total	**70 credits**	

*Core curses/ compulsory courses

Ph.D. (Community Science) in Resource Management and Consumer Science

Course Code	Course Title	Credit Hours	Remarks
	Major Courses		
RMCS 601*	Trends in Resource Management	3 (3+0)	Changed the title and added content on skills and tools for better resource management.
RMCS 602*	Occupational Biomechanics	3 (2+1)	Modified the content focusing on biomechanical analysis for designing work environment that minimizes load on worker's body
RMCS 603	Globalization and Consumer Economics	3 (2+1)	Content modified to focus on changes in consumer pattern.
RMCS 604	Space Designing and Managerial Dimensions for Special needs	3(1+2)	Changed the title and included recent developments and transitions in space designing for special needs.
RMCS 605	Physical Ergonomics	3(1+2)	New course is added to make the students understand the potential effects of physical load on human body.
RMCS 606	Environmental Issues and Challenges	2 (2+0)	Added challenges due to recent environmental issues.
RMCS 607	Family Dynamics and Women Power	3 (2+1)	No major changes made.
RMCS 608	Special Project	2(0+2)	

Course Code	Course Title	Credit Hours	Remarks
	Minor Courses		
FN 604	Global Nutrition Problems	2(2+0)	Proposed minor courses from subjects closely related to a student's major subject. Apart from these courses a student can register any other course offered by any other departments.
FN 608	Energy Metabolism	2(2+0)	
EECM 602	Impact Assessment of Development Programmes	3(1+2)	
EECM 603	Scaling Techniques for Behavioural Research	3(1+2)	
EECM 607	Media application and product promotion	4(2+2)	
HDFS 608	Qualitative research methods	3(2+1)	
ATS 602	Technical Textiles	3(2+1)	
ATS 605	Functional Clothing	3(2+1)	
ATS 607	Operational Management in Textiles and Apparel	2(2+0)	

Supporting Courses

A student can opt any course related to the topic of research offered by other faculties of agriculture university or SWAYAM/ MOOCS or other online courses up to a maximum of 5 credits.

RMCS 691	Doctoral Seminar I (Core Field)	1 (1+0)
RMCS 692	Doctoral Seminar II (Optional Field)	1 (1+0)
RMCS 699	Research	75
	Total	**100 Credits**

*Compulsory core curses

Course Title with Credit Load
M.Sc. in Resource Management and Consumer Science

Course No	Course Title	Credit Hours	Semester
	Major Courses		
RMCS 501*	Resource Management: Principles and Practices	3 (3+0)	
RMCS 502*	Human Factors and Ergonomics	3 (2+1)	
RMCS 503*	Interior Space Planning	3 (1+2)	
RMCS 504*	Consumer Economics	3 (2+1)	
RMCS 505	Work and Work Station Design	3 (1+2)	
RMCS 506	Colour and Lighting in Interiors	3 (2+1)	
RMCS 507	Consumer Issues and Legislations	2 (2+0)	
RMCS 508	Product Design	3 (1+2)	
RMCS 509	Ergonomic Research Techniques	3 (1+2)	
RMCS 510	Housing and Energy Efficient Building Design	3 (2+1)	
RMCS 511	Technical Drawings	3 (1+2)	
RMCS 512	Interior Design Business Management	3 (1+2)	
RMCS 513	Environmental Resource Management	2 (1+1)	
RMCS 514	Special Project	2 (0+2)	
	Minor Courses**		
FN 505	Nutrition and Physical fitness	3 (2+1)	
FN 509	Food Safety and Standards	3 (2+1)	
FN 513	Human Physiology	3 (3+0)	
EECM 502	Development communication	3 (2+1)	
EECM 505	Dynamic communication skills	2 (0+2)	
EECM 507	Organisational development and HRD	2 (1+1)	
EECM511	Climate Change Management	2 (1+1)	
HDFS 503	Methods and Techniques of Assessment in Human Development	3 (2+1)	
HDFS 506	Management of differently abled	3 (2+1)	
ATS 512	Apparel and Textile Product Development	2 (1+1)	

Supporting Courses

Research methodology	3 (2+1)
Statistics	3 (2+1)

Course No	Course Title	Credit Hours	Semester
	Common Courses Library and Information Services	1(0+1)	
	Technical Writing and Communication Skills	1(0+1)	
	Intellectual Property and its management in Agriculture	1(0+1)	
	Basic Concepts in Laboratory Techniques	1(0+1)	
	Agricultural Research, Research Ethics and Rural Development Programmes	1(0+1)	
RMCS 591	Seminar	1(0+1)	
RMCS 599	Thesis/ Reseach	30 70 credits	

*Core curses/ compulsory courses. **A student can also choose a course from other fields related to the student's research

Course Contents
M.Sc. in Resource Management and Consumer Science

I. Course Title : Resource Management: Principles and Practices
II. Course Code : RMCS 501
III. Credit Hours : 3(3+0)
IV. Theory

Unit I: Nature and functions of management

Importance of management; Management functions; Management principles; Management levels; Functional areas of management; Managerial skills; Managerial roles.

Unit II: Evolution of management thought

Early classic approaches- Scientific management, administrative management and bureaucracy; Neo-classic approaches- human relation approach and behavioral approach; Modern approach; Quantitative approach; Systems approach; Contingency approach.

Unit III: Managerial competencies

Planning and administrative competencies; Decision making- Introduction, nature of managerial decision making, approaches to decision making; Types of decisions; Process of decision making; Tools and techniques of decision making; Creativity and rationality in decision making; Models of decision making behaviour; Risk andcertainty in decision making; Authority and responsibility in decision making; Communication- Functions, factors and features, process, barriers and principles, types and channels; Leadership-Meaning, importance, characteristics and styles.

Unit IV: Management process

Steps in management process; Planning- types and dimensions, planning in systems perspective, factors affecting planning; Organizing- Departmentalization, line and staff relationship; Coordinating – need, types, principles, techniques and problems of coordination; Directing; Controlling.

Unit V: Human behaviour and organization

Introduction to organizational behaviour; Values; Attitudes and performance; Motivation-Importance, contemporary theories of motivation, approaches, elements of sound motivation; Stress management- concepts, causes, consequences, stress managing techniques.

V. Suggested Reading

- Gaurav A. 2010. *Management Functions and Process*, *Management Thought* https://kalyan-city.blogspot.com/2010/06/management-functions-process-management.html
- Hellregel. 2002. *Management*. Thomason Learning, Bombay.
- Henry John. 2019. Functions of Management Process: Planning, Organizing, Leading, Controlling https://iedunote.com/function-of-management-process
- Koontz H and Wechrich H. 2008. *Management*. Tata McGraw Hill Inc., N.Y.
- Draft Richard L. 2015. *Management*. Thomson South-Western.
- Robbins SP and Decenzo DA. 2010. *Fundamentals of Management*. Pearson Education Asia, New Delhi.
- SatyaRaju R and Parthasarthi A. 2009. *Management- Text &Cases*. PHI, New Delhi.
- Stephen PR and Mary AC. 2015. *Management*. 13th Edition. Prentice Hall of India. NewDelhi.
- Subba Rao P. 2017. *Management and Organizational Behaviour* (*Text and Cases*). Himalaya Publishing House, New Delhi.
- Tripathi PC and Reddy PN. 2013. *Principles of Management*. Tata McGraw Hill Education Pvt Ltd, ND.

I. Course Title : Human Factors and Ergonomics

II. Course Code : RMCS 502

III. Credit Hours : 3(2+1)

VI. Theory

Unit I: Introduction to ergonomics

Definition, aim, objectives and scope of ergonomics; Domains of ergonomics; Historical development of ergonomics and human factor; Interface between man machine and environment; Ergonomics in design.

Unit II: Human body systems

Structure and functions of major body systems- parts and basic functions of skeletal system; Properties and functions of muscular system; Components of circulatory system; Parts and functions of respiratory system; Structure and functions of digestive system and nervous system.

Unit III: Human anthropometry

Human anthropometry; Static and dynamic anthropometry; Anthropometric measurements; Normal distribution and percentiles; Anthropometry in ergonomics and design.

Unit IV: Body movement and postures

The functions and movements of skeletal system - functional classification of bones, joints, ligaments and tendons; Neuromuscular aspects of movement; Joints and movements; Classification of joints on the basis of function; Movement at synovial joints; Skeletal muscle as levers; Posture- Work posture, postural discomfort and its impact on work and human health, posture analysis tools.

Unit V: Work physiology

Fundamentals of work physiology; Muscular efforts; Energy consumption; Physical fitness-Measuring physical fitness using different techniques; Physical work capacity and its measurement; Determination of cardiac cost of work; Factors influencing energy requirements and energy costs for various activities.

VII. Practical

1. Collection of anthropometric measurements of school children
2. Analysis of data on school children anthropometry
3. Presentation of report on school children anthropometry
4. Designing study table based on the anthropometric data
5. Measuring the work posture of a worker involved in manual work using RULA/ REBA/OWASA
6. Analysis of work posture data
7. Presentation of report on work posture of person involved in manual work
8. Determination of physical fitness using any one of the technique
9. Analysis of data and presentation of report on physical fitness
10. Measurement of cardiac cost of selected activity
11. Analysis of data on cardiac cost of selected activity
12. Presentation of report on cardiac cost of selected activity
13. Assessment of ergonomic cost of work in terms of physiological indices
14. Analysis of data on ergonomic cost of work
15. Presentation of report on ergonomic cost of work
16. End of Term Assessment

VIII. Suggested Reading

- Benchmark Research and Safety Inc. 2008. *A Brief History of Human Factors and Ergonomics* http://www.benchmarkrs.com/main/human-factors/what.aspx
- Dalela S and Saurabh. 1999. *Text book of Work Study and Ergonomi*cs. Standard Publishers and Distributors, Delhi.
- Galer IAR. 1982. *Applied Ergonomics Handbook*. Butterworth-Heinemann.
- Grandgean E. 1978. *Ergonomics of the Home*. Taylor & Francis, London.
- Grandjean E. 1980. *Fitting the Task to the Man*. Taylor & Francis, London.
- Jain AK. 2017. *Human Anatomy and Physiology*. Arya Publications, Udaipur.
- Panero J and Zelnik M. 1979. *Human Dimension and Interior Space*. Whitney Library of Design.
- Roebuck John A. 2016. *Anthropometric Methods: Designing to Fit the Human Body*. http://www.hfes.org/Publications.
- Rodahl AK, Hans A Dahl and Sigmund B Stromme. 2005. *Text Book of Work Physiology*. CRC Press, London.
- Salvendy (Ed). 2006. *Handbook of Human Factors and Ergonomics*. Third edition, John Wiley and Sons, Hoboken, NJ.

I. Course Title : Interior Space Planning

II. Course Code : RMCS 503

III. Credit Hours : 3(1+2)

VI. Theory

Unit I: Interior design and user comfort

Residential buildings- Types and its characteristics; Commercial buildings- Types and its characteristics; Effect of interior design on user comfort- residential, commercial, special needs.

Unit II: Building planning principle

Functional and aesthetic considerations in the use of elements of design; Functional and aesthetic considerations in the use of principles of design; Housing principles for designing public private and circulation spaces; Advances in design process of residential interiors-Personal space, public space, utility space; Advances in design process of commercial interiors- Service institutions, marketing institutions; Recent trends in interior space management.

Unit III: Space standards

Space standards for various rooms in residential and commercial buildings; Building materials and their standards; Space saving furniture.

Unit IV: Building services

Electrical and safety fittings; House wiring; Plumbing systems for residential and commercial buildings; Sanitary fittings and fixtures for residential and commercial buildings.

VII. Practical

1. Preparation of a schedule to collect information regarding the characteristics of residential and commercial buildings
2. Visits to identify the characteristics of residential buildings
3. Visits to identify the characteristics of commercial buildings
4. Presentation of report on characteristics of residential and commercial buildings
5. Designing a residential house as per space standards –development of conceptual drawings
6. Designing a residential house as per space standards –development of design details and working drawings
7. Designing a residential house as per space standards –portfolio preparation
8. Designing a residential house as per space standards –presentation and group discussion
9. Designing any commercial building as per space standards- development of conceptual drawings
10. Designing any commercial building as per space standards- development of design details and working drawings
11. Designing any commercial building as per space standards- portfolio preparation
12. Designing any commercial building as per space standards- presentation and group discussion
13. Market survey on electrical and sanitary fittings and fixtures
14. Market survey on space saving furniture suitable
15. Presentation of report on sanitary fittings, fixtures and space saving furniture for residential and commercial buildings available in market
16. Cost estimation of residential building (apartment/condominium/row house)
17. Cost estimation of commercial building (Ice cream parlor/Tiffin centre/beauty

salon/ restaurant, etc.)

18. Designing space saving furniture for residential buildings
19. Portfolio preparation on space saving furniture for residential buildings
20. Presentation of report on space saving furniture for residential buildings
21. Design and development of space saving furniture for commercial buildings
22. Portfolio preparation on space saving furniture for commercial buildings
23. Presentation of report on space saving furniture for commercial buildings
24. Project on renovation of a residential building with cost estimation
25. Portfolio preparation on renovation of a residential building with cost estimation
26. Presentation of report and group discussion on renovation of a residential building with cost estimation
27. Project on renovation of a commercial building with cost estimation
28. Portfolio preparation on renovation of a commercial building with cost estimation
29. Presentation of report and group discussion on renovation of a commercial building with cost estimation
30. Preparation of material board and presentation for a residential project
31. Preparation of material board and presentation for a commercial project
32. End term assessment

VIII. Suggested Reading

- Allen PS, Stimpson MF and Jones LM. 2000. *Beginnings of Interior Environments*. Prentice Hall.
- Choudhari SN. 2006. *Interior Design*. Avishkar Publ.
- Gilliatt M. 1981. *The Decorating Book*. Pantheon Books.
- Hamstech Interior Design. 2017. *Importance of Space Planning in Interior Designing* http://www.hamstech.com/blog/importance-of-space-planning-in-interior-designing/
- Panero J and Zelnik M. 1979. *Human Dimension and Interior Space*. Whitney Library of Design.
- Parikh A, Robertson D, Lane T, Hilliard E and Paine M. 2000. *The Ultimate Home Design Source Book*. Conran Octopus.
- Pears A, Lawrence M, Hymers P and Howell J. 2000. *Working with the Professionals*. Marshall Publ.
- Philip S. 2017. *Concept Design and Space Planning*.https://www.designblendz.com/solutions/concept-design-space-planning
- Seetharaman P and Pannu P. 2005. *Interior Design and Decoration*. CBS.
- Zimmerman N. 2003. *Home Workspace Idea Book*. The Taunton Press.

I. Course Title : Consumer Economics

II. Course Code : RMCS 504

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: Consumer behaviour

Consumer behavior; Environmental influences on consumer behaviour; Individual determinants of consumer behavior; Models of consumer behavior - Micro economic model, Nicosia model, Howard-Sheth model, Engel- Block well-Miniard model; Application of consumer behaviour knowledge in marketing; Consumer decision process- Problem recognition, search and evaluation, purchasing process, post purchasing behavior; Researching consumer behaviour.

Unit II: National income

Definition and significance; Concepts of national income; Methods of measurements of national income - value added method, income method, expenditure method, reconciliation of the three measures of national income; Difficulties in measurement of national income- Conceptual difficulties and practical difficulties; National income and Economic welfare.

Unit III: Consumption economics

Concept of consumption economics; Theories of consumption- Engels law of consumption, relative income theory of consumption, life cycle theory of consumption, permanent income theory of consumption; Budget and economy; Fiscal policy; Annual financial statement of the government and budget; Revenue receipts and revenue expenditure; Capital receipts and capital expenditure; Overall budget; Concepts of deficits in government budget; Revenue deficits and fiscal deficit; Taxation- India's tax structure; Tax as a source of public revenue; Direct and indirect taxes; Merits and demerits of taxes; Role of indirect tax in a developing economy; Incidence and effects of taxes; Inflation- Meaning of inflation, types of inflation, causes, effects, measures to check inflation; Deflation- Meaning, deflation and disinflation, causes, effects, measures to control deflation.

Unit IV: Financial systems of India

Introduction to financial system of India; Financial institutions; Financial services; Financial markets; Structure of Indian financial system; Importance of financial system for the economic development; Banking-Types of banking institutes; Functions; Types of loans and advances; Indian money market; Indian capital market; Financial intermediaries and services; Insurance and its regulations.

V. Practical

1. Project work: Study of consumer buying behaviour while buying a selected commodity –Collection of review
2. Formulation of objectives of the study
3. Selection of sample, and study location
4. Designing the data collection tool
5. Pre testing and finalization of data collection tool
6. Collection of data
7. Data analysis
8. Report writing
9. Finalization of report
10. Presentation of the report on "Consumer buying behaviour while buying a selected commodity"

11. Discussion on the findings of the research
12. Visit to any one financial institute
13. Preparation of documents required for applying for a loan
14. Study the trends of stock market index given in magazines or news papers
15. Critical analysis of National Budgets through panel discussion.
16. End of Term assessment

VI. Suggested Reading

- Ahuja HL. 2012. *Modern Micro Economics: Theory & applications*. Chand Company Ltd., New Delhi.
- Chadha R. 1995. *The Emerging Concepts and Strategies*. New Age International & Wiley Eastern.
- Deepashree. 2016. *Introductory Macroeconomics*. Saraswati House Pvt Ltd.
- Dewett KK and Varma JD. 2017. *Elementary Economic Theory*. S. Chand & Company Ltd., New Delhi.
- Dhingra IC and Garg VK. 2002. *Basic Economics & Business Environment*. Sultan Chand & Sons, New Delhi.
- Dhingra IC and Garg VK. 2004. *Economics Fundamentals*. Sultan Chand & Sons, New Delhi.
- Kaur S, Lekhi RK and Joginder S. 1997. *Consumer Economics*. Kalyani Publishers.
- Loudon David L and Albert JDB. 1993. *Consumer Behaviour*. 4th edition. Tata McGrawHill Publishing company Limited, New Delhi.
- Marguerite B. 2000. *Consumer Economics: A Multidisciplinary Approach*. John Wiley &Sons.
- Schiffman LG and Kaunuk LL. 2004. *Consumer Behaviour*. Prentice Hall of India.

I. Course Title : Work and Workstation Design

II. Course Code : RMCS 505

III. Credit Hours : 3(1+2)

IV. Theory

Unit I: Work, worker and workplace

Work, worker and workplace-definition, types and interrelationship**;** Classification of work based on energy consumption and nature of work; Time and energy requirements of work; Introduction to components of worker input- affective, cognitive, temporal and physical.

Unit II: Work measurement techniques

Work measurement techniques- Subjective judgment, Record of past performance, Scientific methods; Tools for work analysis-charts, diagrams, models and photographic aids.

Unit III: Workplace layout and equipment design

Principles of workstation and system design; Design and arrangement of different work centers; Work reaches; Working heights; Visual design parameters- Work surface, space allowance and storage; Design considerations for different workstation designs-Seated work, Standing work, Sit stand work; Controls, displays and information; Visual, auditory and other displays; Quantitative and qualitative information; Methodologies for studying workplace design; Hazards of ill designed workstation.

Unit IV: Physical factors of the work environment

Environmental factors in workplace and their measurement-Heat, light, sound and noise, vibration, radiation, humidity; Effect of environmental parameters on worker and work performance.

V. Practical

1. Selection of workplace unit for taking the anthropometric measurements of worker and dimensions of equipment and furniture used in a selected workplace units
2. Measuring and recording the anthropometric measurements of worker in the selected workplace unit
3. Measuring and recording the dimensions of equipment and furniture used in the selected workplace unit
4. Working on developing design for a workplace unit as per data collected in previous exercise
5. Determining the space relationships as per workers anthropometry
6. Determining the space relationships as per workers posture and movement at selected workstations
7. Developing the 2D design of selected workplace unit
8. Developing the 3D design of selected workplace unit
9. Work measurement in the selected workstation using two hand process charts
10. Analysis of data collected
11. Presentation of report on work done in the selected workstation using two hand process charts
12. Work measurement in the selected workstation using photographic aid
13. Analysis of data on work measurement collected in the selected workstation using photographic aid
14. Presentation of report on work done in the selected workstation using

photographic aid

15. Measuring environmental factors in the workplace: Heat
16. Measuring environmental factors in the workplace: Light
17. Measuring environmental factors in the workplace: Noise
18. Measuring environmental factors in the workplace: Vibration
19. Measuring environmental factors in the workplace: Radiation
20. Measuring environmental factors in the workplace: Humidity
21. Analysis of data collected on environmental parameters
22. Presentation of report on environmental parameters
23. Developing a design layout of a selected commercial workplace: Preparation of check list
24. Collection of data on design features, space relationships, dimensions of equipment and furniture, and environment control parameters in the workplace
25. Analyzing the data
26. Finalizing the dimensions of selected commercial workplace
27. Developing a design layout of the selected commercial workplace based on the DATA.
28. Presentation and group discussion on the design layout of the selected commercial workplace
29. Finalization of design layout of the selected commercial workplace
30. Developing 2D plan of the selected commercial workplace
31. Developing 3D workplace design of the selected commercial workplace
32. End term assessment

VI. Suggested Reading

- Barnes RM. 1980. *Motion and Time Study*. John Wiley & Sons.
- Bridger JD. 1995. *Introduction to Ergonomics*. McGraw-Hill Book Co., Singapore.
- Dalela S and Saurabh. 1999. *Textbook of Work Study and Ergonomics*. Standard Publishers Distributors, Delhi.
- GalerIAR. 1982. *Applied Ergonomics Handbook*. Butterworth-Heinemann.
- Grandgean E. 1978. *Ergonomics of the Home*. London: Taylor & Francis.
- Grandjean E. 1980. *Fitting the Task to the Man*. Taylor & Francis, London.
  https://workdesign.com/2012/08/ergonomics-and-workplace-design/
- Mundel M. 1978. *Motion and Time Study*. Prentice Hall.
- Panero J and Zelnik M. 1979. *Human Dimension and Interior Space*. Whitney Library of Design.
- Singh S. 2007. *Ergonomics Interventions for Health and Productivity*. Himanshu Publications.
- Thomas Jiji. 2012. *Ergonomics and Workplace Design*

I. Course Title : Colour and Lighting in Interiors

II. Course Code : RMCS 506

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: Colour as an interior design element

Historical perspective of colour as an interior design element; Properties of colour - Hue, value and intensity; Approaches and theories of colour.

Unit II: Applications of colour in various elements of interiors

Cultural and psychological effects of colour; Types of colour schemes-Related colour schemes, contrast colour schemes; Factors to consider while choosing colour schemes for buildings; Suitable colour schemes for residential, commercial, public, educational and religious building interiors.

Unit III: Introduction to lighting in interior

Importance and sources of lighting; Cultural and social aspects of lighting; Physiology of vision; Properties of lighting - Reflection, absorption, transmission and diffusion; Types of lighting; Safety and emergency lighting; Lighting requirements for household activities; Lighting requirements in commercial buildings.

Unit IV: Quantity and quality of lighting

Measurement of light and its units; Types of lamps from animal fat lamps to LEDs, their characteristics and suitability to various rooms; Types of lighting based on direction of use, place of use, purpose and portability; Lighting controls- Type, selection, care, maintenance and economic use; Lamp holders; Lighting switches; Motion sensors; Factors affecting the quantity of illumination in a room- Room proportion, colour, texture and cleanliness of room surface, lamp lumen, lamp lumen depreciation; Method of calculating lighting requirements for various rooms; Lighting for outdoor living and gardens.

Unit V: Effect of colour on lighting

Colour rendition; Use of colour and lighting in architecture, materials and finishes from 16th century to the date; Use of colour and lighting in problematic areas to disguise and camouflage.

V. Practical

1. Study of types of colour schemes in residential interiors
2. Study of types of lamps and lighting used in residential interiors
3. Group discussion on use of colour and lighting in interiors
4. Study of types of colour schemes in commercial interiors
5. Study of types of lamps and lighting used in commercial interiors
6. Presentation on use of colour and lighting in commercial interiors
7. Suggesting suitable colour schemes for residential buildings and its cost estimation
8. Suggesting suitable colour schemes for commercial buildings and its cost estimation
9. Group discussion on suitable colour schemes for residential and commercial buildings
10. Suggesting suitable lighting fixtures for residential buildings and its cost estimation
11. Suggesting suitable lighting fixtures for commercial buildings and its cost estimation
12. Group discussion on suitable lighting fixtures for residential and commercial buildings
13. Prepare a colour and lighting plan for problematic areas like space below stair case and estimate the cost
14. Prepare a colour and lighting plan for problematic areas like, irregular shape rooms or narrow areas and estimate the cost
15. Market survey to understand the available safety and emergency lighting systems and presentation of report
16. End term assessment

VI. Suggested Reading

- Cullision PW. 1981. *New Decorating Book*. Meredith Corporation, Iowa.
- James D. 1997. *Lighting*. Cassell Publ, U.K.
- Mark K and James Benya. 2004. *Lighting Design Basics*. John Wiley &Sons, Inc, U.S.A.
- Michael W. 2002. *Advances in Colour Harmony & Contrast for the Home Decorator*. School

of Colour Publ.
- Parikh A *et al.* 2000. *The Ultimate Home Design Source Book*. Conran Octopus, London.
- Sarao M and Laurie Z. 1995. *The Power of Colour*. John Wiley & Son.
- Stepat Dorothy. 1971. *Introduction to Home Furnishings*. MacMilan.
- Tim Anderson. 2018. *Importance of Lighting in Interior Design* https://homeguides.sfgate.com/importance-lighting-interior-design-56751.html

I. Course Title : Consumer Issues and Legislations

II. Course Code : RMCS 507

III. Credit Hours : 2(2+0)

IV. Theory

Unit I: Consumer issues

Changing trends in consumerism; Profile of consumers in India and abroad; Consumer issues and challenges; Social media management; Consumer finance; Multiple taX structure: Gender issues in consumerism; Gender division of labour; Access to decision making; Marketing and gender consumerism; Wealth and gender consumerism; Green consumerism- Definition, objectives and necessity of green consumerism; Agriculture credit in India; Agriculture marketing in India.

Significance of consumer guidance and counseling; Consumer protection measures- Legal and non-legal consumer legislations; The Contract Act 1982; The Sale of Goods Act 1930; The Essential Commodities Act 1955; The Agricultural Produce (Grading and Marking) Act 1937; The Standard of Weights and Measures Act 1976; The Trade Mark Act 1999; The Competition Act 2002; The Bureau of Indian Standard Act 1986; Consumer Protection Act1986; Consumer protection Bill 2018; Right to Information Act 2005; Information Technology Act 2000; Food Safety and Standards Act,2016.

Unit III: Consumer and communication tools

Consumer communication- Significance, history and types; Communication media and social change; Trends in consumer communication; Media and consumer demand; Advertising as a mode of communication; Trends and impact of advertising on consumers; Social media- chats, Blogs, Face book, LinkedIn, Twitter, Instagram, Pinterest, YouTube.

Unit III: On line marketing

E-marketing in India- Evolution; Growth and challenges; Legislative frame work.

V. Suggested Reading

- Bhatt R. 2010. *Consumer Behaviour*. Common Wealth Publishers Pvt. Ltd.
- Clarke J, Janet N, Smith EV and Westmarland L. 2007. *Creating Citizen Consumers*. Sage Publ.
- Jones RN. 2007. *Basic Counseling Skills*. Sage Publ.
- *Nations Guidelines on Consumer Protection*. 2008. https://unctad.org/en/Pages/DITC/CompetitionLaw/UN-Guidelines-on-Consumer- Protection.aspX
- Pant H. 2007. *Advertising & Media*. ABD Publishing.
- Potter WJ. 2008. *Media Literacy*. Sage Publ.
- Seetharaman P and Sethi M. 2001. *Consumerism: Strategies and Tactics*. CBS.
- Sharma S and Kumar D. 2001. A*dvertising*, *Planning*, *Implementation and Control*. Mangal Deep Publ.
- Shukul M and Gandotra V. 2006. *Home Management & Family Finance,* Dominant Publishers & Distributors New Delhi.
- Sparks C. 2008. *Globalization*, *Development and Mass Media*. Sage Publ.

I. Course Title : Product Design

II. Course Code : RMCS 508

III. Credit Hours : 3(1+2)

IV. Theory

Unit I: Introduction to product design

Product Design- Definition, significance and essentials of product design and consumer demand; Product attributes- contextual needs, compatibility, usability,product aesthetics.

Unit II: Approaches to product designing

Concepts in product designing; User-centered design; Universal design; Accessible design; Usable design; Anthropometry in product design; Design consideration in product for geriatrics; Design consideration in product for people with special needs.

Unit III: Outsourced product development (OPD)

Introduction; Importance; Concept and need; Major differentiating factors- technology related, people related, process related; Emerging models of product development.

Unit IV: Product development process

Stages of product development process; Market analysis; Product analysis; Identification and innovation; User-Product relationship and ergonomics; Cognitive and social engineering issues; User interface designing.

Unit V: Product testing

Product testing- definition, purpose, role of government, Industry and consumer organizations; Product testing techniques and devices-product evaluation, quality control and standardization.

V. Practical

1. Checklist for evaluation of a selected consumer product against the manufacturer's guidelines-Literature survey
2. Designing a checklist for evaluation of a selected consumer product against the manufacturer's guidelines
3. Evaluation of the selected consumer product against the manufacturer's guidelines
4. Presentation and group discussion

5-9. Exposure to Outsourced product development (OPD)

10. Conceptualization and development of consumer products with functional alternatives
11. Product Idea generation through brainstorming
12. Evaluation of the product idea generated; Group participation
13. Finalization of product

14-18. Working on design criteria

19. Collection of feedback from market
20. Analyzing the user's option on the design of the consumer product

21-26 Developing the prototype of the product

27. Evaluation of the product developed for identifying the problems through brain storming
28. Proposing design solutions to rectify identified lacunas in the product design

29-31. Finalization of product design

32. End term assessment

VI. Suggested Reading

- Boothroyd G, Dewhurst P and Knight W. 2002. *Product Design for Manufacture and Assembly*.

CRC Press.
- Cross N. 2000. *Engineering Design Methods: Strategies for Product Design*. Reiters Publications.
- Dumas JF and Redish JC. 1993. *A Practical Guide to Usability Testing*. Greenwood Publications.
- Meilgaard M, Civille GV and Carr BT. 2006. *Sensory Evaluation Techniques*. CRC Press.
- Otto KN and Wood KL. 2001. *Product Design: Techniques in Reverse Engineering*. New Age International.
- Parker G and Alstyne MV. 2005. *Management Science: The Theory of Information Product Design*. INFORMS Publications.
- Roozenburg NFM and Eekels J. 1995. *Product Design: Fundamentals and Methods*. Wiley.
- Sharma DD. 2000. *Total Quality Management*. Sultan Chand and Sons.
- Stone H and Sidel JL. 2004. *Sensory Evaluation Practices*. Academic Press.
- Ulrich KT and Eppinger SD. 1995. *Product Design and Development*. Irwin McGraw Hill.

I. Course Title : Ergonomic Research Techniques

II. Course Code : RMCS 509

III. Credit Hours : 3(1+2)

IV. Theory

Unit I: Approaches to research methods in ergonomics

Measurement and information gathering; Ergonomic standards; Observational techniques; Rating scales; Questionnaires and checklist; Digital models and simulation.

Unit II: Subjective assessment tools

NIOSH discomfort survey; The Dutch Musculoskeletal Nordic Questionnaire (DMQ); Nordic Musculoskeletal Questionnaire (NMQ); Cornell Musculoskeletal Discomfort Questionnaire; University of Michigan Upper Extremity Questionnaire (UMUEQ); Job stress Questionnaire; Work Style Questionnaire; NIOSH Generic Job Stress Questionnaire.

Unit III: Postural evaluation tools

Ovako Working Posture Analyzing System(OWAS); Quick Exposure Checklist(QEC); Concise Back Screening Instrument(CBSI); Rapid Upper Limb Assessment (RULA); Plan for Identifying av Belastnings faktorer (PLIBEL); Rapid Entire Body Assessment (REBA); Model for Comprehensive Evaluation of Risks of Musculoskeletal Disorders (MODSI).

Unit IV: Measurement of work effort and fatigue

Borg Rating of Perceived Exertion Scale; Muscle Fatigue Assessment Method; Hand Activity Level (HAL); The Occupational Repetitive Action (OCRA); NIOSH Lifting Equation); The Strain Index.

V. Practical

1. Collection of literature on occupational disorders in any one occupation such as Construction Industry/ Manufacturing industry
2. Review of collected literature to understand the type of disorders prevailing in the selected industry
3. Elicit information on musculoskeletal disorders experienced by workers from a selected field using Nordic Musculoskeletal Questionnaire -Data collection
4. Discuss the merits and demerits of the tool
5. Propose modifications in light of demerits of the tool
6. Gain hands on experience on the use of a selected postural evaluation tool
7. Evaluation of posture adopted by sweepers using a selected postural evaluation tool
8. Identify the level of risk
9. Group discussion on the use of postural evaluation tool
10. Gain hands on experience on the use of a selected muscle fatigue assessment tool
11. Measure the muscle fatigue experienced by workers involved in manual work using the selected muscle fatigue assessment tool
12. Group discussion on the use of muscle fatigue assessment tool
13. Gaining hands on experience on the use of OCRA checklist
14. Identify the risk of upper extremity work related musculoskeletal disorders among workers involved in repetitive work using OCRA checklist
15. Develop a measuring scale to measure work stress: Collection of literature
16. Identifying the parameters to be included in the scale
17. Item collection
18. Identifying the items to be included in the scale

19. Validation of the tool
20. Collection of eXpert remarks on the items included in the scale
21. Modifying the scale as per the remarks of eXperts
22. Testing reliability of the tool- test retest method
23. First phase data collection.
24. Second phase data collection
25. Testing the reliability
26. Finalization of scale
27. Pre testing of scale
28. Modifications as per the identified lacunas
29. Data collection in the field
30. Data analysis
31. Critical evaluation and finalization of the scale
32. End term assessment

VI. Suggested Reading

- *Ergonomic Workplace Analysis Course Manual* compiled by RECOUP Neuromuscloskeletal Rehabilitation Centre, Bangalore.
- Helmut Strasser. 2009. *Principles, Methods and Examples of Ergonomics Research and Work Design*
  https://link.springer.com/chapter/10.1007/978-3-642-01293-8_28
- Hendrick, HW and Kleiner BM. 2001. *Macroergonomics. An Introduction to Work System Design*. Human Factors and Ergonomics Society, Santa Monica, CA.
- McCabe Paul T. 2003. *Contemporary Ergonomics*. Taylors And Francis.
- Neville AS and Alan Hedge. 2004. *Hand Book of Human Factors and Ergonomics Methods*. CRC Press.
- Soares Mand Rebalo F (Ed.). 2016. *Ergonomics in Design Methods &Techniques*. Balkema: CRC Press.
- Suzanne H Rodgers. 1986. *Ergonomic Design for People at Work*. John Wiley & Sons, New York.
- Taylor JC and Felton DF. 1993. *Performance by Design*. Prentice-Hall, Englewood Cliffs, NJ.

I. Course Title : Housing and Energy Efficient Building Design

II. Course Code : RMCS 510

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: Socio cultural and economic issues in housing

Historical perspective of the architectural features of buildings; Ancient science of house design; Role of housing in developing economies; Economic impact of housing; Housing markets and housing policies in India; Housing finance; Role of Government and non-government organizations in providing and regulating housing needs.

Unit II: Recent trends in building design

Emerging techniques in the house construction; Building design- need and scope for energy use and conservation; Design parameters for visual comfort; Day lighting and artificial lighting; Recent developments in building bye-laws; Low-cost building materials and fabrication technologies; Estimation of construction cost and housing finance; Housing research in energy efficient building design.

Unit III: Energy and climate

Structural features of residential buildings in different geo-climatic conditions; Environmental and architectural characteristics and energy consumption; Design parameters for climate and energy control; Eco and Ergo friendly house design; Low and zero carbon buildings and energy infrastructure.

Unit IV: Energy efficient building design

Green building design- Concept; Need and scope for energy use and conservation in building design; Energy efficient design principles and guidelines; Techniques for improving energy efficiency in residential and commercial buildings; Energy efficient building materials and construction technology; Energy flow audit and economy; Energy economy in residential and commercial buildings; Energy efficiency building regulations; Housing and energy models-Residential and commercial.

V. Practical

1. Collection of information on building forms in different geo-climatic regions
2. Presentation and group discussion on building forms in different geo-climatic regions
3. Visits to organizations promoting green building technology
4. Collection of information on green building technology through literature search
5. Presentation and group discussion on green building technology
6. Analysis of research trends in energy efficient building design
7. Panel discussion on energy efficient building design
8. Assessment of existing house plan in terms of energy efficiency
9. Suggesting suitable renovations to improve energy efficiency
10. Evolving Eco friendly housing plan for selected geo-climatic region - development of conceptual drawings
11. Evolving Eco friendly housing plan for selected geo-climatic region- development of design details
12. Presentation and group discussion
13. Housing research in energy efficient building design-review of literature
14. Estimation of cost of construction
15. Energy audit of a residential building
16. End term assessment

VI. Suggested Reading

- Ambadker SN. 2000. *Rural Housing: Agro-socio-economic Impact*. Special Indian Ed. Agrobios.
- Hawkes D and Forster W. 2002. *Energy Efficient Buildings: Architecture, Engineering and Environment*. WW Norton & Co.
- Jefferis A and Madsen DA. 2004. *Architectural Drafting and Design*. Thomas Delmar Co.
- Lal AK. 1999. *Handbook of Low Cost Housing*. New Age International.
- Mahadeva M. 2002. *Housing in India: The Situation, Development and Challenges*. Orient Longman Publ.
- Morris EW. 1979. *Housing Family and Society*. John Wiley & Sons.
- RajaRao YN and Subrahmanyam Y. 2002. *Planning and Designing of Residential Buildings*. Standard Publ.
- Steffy GR. 2002. *Architectural Lighting Design*. John Wiley & Sons.
- Stitt FA. 1999. *Ecological Design handbook: Sustainable Strategies for Architecture*. McGraw Hill.
- University of Calgary. 2007. *Energy Efficient Building Design* https://energyeducation.ca/encyclopedia/Energy_efficient_building_design

I. Course Title : Technical Drawings

II. Course Code : RMCS 511

III. Credit Hours : 3(1+2)

IV. Theory

Unit I: Drafting fundamentals

Measurement and scaling; Lines-Types, quality and weights; Lettering styles; Sheet format and layout; Blocks and layout; Legend and dimension; Conventions and preliminary drawings.

Unit II: Presentation techniques

Orthographic plans- Plan, elevations and sections; Design drawings; Projection drawings; Isometric drawings; Perspective drawings; Rendering and hatching techniques; Presentation boards.

Unit III: Introduction to AutoCAD

Introduction to AutoCAD as 2D drafting tool; Digital drawings tools; Drawing lines and shapes; Modifying lines and shapes; Drawing with accuracy and speed; Organizing plans; Sections and elevations; Drawing and printing to scale; Text styles and sizes; Hatches and dashed lines; Stencils and blocks; Advanced editing tools and Dimensioning drawings.

Unit IV: 3D Modelling using AutoCAD

Introduction to 3D-modelling technique using AutoCAD; 3D basics– axes, Planes and Faces; 3D Object Modification– Rotate, Mirror, Array and Scale; 3D Boolean operations–Union, Subtract, Intersect; 3D Primitive objects– Box, Wedge, Cone, Sphere, Cylinder, Torus and Pyramids; Solid modeling – Revolve, Shell, Taper, Loft, Path extrusion and Sweep.

Unit V: Introduction to 3D Modelling and Rendering

Introduction to 3D Modelling and Rendering; Building Modelling and basic rendering techniques; Using 3DSMax or equivalent; Advanced 3D Modelling-Advanced modeling; Ray rendering engine.

Unit VI: Auto CAD and its application in interior design

Orientation to AutoCAD Main screen and menus; Coordinate systems; Use of Draw and edit menus; Hatching inquiry tools; Layers; 3D Modelling; Co-ordinate system; Primitive tools: Boolean operation; Editing 3D objects; Rendering; Printing; Introduction to ADT- creation of plans, sections, elevations, title marks and dimensioning, schedule table of doors and windows; Create still camera views; Creating a movie file; Walk through; Introduction to 3D Max -standard tool bar command panel; Concept of import and export of objects from ADT and Auto CAD to 3D Studio MAX; Creating objects in 3D Max using standard primitives; Using transforms; Introduction of material; Light; Colour; Render the images and save; Camera animation of walk through.

1. **VII. Practical** Drawing a detailed floor plan showing the use of different lines, lettering styles,sheet format and layout, blocks and layout, legend and dimension, section drawing
2. Drawing a detailed floor plan showing the use of blocks and layout, legend and dimension, section drawing
3. Scale drawing of building components in plan and elevation
4. Preparation of electrical layout for a small building
5. Preparation of plumbing layouts for a small building

6. Working on presentation details for the above plans
7. Evolving floor plans for an existing residential building
8. Drawing views of brick arrangement to scale in two dimensions (Plan, elevation) and three dimension (isometric, oblique and axonometric)
9. Study of buildings and interiors in two and three dimensions
10. Drawing one/single perspectives of interiors
11. Drawing two point perspectives of interiors
12. Creation of texture effects in interior objects
13. Pencil rendering of interiors
14. Colour rendering of interiors
15. Developing a private project and presenting with views
16. Use of Presentation techniques

17-31 Project work: Application of CAD in developing plans and presentation details of any one residential and commercial building

32. End term assessment

VIII. Suggested Reading

- Chiavaroli J. 1999. *AEC Drafting Fundamentals*. Delmar Publishers, London.
- Frey D. 2000. *AutoCAD 2000*. BPB Publications, New Delhi.
- Gill RW. 1975. *The Thames and Hudson Manual of Rendering with Pen and Ink*. Thames and Hudson, London.
- George O. 2007. *Just Enough Auto CAD*. Wiley Publishing Inc.
- Hepler DE and Wallach PI. 1965. *Architecture – Drafting and Design*. McGraw-Hill Book Company, New York.
- Kalee S, Zaidi A and Siddique S. 2004. *Designing and Design of Residential and Commercial Buildings*. Standard Publ.
- Kasu AA. 1995. *An Introduction to Art, Craft, Technique, Science of Profession of Interior Design*. Iqura Publishing Pvt. Ltd., Bombay.
- Kilmer WO and Kilmer R. 2004. *Construction Drawings and Details for Interiors*. Wiley.
- Mitton M. 1999. *Interior Design Visual Presentation*. John Wiley & Sons, New York.
- Shah MG, Kale CM and Patkki SY. 1995. *Building Drawing*. 3rd Edition, Tata McGraw Hill.

I. Course Title : Interior Design Business Management

II. Course Code : RMCS 512

III. Credit Hours : 3(1+2)

VI. Theory

Unit I: Introduction to professional management

Definition of a profession; Principles of interior design business management; Ethics and professional conduct; Establishing interior design practice.

Unit II: Professional components of managing interior work

Legal issues of business; Business management applications; Marketing; Scale of professional fee and charges; Duties of employer under labour welfare provisions; Structure of interior designers office; Conditions of engagement; Risk management.

Unit III: Estimating and costing for interior work

Definition; Importance and types of estimation; Units and mode of measurement; Rate analysis; Bills of quantities; Contract design.

Unit IV: Professional practice

Professional portfolios; Resumes and business cards; Web page and e-service; Professional associations and support systems.

VII. Practical

1. Case study of an established interior design firm
2. Cost estimation for projects
3. Contracting and sub-contracting procedure for the estimated projects
4. Strategic plan for presentation of project for a tender call
5. Working on modalities for establishing an interior design firm
6. Preparation of financial plan for a design firm
7. Working on portfolio and resume design for job in professional firm

8-31. Working with an interior designer for work eXperience

32. End term assessment

XI. Suggested Reading

- Christine MP. 2001. *Interior Design Management: A Handbook for Owners and Managers*. ASID, IIDA.
- Christine MP. 2002. *Professional Practice for Interior Designer*. John Wiley & Sons.
- Cindy C. 2002. *Interior Design Handbook of Professional Practice*. McGraw Hill.
- Kailee Helget May. 2019. *How to start an Interior Business*
- https://www.2020spaces.com/blog-start-an-interior-design-business/
- Terry LP (2002) *Architects Studio Handbook*. McGraw Hill.

I. Course Title : Environmental Resource Management

II. Course Code : RMCS 513

III. Credit Hours : 2(1+1)

IV. Theory

Unit I: General perspectives

Man, environment and economic growth; Industrialization; Urbanization; Consumerism and environment; Environmental informatics; Environment and bio-technology; Environmental ethics.

Unit II: Ecology, environment and sustainability

Ecological environment and sustainability; Environmental dimensions of sustainable development; Equitable use of resources for sustainable development; Economical, political and cultural influences in the use of environmental resources; Role of government and non-government organizations and communities in sustainable development.

Unit III: Environmental waste management

Waste management; Waste management systems in India; Technologies for waste management; Hazardous waste management and treatment; Physical and chemical treatment; Thermal treatment and biological treatment; Hazardous waste treatment; E-Waste; Management of E-waste; Inventory management; Production process modification; Volume reduction; Recovery and reuse; Laws and regulations concerning waste management in India.

Unit IV: Energy and environment

Energy and environment; Economic growth and energy consumption; Increased energy consumption and climate change; Energy policy of India; Energy and sustainability; Sustainable energy resources.

Unit V: Environmental protection and management

Environmental economics- Concepts, evolution and its development; Important processes and technologies; Environmental protection and management; Environmental quality objectives and standards; Approaches with regard to environmental protection; Institutional and policy framework; Ministry of environment and forest, Pollution control boards.

V. Practicals

1. Understanding the impact of urbanization and consumerism on resource utilization- Literature search
2. Report preparation on impact of urbanization and consumerism on resource utilization
3. Presentation and discussion on impact of urbanization and consumerism on resource utilization
4. Visit to any one industry to understand the types of wastes generated and their waste management practices
5. Presentation and group discussion
6. Plan awareness programme to educate college students on their role in environmental protection
7. Organizing awareness camp
8. Project work: Household waste management practices among families- Collection of review
9. Planning the research methodology
10. Designing data collection tool for collecting information on household waste management practices among families

11. Finalization of tool
12. Data collection
13. Data analysis
14. Report preparation on household waste management practices among families on household waste management practices among families
15. Presentation and Group discussion
16. End term assessment

VI. Suggested Reading

- Bhatnagar A. 2010. *Ecology and Environment*. OXford Book Company, Jaipur.
- Bharucha E. 2017. *Text Book of Environmental Studies*. UGC University Press India Pvt. Ltd.
- Chary SN and Vyasula V. 2001. *Environmental Management-An Indian Perspective*. Macmillan India Ltd.
- Joseph K and Nagendran R. 2004. *Essentials of Environmental Studies*. Pearson Education Pvt. Ltd.
- International Hydropower Association. 2017. *Environmental Resources Management* (*ERM*)https://www.hydropower.org/companies/environmental-resources- management-erm
- Kuar A and Roy PK. 2008. *Environmental Resource Management*. Daya publishing House, Delhi.
- Pandey SN and Misra SP. 2011. *Environment and Ecology*. AneBools Pvt. Ltd., New Delhi.
- Singh K and Sisodia A. 2007. *Environmental Economics: Theory and Applications*. Sage Publ.
- Singh S. 2010. *Disaster Management*. Rajdhani printers, Delhi.
- Thakur V. 2012. *A Text Book of Environmental Science*. Scientific Publishers, Jodhpur.

Course Title with Credit Load
Ph.D. in Resource Management and Consumer Science

Course Code	Course Title	Credit Hours	Semester
	Major Courses		
RMCS 601*	Trends in Resource Management	3 (3+0)	
RMCS 602*	Occupational Biomechanics	3 (2+1)	
RMCS 603	Globalization and Consumer Economics	3 (2+1)	
RMCS 604	Space Designing and Managerial Dimensions for Special needs	3 (1+2)	
RMCS 605	Physical Ergonomics	3 (1+2)	
RMCS 606	Environmental Issues and Challenges	2 (2+0)	
RMCS 607	Family Dynamics and Women Power	3 (2+1)	
RMCS 608	Special Project	2 (0+2)	
	Total	22 (13+9)	
	Minor Courses		
FN604	Global Nutrition Problems	2 (2+0)	
FN 608	Energy Metabolism	2 (2+0)	
EECM 602	Impact Assessment of Development Programmes	3 (1+2)	
EECM 603	Scaling Techniques for Behavioural Research	3 (1+2)	
EECM 607	Media application and product promotion	4 (2+2)	
HDFS 608	Qualitative research methods	3 (2+1)	
ATS 602	Technical Textiles	3 (2+1)	
ATS605	Functional Clothing	3 (2+1)	
ATS 607	Operational Management in Textiles and Apparel	2 (2+0)	
	Supporting Courses		

A student can opt any course related to the topic of research offered by other faculties of agriculture university or SWAYAM/ MOOCS or other online courses up to a maximum of 5 credits.

RMCS 691	Doctoral Seminar I (Core Field)	1 (1+0)
RMCS 692	Doctoral Seminar II (Optional Field)	1 (1+0)
RMCS 699	Research	75
	Total	**100 Credits**

*Compulsory core curses

Course Contents
Ph.D. in Resource Management and Consumer Science

I. Course Title : Trends in Resource Management

II. Course Code : RMCS 601

III. Credit Hours : 3(3+0)

IV. Theory

Unit I: Significance and scope of family resource management

Introduction and history of family resource management and household trends; Resource management as a process; Influences on management styles; Life management for singles, families, households and non family households; Advances in the discipline of resource management.

Unit II: History and theories of resource management

Managerial practices and concepts from ancient civilization; Early years of family resource management; Household production and consumption systems during pre modern, modern and post modern periods; Theories in resource management; Pre scientific and post scientific approach; Human and non human resource management; Systems theory; Application of systems theory to households; Economic theory; Human ecology and ecosystems; Contemporary management practices.

Unit III: Managerial competencies

Conflict Management- Concepts, types, sources and levels of conflict; Conflict resolution strategies; Conflict management; Behavioural interventions for handling conflicts; Leadership; Theories of leadership; Types of leadership; Likert's four systems of leadership and managerial grid.

Unit IV: Management of resources

Managing time as a resource; Modern tools and techniques of time management; Qualitative and quantitative time measures; Legislations, policies and research in family management.

Unit V: Organizational behaviour

Organizational culture- Concepts, process and implications of organizational culture; Organizational performance-Concept and process, measures for organizational performance, controlling for organizational performance; Overview of control techniques (Scheduling, CPM, PERT, SWOT analysis, etc.); Effective control systems; Performance appraisal-purpose, methods, essentials of good appraisal system; Organizational change- concepts and nature; Kurt Lewin theory of change; Implementing change; Managing resistance to change.

Unit VI: Managerial ethics and social responsibilities

Managerial ethics- Factors affecting ethical choices; Ethical dilemma; Social responsibility- Concept and approaches; Evaluating institutional social performance; Managing institutional ethics and social responsibility.

V. Suggested Reading

- Elezabeth BG. 2013. *Resource Management for Individuals and Families*. Thomson Learning Inc.
- Hellregel. 2002. *Management*. Thomason Learning, Bombay.
- Koontz H and Wechrich H. 2008. *Management*. Tata McGraw Hill Inc. N.Y.
- Richar LD. 2015. *Management*. Thomson South-Western.

- Robbins SP and Decenzo DA. 2010. *Fundamentals of Management*. Pearson Education Asia, New Delhi.
- Satya Raj R and Parthasarthi A. 2009. *Management- Text & Cases*. PHI, New Delhi.
- Stephen PR and Mary AC. 2015. *Management*. 13th Edition, Prentice Hall of India. New Delhi.
- Subba Rao P. 2017. *Management and Organizational Behaviour* (*Text and Cases*). Himalaya Publishing House, New Delhi.
- Trends in Management- https://www.toppr.com/guides/business-management-and-entrepreneurship/recent-trends-in-management/
- Tripathi PC and Reddy PN. 2013. *Principles of Management*. Tata McGRaw Hill Education Pvt Ltd, ND.

I. Course Title : Occupational Biomechanics

II. Course Code : RMCS 602

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: Biomechanical concepts

Biomechanics as an area of study; The biomechanics of the human skeletal articulations; The biomechanics of human skeletal muscle; Application of biomechanics to movement-Qualitative and quantitative approach.

Unit II: Biomechanics of the human body

The biomechanics of the human upper extremity- shoulder, elbow wrist and hand; The biomechanics of the human lower extremity- Hip, knee, ankle and foot; The biomechanics of the human spine.

Unit III: Occupational biomechanics

Biomechanical oriented ergonomics in workplace; Activity-related soft tissue disorders (ASTDs); Work-related risk factors; Definition and ergonomic guidelines for controlling risk factors; Risk for back injuries in the workplace; Analysis and ergonomic guidelines for controlling.

Unit IV: Ergonomic task analysis and risk assessment

Ergonomic task analysis- Definition, importance and process; Occupational risk factors; Tools and techniques for identifying posture related risk factors; Tools and techniques for identifying risk factors related to forceful exertion; Tools and techniques for identifying risk factors related repetitive motion; Tools and techniques for identifying risk factors related workstation design; Tools and techniques for identifying risk factors related workplace environment; Ergonomic check points; Development of ergonomic checkpoints for various occupations.

Unit V: Application of biomechanics

Application of biomechanics for occupational safety; Use of SAMMIE (System for Aiding Man Machine Interaction Evaluation) and CAD system in occupational designs.

V. Practicals

1. Assessing postural risks in a computer workstation
2. Designing ergonomic guidelines to overcome postural risks
3. Designing a tool to identify hazards in construction work
4. Collection of data on hazards in construction work
5. Preparation of report on hazards in construction work
6. Presentation of report and group discussion
7. Identification of hazards in agricultural operations-field level observation
8. Preparation of schedule for identification of hazards in agricultural operations
9. Data collection on hazards in agricultural operations
10. Preparation of report on hazards in agricultural operations
11. Presentation of report and group discussion
12. Designing ergonomic guidelines for risk elimination
13. Measuring occupational stress using a standardized tool
14. Collection of data on occupational stress
15. Preparation and presentation of report on occupational stress
16. End term assessment

VI. Suggested Reading

- Allan Toomingas, Svend Erik Mathiassen, Ewa WT. 2011. *Occupational Physiology*. 1st Edition, CRC Press, Taylor and Francis Group, London.
- Ayub MM and Mittal A. 1998. *Manual Material Handling*. Taylor and Francis, London.
- Chapanis A. 1996. *Human Factors in Systems Engineering*. John Wiley and Sons, New York\.
- Dalela S and Saurabh. 1999. *Text Bbook of Work Study and Ergonomics*. Standard Publishers Distributors, Delhi.
- John R Wilson and Nigel Corlett. 2005. *Evaluation of Human Work*. Third Edition Taylor and Francis Group, London.
- Kumar Shrawan. 2007. *Biomechanics in Ergonomics*. Second Edition, www.crcpress.com/product/isbn/
- Meister D. 1989. *Conceptual Aspects of Human Factors*. Johns Hopkins University Press, Baltimore, MD.
- Panero J and Zelnik M. 1979. *Human Dimension and Interior Space*. Whitney Library of Design.
- Tayyari F and Smith JL. 1997. *Occupational Ergonomics Principles and Applications*. Chapman and Hall, London.
- Wilson JR and Haines HM. 1997. Participatory Ergonomics.In: *SalvendyG* (*Ed.*) *Handbook of Human Factors and Ergonomics*. 2nd Edition, Taylor & Francis, Bristol, PA.

I. Course Title : Globalization and Consumer Economics

II. Course Code : RMCS 603

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: The ontology of consumer economics

Consumer motivation- Concept, components of motivation; Maslow's motivational theory and consumer behaviour; Consumer decision process- Problem or need recognition, information search, evaluation of alternatives, purchase decision, post-purchase decision; Models of buyer decision making -Economic model, psychological models, consumer behaviour models; Influence of purchase decision- external and internal; Consumer decision styles; Risk in consumer behavior -functional risk, physical risk, financial risk, social risk, psychological risk, time risk; Adoption and diffusion of innovations; Impulse buying- definition and types; Factors influencing impulse buying behavior -consumer related factors, Situational characteristics, product characteristics, store related factors, consumer behaviour.

Unit II: Global markets

Definition and importance; Features of global marketing; Forces affecting global marketing; Objectives of global marketing; Global marketing environment; Global marketing strategies; Difference between global and international market; Advantages and disadvantages of global marketing.

Unit III: New economic policies

Introduction to new economic policies- Liberalization, privatization, globalization; Privatization-introduction, objectives; Types of privatization; Problems of privatization; Privatization in India; Privatization and global impact; Globalization-meaning, trends, factors influencing globalization; Impact of globalization on Indian economy; Positive and negative impact of globalization in India; World Trade Organization(WTO) –objectives and functions; WTO agreement; Benefits of WTO; WTO and developing countries; WTO agreement on agriculture and subsidies; General Agreement on Tariff and Trade (GATT)-Purpose, implications of GATT agreement in various areas.

Unit IV: The services

Consumer services; Service providers and their obligations towards consumers; Citizen Charter- Vision, mission objectives, importance in public administration; Goods and Service Tax (GST)- Components of GST, benefits of GST, impact of GST on consumers.

Unit V: Agriculture and Indian economy

Indian agriculture policy; Agriculture credit in India; National agricultural insurance schemes; Agriculture marketing in India; Sustainable agriculture and food security in India; Government programmes for increasing family food security and financial security of consumers.

V. Practicals

1. Project work: Study on impulse buying behaviour among teenage consumers-collection of review
2. Formulation of objectives for the study
3. Finalization of method of research
4. Designing a data collection tool
5. Data collection on impulse buying behaviour among teenage consumers

6. Data analysis and report writing
7. Presentation of report on impulse buying behaviour among teenage consumers
8. Presentation of the report on impulse buying behaviour among teenage consumers
9. Critical analysis of citizen charter of electricity department
10. Study the crop insurance scheme
11. Conduct farmer awareness camp on crop insurance scheme
12. Study the implementation of any one government programme for increasing family food security and financial security
13. Identify structural and functional aspects of any one agriculture market
14. Observe the functioning of selected agriculture market
15. Group discussion on functional aspects of agriculture market
16. End term assessment

VI. Suggested Reading

- Dasgupta Biplab. 2005. *Globalization*. Sage Publications, New Delhi.
- Kotabe Masaki and Helsen Kristiaan. 2004. *Global Marketing Management*. 3rd Edition, John Wiley & Sons.
- Loudon DL. 1988. *Consumer Behavior: Concepts and Applications*. McGraw Hill, London.
- Nayar BR. 2007. *India's Globalization*. Vistaar Publication.
- Rajagopal. 2007. *Globalization and Consumer Behavior*. https://link.springer.com/chapter/10.1057%2F9781137281920_11
- Schiffman LG. 2004. *Consumer Behaviour*. Prentice Hall.
- Schiffman LG and Wisenblit JL. 2015. *Consumer Behaviour*. 11th Edition.
- Sharma AK. 2006. *Consumer Behaviour*. Global Vision Publcation.
- Sherlekar SA. 2012. *Marketing Management*. Himalaya Publishing House, Delhi.
- Srivastava R. 2011. *Marketing Skills in Globalisation*. Subline Publications, Jaipur.

I. Course Title : **Space Designing and Managerial Dimensions for Special Needs**

II. Course Code : **RMCS 604**

III. Credit Hours : **3(1+2)**

IV. Theory

Unit I: Introduction to interiors for special needs

Types of disabilities and their needs; Barriers in residential and commercial buildings; Theoretical perspectives on efficiency; Comfort and safety; Physical environment; Architectural dimensions- Flooring, stairs, storage, workstations, furniture, fixtures, fitments and equipment.

Unit II: Universal design

Adapted; Adaptable; Barrier free; Accessible and Universal design-Meaning, differences and features; Principles to be followed in residential and commercial buildings; Suitability of elements and principles of design- lighting, colours, textures, arrangement of furnishings, floor coverings, window placement, etc. for people with special needs.

Unit III: Managerial dimensions

Managerial dimensions with special reference to time, money and energy for people with special needs; Managerial dimensions with special reference to food and health for people with special needs; External environment support systems for people with special needs; Guidelines for support systems.

Unit IV: Policies and institutional support

Policies and institutional support for people with special needs; Legal provisions; Access standards and regulations; Physical amenities to be provided for people with special needs; Qualities; Roles and responsibilities of special care managers.

V. Practicals

1. Identifying the existing barriers and accessibility features provided in residential buildings for people with special needs – preparation of check list
2. Data collection
3. Presentation and group discussion
4. Identifying the existing barriers and accessibility features provided in commercial buildings for people with special needs -preparation of check list
5. Data collection
6. Presentation and group discussion
7. Design and development of scale model for residential and commercials buildings for visually impaired people – preparation of conceptual drawings
8. Design and development of scale model for residential and commercials buildings for visually impaired people – preparation floor plan, elevation
9. Design and development of scale model for residential and commercials buildings for visually impaired people – preparation of landscape plans,
10. Design and development of scale model for residential and commercials buildings for visually impaired people – Preparation of scale model
11. Presentation and discussion
12. Design and development of scale model for residential and commercials buildings for hearing impaired people - Preparation of conceptual drawings
13. Design and development of scale model for residential and commercials buildings for hearing impaired people - Preparation of floor plan, elevation
14. Design and development of a scale model for residential and commercials buildings

for hearing impaired people - Preparation of landscape plans,
15. Design and development of a scale model for residential and commercials buildings for hearing impaired people - Preparation of scale model
16. Presentation and discussion
17. Design and development of a scale model for residential and commercials buildings for physically challenged people - Preparation of conceptual drawings
18. Design and development of a scale model for residential and commercials buildings for physically challenged people - Preparation of floor plan, elevation
19. Design and development of a scale model for residential and commercials buildings for physically challenged people - Preparation of d landscape plans,
20. Design and development of a scale model for residential and commercials buildings for physically challenged people - Preparation of scale model
21. Presentation and discussion
22. Visit to old age homes– Preparation of observation tool
23. Collection of data on living conditions in old age homes
24. Presentation of information and group discussion
25. Visit to schools for children with special needs
26. Collecting and presenting the information on living conditions in the school
27. Design and development of a scale model of an old age home with universal design features - Preparation of conceptual drawings
28. Design and development of a scale model of an old age home with universal design features - Preparation of floor plan, elevation
29. Design and development of a scale model of an old age home with universal design features - Preparation of landscape plans,
30. Design and development of a scale model of an old age home with universal design features - Preparation of scale model
31. Presentation and group discussion
32. End term assessment

VI. Suggested Reading

- Bridger RS. 1994. *Introduction to Ergonomics*. McGraw Hill.
- Dalela S and Saurabh. 1999. *Textbook of Work Study and Ergonomics*. Standard Publ.
- Designing for disabled children and children with special educational needs- https://www.unicef.org/devpro/files/CFSManual_Ch03_052009.pdf
- Grandjean E. 1978. *Ergonomics of the Home*. Taylor & Francis.
- Ian G. 2006. *Applied Ergonomics Handbook*. Butterworths.
- Panero JZ. 1979. *Human Dimensions and Interior Space*. The Architectural Press.
- Singh S. 2007. *Ergonomics Interventions for Health and Productivity*. Himanshu Publ.

I. Course Title : Physical Ergonomics

II. Course Code : RMCS 605

III. Credit Hours : 3(1+2)

IV. Theory

Unit I: Workplace hazards

Workplace hazards; Types, sources and classification; Hazard identification through interactive exercises; Employee survey methods; Injury log assessment; Hazard control methods.

Unit II: Work related musculoskeletal disorders

Workplace risk factors and evidence for work relatedness -posture, force, repetition, vibration, contact stress, environment; Upper limb disorders-Tenosynovitis, Carpal Tunnel Syndrome (CTS) and Tennis elbow, Repetitive Strain Injuries (RSI); Lower limb disorders-Osteoarthritis, Knee bursitis, Meniscal lesions, Stress reaction injuries, Varicose veins.

Unit III: Ergonomic guidelines for occupational health

Ergonomic program for best practices in work place and hazard reduction; Methods for integrating ergonomics into existing occupations; Workplace evaluation; Risk factor checklists; Hazard reduction- engineering control, administrative controls.

Unit IV: Systems approach to ergonomics

Organizational aspects of the human; Work interface to enhance safety; Designing work with systematic procedures to enhance safety; Safety and ergonomics culture.

Unit V: Digital human model for ergonomic analysis

Virtual ergonomics and its advantage; Introduction to digital human modeling and simulation; Techniques of virtual ergonomics evaluation using digital human modeling.

V. Practicals

1. Identifying common hazards in a selected manufacturing industry through literature search
2. Developing a check list for identifying hazards in a selected manufacturing industry
3. Content validation of the check list
4. Pretesting of check list
5. Establishing the reliability
6. Collection of data on hazards in a selected manufacturing industry
7. Data analysis for identification of occupational hazards
8. Preparation of report on hazards in a selected manufacturing industry

9-12. Identification of ergonomic best practices through literature search to safe guard occupational health in manufacturing industry

13. Planning ergonomic intervention programme

14-28. Implementations of ergonomic interventions in the manufacturing industry

29. Collection of feedback on effectiveness of ergonomic interventions
30. Preparation of report
31. Presentation of report and group discussion
32. End term assessment

VIII. Suggested Reading

- Ayub MM and Mittal A. 1998. *Manual Material Handling*. Taylor and Francis, London.
- Chapanis A. 1996. *Human Factors in Systems Engineering*. John Wiley and Sons, New York.
- Dalela S and Saurabh. 1999. *Text Book of Work Study and Ergonomics*. Standard Publishers Distributors, Delhi.
- John R Wilson and Nigel Corlett. 2005. *Evaluation of Human Work*. Third Edition, Taylor and Francis Group, London.
- Kumar Shrawan. 2007. *Biomechanics in Ergonomics*. Second Edition, www.crcpress.com/product/isbn/
- Meister D. 1989. *Conceptual Aspects of Human Factors*. Baltimore, MD: Johns Hopkins University Press.
- Panero J and Zelnik M. 1979. *Human Dimension and Interior Space*. Whitney Library of Design.
- Tayyari F and Smith JL. 1997. *Occupational Ergonomics Principles and Applications*. Chapman and Hall, London.
- Toomingas Allan, Svend Erik Mathiassen and Ewa WT. 2011. *Occupational Physiology*. 1st Edition, London, CRC Press, Taylor and Francis Group.
- Wilson JR and Haines HM. 1997. Participatory Ergonomics In: *Salvendy G* (*Ed.*) *Handbook of Human Factors and Ergonomics*. 2nd Edition, Taylor & Francis, Bristol.

I. Course Title : Environmental Issues and Challenges

II. Course Code : RMCS 606

III. Credit Hours : 2(2+0)

IV. Theory

Unit I: Technology and environment

Technology, environment and sustainable development; Positive and negative effect of technological advancement; Effect of technology on organisms and their habitat; Impact of industrialization on environment; Environmental consequences of agricultural development; Environmental effects of information and communication technologies.

Unit II: Global environmental issues

Global environmental issues; Challenges in building governance mechanism; Efforts at international forums; Climate change and global warming; Conservation of biodiversity and wildlife; Over population and land degradation; Exploitation of natural resources and energy crisis; Depletion of ozone layer; Acid rain; Nuclear power; Oil spill pollution; Dumping of hazardous waste.

Unit III: Environmental management system

Environmental management system; Carbon credits a market based instrument for environmental benefit; Objectives and functioning of national and international organizations in environment conservation; Environmental standards in India; Environmental management approaches; Environment audit; Methodology for environment impact assessment; Environment education.

Unit IV: Environment and human health

The effect of global environmental change on vector-borne diseases and parasites; Health effects of particulate matter in environment; Human health implications of exposure to chemical residues in the environment; Neuro toxic effects of environmental contaminants on human health; Environmental factors influencing puberty onset; Cancer risk correlated to environment, diet and genetic factors, food and fertility; Climate change and Infectious diseases; Environmental health hazards in various occupations.

V. Suggested Reading

- Bharucha E. 2017. *Text Book of Environmental Studies*. UGC University Press India Pvt. Ltd.
- Bhatnagar A. 2010. *Ecology and Environment*. Oxford Book Company, Jaipur.
- Chary SN and Vyasula V. 2001. *Environmental Management-An Indian Perspective*. Macmillan India Ltd.
- Joseph K and Nagendran R. 2004. *Essentials of Environmental Studies*. Pearson Education Pvt. Ltd.
- Kumar A and Roy PK. 2008. *Environmental Resource Management*. Daya Publishing House, Delhi.
- Rao VP. 2002. *Text Book of Environmental Engineering*. Prentice Hall.
- Singh K and Sisodia A. 2007. *Environmental Economics: Theory and Applications*. Sage Publ.
- Singh S. 2010. *Disaster Management*. Rajdhani Printers, Delhi.
- Thakur V. 2012. *Text Book of Environmental Science*. Scientific publishers, Jodhpur.
- Tiwari M, Khulbe K and Tiwari A. 2016. *Environmental Studies*. I.K. International Publishing House Pvt. Ltd., New Delhi.

I. Course Title : Family Dynamics and Women Power

II. Course Code : RMCS 607

III. Credit Hours : 3(2+1)

IV. Theory

Unit I: Women and family

Role analysis of Indian home makers during ancient period, medieval period and modern times; Impact of change in the role of women on the family system; Roles and responsibilities of women in various spheres of life; Causes of change in women's role in family and its impact on the family.

Unit II: Family dynamics

Understanding family dynamics; Family dynamics and its influences on family; Theoretical and conceptual framework to study family dynamics; Institutional norms of family; Family structure; Family ecology and family life development programmes; Economic and psychological cost of gainful employment of women in the family.

Unit III: Family stress management

Family stress- meaning, sources and symptoms, causes, effects and consequences of stress; Stress and burnout - definition of burnout, Difference between stress and burnout, major signs of burnout; Stress and coping strategies; Types of coping strategies- appraisal focused, problem focused, emotion focused, occupation focused; Work stress-sources, consequences and coping strategies; Social support systems for facilitating women's work participation in family and society; Quantitative methods for measuring the perception of stress.

Unit IV: Women and law

Status of women in Indian; Women in family; Women and education; Women reservation; Women's economic social and cultural rights; Constitutional provisions and privileges for women in India; Special initiatives for women- National commission for women, reservation for women in local self-government, the national plan of action for the girl child(1991-2000); National policy for the empowerment of women,2001; Indian laws for the protection of women's rights against domestic violence; Women's economic empowerment and the changing world of women work; International initiatives for women's economic empowerment; United nation's bodies for women's rights; Women in the workforce- Organized and unorganized sectors; Women and occupational health and safety; Provisions for health and safety under occupational health laws in India.

V. Practical

1. Analysis of aspects of family dynamics in different stages of family life cycle through case study
2. Report presentation and discussion
3. Evaluate implementation of any one government programme/scheme through survey-Formulation of guidelines
4. Evaluate implementation of any one government programme/scheme through survey-Field survey
5. Evaluate implementation of any one government programme/scheme through survey-Preparation of report
6. Report presentation and discussion
7. Finding out awareness about constitutional provisions and welfare schemes for women-preparation of data collection tool

8. Finding out awareness about constitutional provisions and welfare schemes for women-data collection
9. Finding out awareness about constitutional provisions and welfare schemes for women-data analysis
10. Finding out awareness about constitutional provisions and welfare schemes for women-report writing
11. Report presentation and discussion
12. Review of stress measuring tools and techniques-Collection of literature
13. Presentation on stress measuring tools and techniques
14. Group discussion on stress measuring tools and techniques
15. Proposing modifications for refinement of tool
16. End term assessment

IX. Suggested Reading

- Becvar D and Becvar R. 2002. *Family Therapy: A Systemic Integration*. Pearson Education, Australia.
- Brian J and Carrie LY. 2017. *Family Relationships, Marital Relationships*- https://family.jrank.org/pages/1316/Power.html
- Dasgupta S and Lal M. 2007. *The Indian Family in Transition*. Sage Publication, New Delhi.
- Ghadially R. 2007. *Urban Women in Contemporary India*. Sage Publication, New Delhi.
- Krishna S. 2007. *Women's Livelihood Rights*. Sage Publication, New Delhi.
- Manji F. 2006. *Development and Rights*. Rawat Publication.
- Paxton P and Hughes MM. 2007. *Women, Politics and Power*. Pine Forge Press.
- Thakur S. 2013. *Encyclopedia of Women Empowerment*. Centrum Press, New Delhi.
- Tata Institute of Social Sciences. 1994. *Enhancing the Role of the Family as an Agency for Social and Economic Development*. Bombay.