CH. SARWN KUMAR HIMACHAL PRADESH KRISHI VISHVAVIDYALAYA,
PALAMPUR, DISTRICT KANGRA-176 062 (H.P.)
"OFFICE OF THE REGISTRAR, ACADEMIC BRANCH"

☎: 01894-230383/230394 Fax: 01894-230511 Email.registrar@hillagric.ac.in

No. QSD.5-6/CSKHPKV/Acad/Vol. V/- 23185-249 Dated, Palampur the: 04 MAY 2024

NOTIFICATION

The Academic Council vide resolution No.10 of the proceedings of its 201th meeting held on 28.03.2024 keeping in view of the National Education Policy, 2020 has approved to implement four year Undergraduate programme (FYUGP)/ (B.SC. Hons./ B.Sc. Hons. with Research) in Physical Sciences and Life Sciences as per NEP-2020 from the Academic Year 2024-25 in the College of Basic Sciences, CSKHPKV, Palampur as per **Annexure A** and also revised the Course Structure/Course Catalogue, Academic Regulations, Academic Forms, name of degree, minimum eligibility qualification, etc. as per annexures **Annexure I to V**.

Accordingly, the above changes will be applicable to the students admitted to four year Undergraduate programme (FYUGP)/ (B.SC. Hons./ B.Sc. Hons. with Research) in Physical Sciences and Life Sciences as per NEP-2020 from the Academic Year 2024-25 in the College of Basic Sciences , CSKHPKV, Palampur.

OFFICE OF THE REGISTRAR ★ CSK HPKV PALAMPUR ★

Registrar,
CSKHPKV, Palampur.

Endst. No. even

Dated: even

Copy of above is forwarded to the following for information and necessary action:

1. All the Statutory Officer, CSKHPKV, Palampur
2. All the Heads of Departments, CSKHPKV, Palampur.
3. The Secretary to Vice-Chancellor, CSKHPKV, Palampur.
4. The Private Secretary to Vice-Chancellor, CSKHPKV, Palampur.
5. The Sr. Private Secretary to Registrar, CSKHPKV, Palampur.
6. The Incharge, Unversity Network System, CSKHPKV, Palampur with the request to upload the notification on the University website.
7. The Jt. Director (Information & Public Relations) CSK HPKV, Palampur.
8. The Meeting Assistant, Academic Branch, CSK HPKV, Palampur.
9. Guard file.

Registrar,
CSKHPKV, Palampur.

<u>Annexure A</u>

FOUR YEAR UG PROGRAMME (FYUGP) [B.SC. HONS./ B.SC. HONS. WITH RESEARCH] IN PHYSICAL SCIENCES AND LIFE SCIENCES AS PER NATIONAL EDUCATION POLICY-2020 FROM THE ACADEMIC YEAR 2024-2025 ONWARDS

1.	**Upgradation of three year UG programme to Four Year UG Programme (FYUGP) [B.Sc. Hons./ B.Sc. Hons. with Research] in Physical Sciences and Life Sciences as per National Education Policy-2020 from the Academic year 2024-2025 onwards.**
	With the announcement of National Education Policy-2020 and to keep pace with the neighbouring institutes, three year UG programme of College of Basic Sciences, CSKHPKV, Palampur upgraded to Four Year UG Programme (FYUGP) [B.Sc.Hons./ B.Sc. Hons. with Research] in Physical Sciences and Life Sciences as per National Education Policy-2020 and its latest UGC guidelines regarding 'Curriculum and Credit Framework for Under Graduate Programmes', 'National Credit framework', Multiple Entry & Exit' and further time to time directions from the competent authority, **from Academic year 2024-2025 onwards** for its implementation.
2.	**Revision of course structure and course catalogue for implementation of FYUGP [B.Sc. Hons./ B.Sc. Hons. with Research] in Physical Sciences and Life Sciences**
	The course structure and course catalogue as per National Education Policy-2020 & its latest UGC guidelines regarding 'Curriculum and Credit Framework for Under Graduate Programmes', 'National Credit framework', Multiple Entry & Exit' and further time to time directions revised as Annexure I, II, III: **Annexure-I** : **Course structure for Degree Programmes** **Annexure-II** : **Course Catalogue for B.Sc.(Hons.)/B.Sc.(Hons. with Research) in Life Sciences** **Annexure-III** : **Course Catalogue for B.Sc.(Hons.)/B.Sc.(Hons. with Research) in Physical Sciences**
3.	**Revision/modification of current Academic Regulations Chapter XXII 'System of Examination for Undergraduate Degree in Basic Sciences under CBCS' and to introduce/add as a new chapter i.e. Chapter XXIII 'System of Examination for FYUGP [B.Sc. Hons./ B.Sc. Hons. with Research] in Physical Sciences and Life Sciences'**
	The current Academic Regulations Chapter XXII 'System of Examination for Undergraduate Degree in Basic Sciences under CBCS' revised/modified and added as a new chapter i.e. Chapter XXIII 'System of Examination for FYUGP [B.Sc.Hons./ B.Sc. Hons. with Research] in Physical Sciences and Life Sciences' as per National Education Policy-2020 as per **Annexure-IV**: **Chapter-XXIII 'System of Examination for Undergraduate Degree in Basic Sciences under NEP'.**

4.	**Revision of current Academic forms for various reports for implementation of FYUGP [B.Sc. Hons./ B.Sc. Hons. with Research] in Physical Sciences and Life Sciences**
	The following Academic forms modified as per Annexure V for implementation of FYUGP [B.Sc.Hons./ B.Sc. Hons. with Research] in Physical Sciences and Life Sciences as per National Education Policy-2020 and its latest UGC guidelines: **Annexure-V :** **Academic Forms for various reports viz.** a. Acad.Form.9(b) : Appointment of Advisory Committee-Annexure-V(a) b. Acad.Form.25(b) : Panel of External Examiner-Annexure-V(b) c. Acad.Form.26(c) : Report of Internal Evaluation of Academic Project / Pre-Research-Annexure-V(c) d. Acad.Form.26(d) : Report of External Evaluation of Theory / Academic Project / Research Dissertation-Annexure-V(d) e. Acad.Form.27(c) : Instructors Report-Annexure-V(e) f. Acad.Form.28(c) : Students' Semester Report-Annexure-V(f) g. Acad.Form.29(d) : Application for Scrutiny of Answer Books-Annexure-V(g) h. Acad.Form.29(e) : Application for Re-evaluation/Re-examination-Annexure-V(h) i. Acad.Form.37(a) : Academic Project/Research Proposal-Annexure-V(i) j. Acad.Form.32(d) : Provisional Degree Certificate-Annexure-V(j) k. Acad.Form.33(e) : Transcript of Academic Record-Annexure-V(k)
5.	**With the introduction of Four Year Undergraduate Programme in the College of Basic Sciences, the name of the degrees modified/changed and amended the Academic Regulation 2.1 as under:**

Existing Provision	Amended Provision
The University shall award the degrees in the following programmes : i) Bachelor of Science (Hons.) Agriculture ii) Bachelor of Science (Hons.) Community Science iii) Bachelor of Technology (Food Technology) iv) Bachelor of Veterinary Science and Animal Husbandry **v) Bachelor of Science(Physical Sciences/Life Sciences)** vi) Bachelor of Science (Hospitality and Hotel Administration)	The University shall award the degrees in the following programmes : i) Bachelor of Science (Hons.) Agriculture ii) Bachelor of Science (Hons.) Community Science iii) Bachelor of Technology (Food Technology) iv) Bachelor of Veterinary Science and Animal Husbandry ***v)*** **Bachelor of Science (Hons.)/ Bachelor of Science (Hons. with Research) Physical Sciences(Discipline/Subject)** *(under National Education Policy)* vi) **Bachelor of Science (Hons.)/ Bachelor of**

	vii) Master of Science in Agriculture (Discipline/Subject) viii) Master of Business Administration (Agribusiness) ix) Master of Science (Discipline/Subject) x) Master of Science in Home Science (Discipline/Subject) xi) Master of Veterinary Science (Discipline/Subject) xii) Doctor of Philosophy in (-----faculty------) (Discipline/Subject)	**Science (Hons. with Research) Life Sciences(Discipline/ Subject)** *(under National Education Policy)* vii) Bachelor of Science (Hospitality and Hotel Administration) viii) Master of Science in Agriculture (Discipline/Subject) ix) Master of Business Administration (Agribusiness) x) Master of Science (Discipline/Subject) xi) Master of Science in Home Science (Discipline/Subject) xii) Master of Veterinary Science (Discipline/Subject) xiii) Doctor of Philosophy in (-----faculty------)(Discipline/Subject) Note: Under National Education Policy, the student may opt to exit the Four Year Degree Programme before the completion of the requisite degree programme with a Certificate/Diploma/Bachelors' Degree after successful completion of first/second/third year respectively, as per the provisions in the Academic Regulation

6. **In the light of National Education Policy and Four Year undergraduate programme, the Minimum Eligibility Qualifications for Admission modified under Academic Regulation 2.2.1 (4) as under:**

Existing Provision		Amended Provision	
B.Sc. Physical Sciences (Physics, Chemistry & Mathematics) / B.Sc. Life Sciences (Botany, Zoology & Chemistry)	Qualification: 10+2/ Intermediate/ Higher Secondary or equivalent examination conducted by an Education Board/ University/ Council (duly recognized by the H.P. Board of School Education, Dharamshala / MHRD, New Delhi). Subjects: PCB for B.Sc. Life Sciences (Botany, Zoology & Chemistry) and PCM for B.Sc. Physical Sciences (Physics, Chemistry & Mathematics). Minimum Percentage: 50% marks for General/ OBC category (40% for SC/ST/DA category) in aggregate of English, Physics, Chemistry,	**i) Bachelor of Science (Hons.)/ Bachelor of Science (Hons. with Research) Physical Sciences (Discipline/ Subject)**	Qualification: 10+2/ Intermediate/ Higher Secondary/equivalent stage of education corresponding to Level-4 or equivalent examination conducted by an Education Board/ University/ Council (duly recognized by the H.P. Board of School Education, Dharamshala / MHRD, New Delhi). Subjects: PCM for B.Sc. Physical Sciences (Physics, Chemistry & Mathematics). Minimum Percentage: 50% marks for General/ OBC category (40% for SC/ST/DA category) in aggregate of English, Physics, Chemistry, Mathematics with not less than pass marks in each

	Biology/Mathematics with not less than pass marks in each subject. **OR** Any examination of a University/ Education Board/ College/ School in a foreign country recognized by the University as equivalent for the purpose with good knowledge of English.		subject. **OR** Any examination of a University/ Education Board/ College/ School in a foreign country recognized by the University as equivalent for the purpose with good knowledge of English.
		ii) Bachelor of Science (Hons.)/ Bachelor of Science (Hons. with Research) Life Sciences(Discipline/ Subject)	Qualification: 10+2/ Intermediate/ Higher Secondary/ equivalent stage of education corresponding to Level-4 or equivalent examination conducted by an Education Board/ University/ Council (duly recognized by the H.P. Board of School Education, Dharamshala / MHRD, New Delhi). Subjects: PCB for B.Sc. Life Sciences (Botany, Zoology & Chemistry). Minimum Percentage: 50% marks for General/ OBC category (40% for SC/ST/DA category) in aggregate of English, Physics, Chemistry, Biology with not less than pass marks in each subject. **OR** Any examination of a University/ Education Board/ College/ School in a foreign country recognized by the University as equivalent for the purpose with good knowledge of English.
		Note:	The student shall be admitted to Fourth year (VII Semester) either for B.Sc.(Hons.) Life Sciences/Physical Sciences or for B.Sc.(Hons. with Research) Life Sciences/Physical Sciences and the admission shall be

			based on: • availability of seats, which shall be notified by the Dean of the college before the start of the End-term examination of VI semester • preference/choice of the student (for degree as well as for discipline) to be exercised during the End-term examination of VI semester • the performance of the student (CGPA) till the V semester

7.	**With the introduction of Four Year Undergraduate Programme in the College of Basic Sciences, the minimum credit hours modified for Bachelors' Degree and added under Acad.Reg.13.5.1 in the chapter XIII**

Existing Provision	**Amended Provision**
The minimum credit hours required for the following Bachelor's degree programmes shall be as per the approved course curriculum by the Academic Council from time to time including compulsory non-credit courses: i) Bachelor of Science (Hons) Agriculture : 180 ii) Bachelor of Science (Hons) Home Science : 175 iii) Bachelor of Technology (Food Science &Technology) : 180 iv) Bachelor of Veterinary Science and Animal Husbandry ***81 credits (equivalent to 179 credit hours)*** v) B.Sc. Physical Sciences under CBCS (Also see notification dated 3/2017 :125	The minimum credit hours required for the following Bachelor's degree programmes shall be as per the approved course curriculum by the Academic Council from time to time including compulsory non-credit courses: i) Bachelor of Science (Hons) Agriculture : 180 ii) Bachelor of Science (Hons) Home Science : 175 iii) Bachelor of Technology (Food Science &Technology) : 180 iv) Bachelor of Veterinary Science and Animal Husbandry *81 credits (equivalent to 179 credit hours)* v) B.Sc. Physical Sciences under CBCS (Also see notification dated 3/2017 :125 B.Sc. Physical Sciences under

B.Sc. Physical Sciences under CBCS excluding compulsory non-credit courses: 125 minimum credit hours vi) B.Sc. Life Sciences under CBCS(Also see notification dated 3/2017 B.Sc. Life Sciences under CBCS excluding compulsory non-credit courses: 125 minimum credit hours :125 vii) B.Sc. (Hospitality & Hotel Management) : 151	CBCS excluding compulsory non-credit courses: 125 minimum credit hours vi) B.Sc. Life Sciences under CBCS(Also see notification dated 3/2017 B.Sc. Life Sciences under CBCS excluding compulsory non-credit courses: 125 minimum credit hours :125 vii) B.Sc. (Hospitality & Hotel Management) : 151 **viii) B.Sc. (Hons.) Life Sciences(Discipline/ Subject)* : 168** **ix) B.Sc. (Hons.) Physical Sciences(Discipline/ Subject)* : 168** **x) B.Sc. (Hons. with Research) Life Sciences(Discipline/ Subject)* : 168** **xi) B.Sc. (Hons. with Research)Physical Sciences(Discipline/ Subject)* : 168**	*The student may opt to exit the Four Year Degree Programme before the completion of the requisite degree programme with a Certificate/Diploma/Bachelors' Degree as per the Academic Regulations 23.19.1

8. **With the introduction of Four Year Undergraduate Programme in the College of Basic Sciences, the minimum requirement for obtaining Bachelors' Degree amended/modified to 5.0/10.0 in the Acad.Reg.13.5.4**

Existing Provision	Amended Provision
A candidate shall not be declared successful in Bachelor's degree programme unless:	A candidate shall not be declared successful in Bachelor's degree programme unless:

	Existing Provision	Amended Provision
	i) he/she obtains at least 5.0/10.0 grade point in all the prescribed courses, ii) he/she obtains 'S' grade in non-credit courses and other prescribed requirements and iii) he/she achieves a minimum OGPA in the programme as given below : a) Bachelor of Veterinary Science and Animal Husbandry : 5.00/10.00 b) Other undergraduate programmes : 5.50/10.00	i) he/she obtains at least 5.0/10.0 grade point in all the prescribed courses except in case of undergraduate programmes of Basic Sciences where minimum requirement for a course shall be 4.0/10.0, ii) he/she obtains 'S' grade in non-credit courses and other prescribed requirements and iii) he/she achieves a minimum OGPA in the programme as given below : a) Bachelor of Veterinary Science and Animal Husbandry : 5.00/10.00 **b) Certificate/Diploma/B.Sc./ B.Sc.(Hons.)/B.Sc.(Hons. with Research) in Basic Science programmes: 5.0/10.0** c) Other undergraduate programmes : 5.50/10.00
9.	**The Academic Regulation 13.7.1 modified/amended in the light of Four Year Degree Programme**	

Existing Provision	Amended Provision
The Vice-Chancellor shall approve the final results of the students and the Registrar shall issue Provisional Degree Certificates **{Academic Forms No. 32 (a), 32 (b) and 32(c)}** and Transcript of Academic Records **{Academic Forms No. 33 (a), 33 (b), 33(c), 33(d) and 33(e)}**. It shall be open to Vice-Chancellor to withhold the result of a student on any ground that may appear valid.	The Vice-Chancellor shall approve the final results of the students and the Registrar shall issue Provisional Degree Certificates **{Academic Forms No. 32 (a), 32 (b),32(c) and 32(d)}** and Transcript of Academic Records **{Academic Forms No. 33 (a), 33 (b), 33(c), 33(d), 33(e) and 33(f)}**. It shall be open to Vice-Chancellor to withhold the result of a student on any ground that may appear valid.

Annexure I

Course Structure for Multidisciplinary Four Year Under Graduate Programme [FYUGP]

Sem.	Discipline Specific Course (DSC)/ Higher Level Discipline Specific Course (HLDSC)/ Higher & Applied Area Minor (HAAMinor)	Ability Enhancement Course (AEC) Discipline Specific Elective (DSE)	Skill Enhancement Course (SEC) Minor	IAPC (Internship/Apprenticeship/Projects/ Community Engagement/Vocational Courses)	Value Added Courses (VAC)	Other Activities (NC)	Total Credit Hours
I	DSC I – A (4) DSC I – B (4) DSC I – C (4)	AEC I (3)	SEC I (3)	IAPC I (2) (from Pool of Courses)	VAC I (2) (from Pool of Courses)	NCC/NSS (2 NC)	22 +2 NC
II	DSC II –A (4) DSC II– B (4) DSC II– C (4)	AEC II (3)	SEC II (3) (from Pool of Courses)	IAPC II (2) (from Pool of Courses)	VAC II (2) (from Pool of Courses)	NCC/NSS (2 NC)	22 + 2 NC
	Students exiting the programme after securing 44 credits + 4 NC will be awarded UG Certificate after 1st Year						**44 + 4 NC**
III	DSC III – A (4) DSC III – B (4) DSC III – C (4)	DSE I A/B/C (4)		IAPC III (2) (from Pool of Courses)	VAC III (2) (from Pool of Courses) VAC IV (2) (from Pool of Courses)	NCC/NSS (2 NC)	22 +2 NC
IV	DSC IV – A (4) DSC IV – B (4) DSC IV – C (4)	AEC III (3) DSE II A/B/C (4)	SEC III (3) (from Pool of Courses)			NCC/NSS (2 NC)	22 +2 NC
	Students exiting the programme after securing 88 credits + 8 NC will be awarded UG Diploma after 2nd Year.						***88 + 8 NC***
V	DSC V – A (4) DSC V – B (4) DSC V – C (4)	-	Minor I [RM] (3) Minor II (3)	AW I (2)		NCC/NSS (2 NC)	20 +2 NC
VI	DSC VI – A (4) DSC VI – B (4) DSC VI – C (4)	DSE III A/B/C (4)	Minor III (3) (from Pool of Courses)	Seminar I A/B/C (1)	-	NCC/NSS (2 NC)	20 +2 NC
	Students exiting the programme after securing 128 credits + 12 NC will be awarded UG Degree in Physical Sciences/Life Sciences.						**128 + 12 NC**
	Students will opt any one Major discipline out of A/B/C for HLDSCs and HAA Minor from Subjects Closely related to chosen Major discipline						
VII	HLDSC- I (4) HLDSC- II (4) HLDSC -III (4) HAAMinor- I (4) HAA Minor- II (4)	-	-	R- I (4)	-	-	20
VIII	HLDSC- IV (4) HLDSC- V (4) HLDSC -VI (4) HAAMinor- III (4)	-	-	R- II (8) or Academic Project (4)	-	-	20
	Students will be awarded UG Degree (Honors) or (Honors with Research) in the relevant Discipline/Subject upon securing 168 credits + 12 NC.						**168 + 12 NC**

Annexure II

COLLEGE OF BASIC SCIENCES

CSKHPKV, Palampur (H.P.)

Four Years Undergraduate Programme

(Under National Education Policy 2020)

Course Catalogue

2024-25 onwards

B.Sc.(Hons.) Life Sciences /

B.Sc.(Hons. with Research) Life Sciences

Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya
COLLEGE OF BASIC SCIENCES
Palampur Distt Kangra Himachal Pradesh 176 062 India

Contents

FOUR YEARS UNDER GRADUATE PROGRAMME (FYUGP)

The Undergraduate Curriculum Framework- 2022 (UGCF) is meant to bring about systemic change in the higher education system in the University and align itself with the National Education Policy 2020. In accordance with the NEP 2020, the UGC has formulated a new student-centric "Curriculum and Credit Framework for Undergraduate Programmes (CCFUP)" incorporating a flexible choice-based credit system, multidisciplinary approach, and multiple entry and exit options. This will facilitate students to pursue their career path by choosing the subject/field of their interest. This new curriculum framework will have the features such as:

Flexibility to move from one discipline of study to another;
Opportunity for learners to choose the courses of their interest in all disciplines;
Facilitating multiple entry and exit options with UG certificate/ UG diploma/ or degree depending upon the number of credits secured;
Flexibility for learners to move from one institution to another to enable them to have multi and/or interdisciplinary learning;
Flexibility to switch to alternative modes of learning (offline, ODL, and Online learning, and hybrid modes of learning).

The Regulations for Academic Bank of Credit (ABC) and guidelines for Multiple Entry and Exit are already framed by UGC for adoption by Higher Education Institutes (HEIs) to facilitate the implementation of the proposed CCFUP.

Academic Credit: An academic credit is a unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.

Types of Courses:

Courses in a programme will be of the following types:

i) **Core Course:** Compulsory course to be studied by the student as a core requirement. These courses will consist of major and minor stream cores.

a) **Discipline Specific Course (DSC):** DSCs shall be the major course of that particular discipline which are to be compulsory studied and will be appropriately graded and arranged across the semesters of study. The DSCs specified in the framework would be identified by the concerned department as major courses to be taught in a programme.

b) **Discipline Specific Elective Course (DSE):** A pool of courses of a particular discipline which are offered as specific/ specialized/ advanced/ supportive to the discipline/ subject of study. Student is required to choose one course from available pool.

c) **Minor:** A group of interdisciplinary courses which are offered in addition to DSC and DSE courses, related to the applied area of the discipline/ subject of the study.

d) **Higher Level Discipline Specific Courses (HLDSC):** The courses, which should compulsorily be studied by a candidate as a core requirement for Hons. / Hons. with research in one of the main discipline/ subject of study.

e) **Higher Level and Applied AreaMinor (HAA Minor):** The courses broader and applied understanding of the one of the main discipline / main field of study.

ii) Ability Enhancement course (AEC), Skill Enhancement Course (SEC) & Value Addition Course (VAC): The supplementary courses offered as follows:

a) **AEC:** Language and communication development courses mandatory for all disciplines.
b) **SEC:** Skill-based courses in different disciplines aimed at providing hands-on training and skills to the students.
c) **VAC:** Courses aimed towards personality building; embedding ethical, cultural, and constitutional values to the students.

iii) **Internship/Apprenticeship/ Project/Community engagement (IAPC):** Job-orientedcourses aimed at the Vocational training and community exposure to the students.

iv) **Academic Project/Research:** Students undergoing 4-Year Bachelor's degree (Hons. / Hons. with Research) shall execute an academic project or undertake research aimed at developing thinking skills required for pursuing higher studies.

Table 1: Structure for Multidisciplinary Four Year Under Graduate Programme (FYUGP) Under Multiple Entry and Multiple Exist (ME-ME)

Sem.	Discipline Specific Course (DSC)/ Higher Level Discipline Specific Course (HLDSC)/ Higher & Applied Area Minor (HAA Minor)	Ability Enhancement Course (AEC) Discipline Specific Elective (DSE)	Skill Enhancement Course (SEC) Minor	IAPC (Internship/Apprenticeship/Projects/ Community Engagement/Vocational Courses)	Value Added Courses (VAC)	Other Activities (NC)	Total Credit Hours
I	DSC I – A (4) DSC I – B (4) DSC I – C (4)	AEC I (3)	SEC I (3)	IAPC I (2) (from Pool of Courses)	VAC I (2) (from Pool of Courses)	NCC/NSS (2 NC)	22 +2 NC
II	DSC II –A (4) DSC II– B (4) DSC II– C (4)	AEC II (3)	SEC II (3) (from Pool of Courses)	IAPC II (2) (from Pool of Courses)	VAC II (2) (from Pool of Courses)	NCC/NSS (2 NC)	22 + 2 NC
	Students exiting after securing 44 credits + 4 NC will be awarded UG Certificate after 1st Year						**44 + 4 NC**
III	DSC III – A (4) DSC III – B (4) DSC III – C (4)	DSE I A/B/C (4)		IAPC III (2) (from Pool of Courses)	VAC III (2) (from Pool of Courses) VAC IV (2) (from Pool of Courses)	NCC/NSS (2 NC)	22 +2 NC
IV	DSC IV – A (4) DSC IV – B (4) DSC IV – C (4)	AEC III (3) DSE II A/B/C (4)	SEC III (3) (from Pool of Courses)			NCC/NSS (2 NC)	22 +2 NC
	Students exiting after securing 88 credits + 8 NC will be awarded UG Diploma after 2nd Year.						***88 + 8 NC***
V	DSC V – A (4) DSC V – B (4) DSC V – C (4)	-	Minor I [RM] (3) Minor II (3)	AW I (2)		NCC/NSS (2 NC)	20 +2 NC
VI	DSC VI – A (4) DSC VI – B (4) DSC VI – C (4)	DSE III A/B/C (4)	Minor III (3) (from Pool of Courses)	Seminar I A/B/C (1)	-	NCC/NSS (2 NC)	20 +2 NC
	Students exiting after securing 128 credits + 12 NC will be awarded UG Degree in Physical Sciences/Life Sciences.						**128 + 12 NC**
	Students will opt any one Major discipline out of A/B/C for HLDSCs and HAA Minor from Subjects Closely related to chosen Major discipline						
VII	HLDSC- I (4) HLDSC- II (4) HLDSC -III (4) HAAMinor- I (4) HAA Minor- II (4)	-	-	R- I (4)	-	-	20
VIII	HLDSC- IV (4) HLDSC- V (4) HLDSC -VI (4) HAAMinor- III (4)	-	-	R- II (8) or Academic Project (4)	-	-	20
	Students will be awarded UG Degree (Honors) or (Honors with Research) in the relevant Discipline/Subject upon securing 168 credits + 12 NC.						**168 + 12 NC**

Table 2: Types of Courses for Four Year Under Graduate Programme (FYUGP)

Sr. No	Type of Courses	Credits		
		Theory (No. of Courses x Credits)	**Practical/Tutorial** (No. of Courses x Credits)	**Total**
I	**Discipline Specific Course [DSC]** (4 Credits) (18 Courses)	18 x 3 = 54	18 x 1 =18	72
II	**Discipline Specific Elective [DSE]** (4 Credits) (3 Courses)	3 x 3 = 9	3 x 1 = 3	12
III	**Minor Courses** (3 Credits) (3 Courses)	3 x 2 = 6	3 x 1 = 3	9
IV	**Higher Level Discipline Specific Course[HLDSC]** (4 Credits) (6 or 5 Courses)	6 x 3 = 18 or 5 x 3 = 15	6 x 1 = 6 or 5 x 1 = 5	24 or 20
V	**Academic Project***(4 Credits)or **Research Dissertation**$(12 Credits)	-	1 x 4= 4 or 1 x 12 = 12	4 or 12
VI	**Higher Level & Applied Area Minor [HAA Minor]** (4 Credits) (3 or 2Courses)	3 x 3 = 9 or 2 x 3 = 6	3 x 1 = 3 or 2 x 1 = 2	12 or 8
VII	**Ability Enhancement Courses [AEC]** (3 Credits) (3 Courses)	3 x 2 = 6	3 x 1 = 3	9
VIII	**Skill Enhancement Courses [SEC]** (3 Credits) (3 Courses)	3 x 2 = 6	3 x 1 = 3	9
IX	**Internship/Apprenticeship/Projects/Community Engagement [IAPC]** (2 Credit) (3 Courses)	3 x 1 = 3	3 x 1 = 3	6
X	**Academic Writing [AW]** (2 Credit) (1 paper)	2 x 1 = 2	-	2
XI	**Seminar**(1 Credit) (1 paper)		1 x 1 = 1	1
XII	**Value Added Courses [VAC]** (2 Credits) (4 Courses)	4 x 1 = 4	4 x 1= 4	8
XIII	**Other Activities [NCC/NSS]** (2 Non-Credit)	-	6 x 2 = 12(NC)	12(NC)
Total Credits		**117 or 111**	**51 or 57 + 12 (NC)**	**168 + 12(NC)**

***Student opting for UG degree (Hons.) shall passsixcourses of HLDSC, threecourses of HAA Minor and Academic Project of 4 Credits.**

$ Student opting for UG degree (Hons. with Research) shall pass five courses of HLDSC, two courses of HAA Minor and Research Dissertation of 12 Credits.

 # A maximum of 40% of the credits in each category can be earned from UGC approved online platforms (SWAYAM etc.).

Table 3: Details of Courses to be offered to Four Year Under Graduate Programme (FYUGP) Life Sciences (Semester-wise)

Year	Semester	Discipline/Subject/ Type of Course	Type of Course Code	Course No.	Course Title	Course Cr. Hrs.
First	I	Botany	DSC-I-A	Bot.111	Diversity of Algae and Mycology	3+1
		Zoology	DSC-I-B	Zoo.111	Diversity of Non-Chordates	3+1
		Chemistry	DSC-I-C	Chem.111	Atomic Structure & Chemical Bonding	3+1
		English	AEC-I	Eng.111	General English Language	2+1
		Computer	SEC- I	Comp.111	Computer Applications	2+1
		Internship/Apprenticeship/Projects/Community engagement/ Vocational Courses)	IAPC -I	*Any one of the following:*		
				IPAC111 /Bio.111	Vermi-composting	1+1
				IPAC112 /Zoo.112	Freshwater Aquaculture	1+1
		Environmental Science	VAC-I	Env.111	Introduction to Environmental Studies	2+0
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
	Total Credit Hours in Semester-I					***22+2(NC)***
	II	Botany	DSC-II-A	Bot.121	Diversity of Cryptograms	3+1
		Zoology	DSC-II-B	Zoo.121	Diversity of Chordates	3+1
		Chemistry	DSC-II-C	Chem.121	Basic concepts and Aliphatic Hydrocarbons	3+1
		English	AEC-II	Eng.121	English Communication	2+1
		Statistics/GIS/ Biochemistry	SEC- II	*Any one of the following:*		
				Stat.121	Elements of Statistics	2+1
				GIS.121	Geographic Information System	2+1
				Biochem.121	Biochemical Constituents of food grains, fruits, and Vegetables	2+1
		Internship/Apprenticeship/Projects/Community engagement/ Vocational Courses)	IAPC -II	*Any one of the following:*		
				IAPC121 /Micro.121	Biofertilizer Production	1+1
				IAPC122 /Agron.361	Organic Farming	1+1
				IAPC123 /EECM 121	Community Organization	1+1
		Sociology	VAC-II	Soc.121	Human values and Ethics	2+0
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
Total Credit Hours in Semester-II						***22 +2(NC)***
Second	I	Botany	DSC-III-A	Bot.211	Diversity of Gymnosperms and Angiosperms	3+1

		Zoology	DSC-III-B	Zoo.211	Animal Physiology	3+1
		Chemistry	DSC-III-C	Chem.211	States of Matter and Chemical Kinetics	3+1
		Botany/Zoology/ Chemistry	DSE-I- A/B/C	*Any one of the following:*		
				Bot.212/ Zoo. 212	Ecology	3+1
				Bot.213	Genetics	3+1
				Zoo.213	Basic Cell Biology	3+1
				Chem.212	Basic Concepts and Photochemistry	3+1
				Chem.213	Spectroscopy	3+1
		Internship/Apprenticeship/Projects/Community Engagement/ Vocational Courses	IAPC -III	*Any one of the following:*		
				IAPC211 /Zoo.214	Finfish Breeding and Hatchery Management	1+1
				IAPC212/ HHA 117	Personality Development and Communication Skills	1+1
				IAPC213/ HHA 237	Event Management	2+0
				IAPC214/ Hort.111	Fundamentals of Horticulture	1+1
		Zoology/Value Added course	VAC-III	*Any one of the following:*		
				VAC211/ Zoo.215	Ornamental Fish Production and Management	1+1
				VAC212/ HHA 355	Food Safety and Quality	2+0
		Zoology/Value Added course	VAC-IV	*Any one of the following:*		
				VAC213/ Zoo.216	Fish Products and By-Products Technology	1+1
				VAC214/	Drone Technology	1+1
				VAC215/	Digital Empowerment	0+2
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
	Total Credit Hours in Semester-III					***22+2(NC)***
	II	Botany	DSC-IV-A	Bot.221	Plant Systematics	3+1
		Zoology	DSC-IV-B	Zoo.221	Animal Genetics	3+1
		Chemistry	DSC-IV-C	Chem.221	Chemistry of s- and p-Block Elements	3+1
		Botany/Zoology/ Chemistry	DSE-II- A/B/C	*Any one of the following:*		
				Bot.222/ Zoo. 222	Biochemistry	3+1
				Bot.223	Introduction to Plant Physiology	3+1
				Zoo.223	Evolutionary Biology	3+1
				Chem.222	Analytical Chemistry	
				Chem.223	Organometallics, Heterocylic and Polynuclear Hydrocarbons	3+1

		Ability Enhancement Course	AEC-III	AEC221/	Any Language Course available from the UGC approved platform (Swayam, etc.).	2+1/3+0
		Chemistry/Computer/ Microbiology	SEC- III	*Any one of the following:*		
				Chem.224	Chemistry of Cosmetics and Perfumes	2+1
				Comp.221	Computer Programming	2+1
				Comp.222	Databases and SQL	2+1
				Micro.221	Techniques in Microbiology	2+1
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
Total Credit Hours in Semester-IV						***22 +2(NC)***
Third	I	Botany	DSC-V-A	Bot.311	Cell Biology	3+1
		Zoology	DSC-V-B	Zoo.311	Comparative Anatomy of Vertebrates	3+1
		Chemistry	DSC-V-C	Chem.311	Chemistry of Functional Groups	3+1
		Research Methodology	Minor I	RM 311	Research Methodology	3+0
		Computer	Minor II	Comp.311	Programming using Python	2+1
		Academic Writing	AW	AW 311	Academic Writing	2+0
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
	Total Credit Hours in Semester-V					***20 + 2 (NC)***
	II	Botany	DSC-VI-A	Bot.321	Economic Botany	3+1
		Zoology	DSC-VI-B	Zoo.321	Applied Zoology	3+1
		Chemistry	DSC-VI-C	Chem.321	Chemical Thermodynamics and Electrochemistry	3+1
		Botany/ Zoology/ Chemistry	DSE-III-A/B/C	*Any one of the following:*		
				Bot.322	Medicinal Botany and Ethnobotany	3+1
				Bot.323	Reproductive Biology	3+1
				Zoo.322	Developmental Biology	3+1
				Zoo.323	Aquatic Biology	3+1
				Chem.322	Chemistry of Polymers	3+1
				Chem.323	Molecules of Life	3+1
		Microbiology/ Biochemistry/ Biotechnology/ Bioinformatics	Minor III	*Any one of the following:*		
				Microt.321	Microbial Genetics	2+1
				Biochem.321	General Biochemistry	2+1
				Bot.324/ Zoo.324	Introduction to Biotechnology	2+1
				Bot.325/ Zoo.325	Introduction to Bioinformatics	2+1
		Botany/Zoology/ Chemistry	Seminar I – A/B/C	Bot.391/ Zoo.391/ Chem.391	Seminar	1+0
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
Total Credit Hours in Semester-VI						***20 + 2 (NC)***
Fourth	I	Botany/Zoology/	HLDSE-I	*Any one from the discipline of choice, of the following:*		

		Chemistry		Bot.411	Phycology	3+1
				Zoo.411	Immunology	3+1
				Chem.411	Group Theory and X-ray Crystallography	3+1
			HLDSE-II	*Any one from the discipline of choice, of the following:*		
				Bot.412	Bryology	3+1
				Zoo.412	Entomology	3+1
				Chem.412	Chemistry of Natural Products	3+1
			HLDSE-III	*Any one from the discipline of choice, of the following:*		
				Bot.413	Mycology and Microbiology	3+1
				Zoo.413	Aquaculture and Fisheries	3+1
				Chem.413	Statistical Thermodynamics and Quantum Chemistry	
		Botany/Zoology/ Chemistry	HAAMinor-I and HAAMinor-II	*Any two from the discipline of choice [for Honors only], of the following:* *or* *Any one from the discipline of choice [for Honors with Research], of the following:*		
				Bot.414/ Zoo. 414	Cytogenetics	3+1
				Bot.415	Advances in Plant Physiology	3+1
				Zoo.415	Wildlife and its Conservation	3+1
				Chem.414	Advanced Organometallics	3+1
				Chem.415	Solutions, Colligative Properties, and Chemistry of Nano-materials	3+1
		Botany/Zoology/ Chemistry	R-I	Bot.491/ Zoo.491/ Chem.491	Pre-Research	0+4
	Total Credit Hours in Semester-VII = 20					
	II	Botany/ Zoology/ Chemistry	HLDSE-IV	*Any one from the discipline of choice, of the following:*		
				Bot.421	Pteridophytes	3+1
				Zoo.421	Parasitology	3+1
				Chem.421	Bioinorganic Chemistry	3+1
			HLDSE-V	*Any one from the discipline of choice, of the following:*		
				Bot.422	Gymnosperm	3+1
				Zoo.422	Human Physiology	3+1
				Chem.422	Pericyclic and Asymmetric Synthesis	3+1
			HLDSE-VI	*Any one from the discipline of choice, of the following:*		
				Bot.423	Reproductive Biology	3+1
				Zoo.423	Principle of Ecology	3+1
				Chem.423	Surfaces and Macromolecules	3+1

		Botany/ Zoology/ Chemistry	HAAMinor-III	*Any one from the discipline of choice, of the following:*		
				Bot.424/ Zoo.424	Biotechnology and Bioinformatics	3+1
				Chem.424	Advanced Spectroscopy	3+1*
		Botany/Zoology/ Chemistry	R-II	Bot.492/ Zoo.492/ Chem.492	Research	0+8
		Botany/Zoology/ Chemistry	Project	Bot.493/ Zoo.493/ Chem.493	Academic project	0+4
Total Credit Hours in Semester-VIII= 20						
TOTAL CREDIT HOURS TO BE STUDIED						***168+12(NC)***

BOTANY
(DISCIPLINE – A)

DISCIPLINE SPECIFIC COURSES:

Bot.111 **Diversity of Algae and Mycology** **3+1**

LEARNING OBJECTIVES:

The primary objective of this course is:
- To know general account of thallus organization, classification, economic importance, reproduction, and life history of Algae
- To introduce general characteristics, classification, and economic importance of fungi

LEARNING OUTCOMES:

This course will enable the students to understand:
- The morphology, anatomy, physiology, reproduction, and life cycle pattern.
- Gain knowledge about uses of microbes in various fields.
- Develop conceptual skills about identifying microbes, pathogens, biofertilizers, and lichens.

THEORY (45 Hours)

UNIT – I: Microbes **(12Hours)**

Discovery, general structure, replication (general account), DNAvirus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Citrus canker and, AIDS. Economic importance; Structure, nutrition, reproduction and economic importance and general account of cyanobacteria

UNIT – II: Algae **(16Hours)**

General characters, classification and economic importance, important features and life history of Chlorophyceae-*Volvox, Oedogonium*, Bacillariophyceae- diatoms, general account, Xanthophyceae-*Vaucheria*, Phaeophyceae-*Ectocarpus*, Rhodophyceae-*Polysiphonia.*

UNIT – III: Fungi **(17Hours)**

General Characters, range of thallus organization, cell wall composition, nutrition, classification and economic importance, important feature and life history of mastigomycotina – *Albugo,Phytophthora, Zygomycotina-Rhizopus*, Ascomycotina-*saccharomyctes, Eurotium, Peziza*; Basidimycotine-*Puccina,Agaricus, deuteromycotina Cercospora; Colletortichum.*
Definition, symptom, classification, and etiology of following diseases: White rust, late blight of potato, early blight of potato, apple scab, loose smut of wheat, rust of wheat, red rot of sugarcane. General account of lichens. Mycorrhizae: classification & significance.

PRACTICAL (30 Hours)

1. Study of representative member of Algae, Bacteria and Viruses;

2. Symptomology of some diseases: citrus canker, bacterial blight of paddy, TMV, little leaf of brinjal etc.
3. Gram staining of bacteria: Sterilization method.
4. Morphological study of representative members of Fungi-Peronospora, Albugo, Mucor, Pilobolus, Yeast, Emericella, Chaetomium. Pleospora, Morchella, Melanspora, Phallus, Polyporus, Drechslera, Phoma, Penicillium, Aspergillus, Collectotrichum;
5. Symptomology of disease specimens-White rust, downy mildew, powdery mildew, rusts smuts, ergot, groundnut leaf spot and citrus canker;
6. Sterilization method, preparation of media and stains.

SUGGESTED READINGS:

1. Alexopoulous, C.J., Mims, C.W. and Blackwell, M. Introductory Mycology (4th Edition),
2. Wiley - Blackwell, USA.
3. Sharma, O.P., 2004, Text Book of Thallophytes. McGraw Hill Publishing Co., India. 2ndedition.
4. Sharma, P.D., 2004, The Fungi, (2nd Edition) Rastogi Publication, India
5. Kumar,H.D.1999.IntroductoryPhycology.AffiliatedEast-West.PressPvt.Ltd.Delhi.
6. Tortora,G.J.,Funke,B.R.,Case,C.L.(2010).Microbiology:AnIntroduction,PearsonBenjamin Cummings, U.S.A. 10th edition.

Bot.121 Diversity of Cryptogams 3+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To learn about their general characters and classification.

General characteristics, classification, and economic importance of bryophytes and Pteridophytes.

LEARNING OUTCOMES:

This course will enable the students to understand:
Knowledge of morphological, anatomical, and reproductive diversity within bryophytes and Pteridophytes.
Understanding the economic importance of cryptogams.
To learn about the land adaptation of bryophytes and pteridophytes

THEORY (45 Hours)

UNIT – I: Bryophytes (20Hours)

General characteristics, adaptations to land habit, range of thallus organization, classification (upto family), Morphology, structure, reproduction and life history of *Marchantia,Anthoceros and Funaria*, economic and ecological importance with special reference to *Sphagnum.*

UNIT –I I: Pteridophytes (25 Hours)

General characteristics, classification (upto family); Morphology, anatomy and reproduction and life history of Psilotum Selaginella, Equisetum Pteris and Marsilea, evolution of stele, heterospory and origin of seed habit; general account of fossil pteriodophyta with special reference to Rhynia; Ecological importance of Pteridophytes.

PRACTICAL (30 Hours)

1. ***Marchantia***- morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemmacup,w.m.gemmae(alltemporaryslides),v.s.antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
2. ***Anthoceros***- morphology of thallus, w.m. rhizoids and scales,,v.s.antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
3. ***Funaria***- morphology, w.m. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, l.s. capsule andprotonema.
4. ***Selaginella***- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus, w.m. microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
5. ***Equisetum***-morphology,t.s.internode,l.s.strobilus,t.s.strobilus,w.m.sporangiophore, w.m. spores (wet and dry)(temporary slides); t.s rhizome (permanent slide).
6. ***Pteris***-morphology,t.s.rachis,v.s.sporophyll,w.m.sporangium,w.m.spores (temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).

SUGGESTED READINGS:

1. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
2. Parihar,N.S.(1991). An introduction to Embryophyta. Vol.I. Bryophyta. Central Book Depot, Allahabad.
3. Bierhorst D.W. (1971). Morphology of vascular plants. Mac Millan Publishers. New York.
4. Cavers, F. (1911). The interrelationship of Bryophytes. New Phytology. Reprint No. 4: 1-203.

Bot.211 Diversity of Gymnosperms and Angiosperms 3+1

LEARNING OBJECTIVES:

The primary objective of this course is:
- To learn about their general characters, diversity, and classification.
- Emphasis will be given at their morphology and anatomy.

LEARNING OUTCOMES:

This course will enable the students to understand:
- About the morphological and anatomical feature of gymnosperm and Angiosperm.
- Learn about the plant tissues of Angiosperms

Understanding the economic importance of Phanerogams.

THEORY (45 Hours)

UNIT –I: Gymnosperms (20 Hours)

General characteristics, and classification. Classification (upto family), morphology, anatomy, and reproduction of *Cycas Pinus* and *Gnetum* and their comparative study of morphology, anatomy, gametogenesis and embryology. Ecological and economical importance.

UNIT II: Meristematic and Permanent Tissues (5 Hours)

The shoot apex and its histological organization, the root apical meristem, simple and complex tissues.

UNIT III: Organs **(6 Hours)**

Structure of dicot and monocot stem, root and leaves, vascularisation of primary shoot in monocotyledons and dicotyledons, formation of internodes,

UNIT IV: Secondary Growth **(8 Hours)**

Vascular cambium-structure and function, formation of secondary xylem, a general account to wood structurein relation to conduction of water and minerals, characteristics of growth rings, sapwood and heartwood, role of woody skeleton, secondary phloem structure- function relationship, periderm. Secondary growth in root

UNIT V: Adaptive and Protective Systems **(6 Hours)**

Epidermis,cuticle and stomata, general account of adaptations in xerophytes and hydrophytes.

PRACTICAL (30 Hours)

1. ***Cycas***- complete morphological features (coralloid roots, bulbil, leaf),
2. ***Cycas***- anatomy t.s. coralloid root, t.s. rachis, v.s. leaflet, v.s. microsporophyll,w.m.spores(temporaryslides),l.s.ovule,t.s.root(permanent slide).
3. ***Pinus***-morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m. dwarf shoot,
4. ***Pinus***- Anatomy t.s. needle, t.s. stem,, l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), l.s. female cone, t.l.s. & r.l.s. stem(permanent slide).
5. Anatomy of primary and secondary growth in monocots and dicots using hand sections (or prepared slides).

SUGGESTED READINGS:

1. Bhatnagar, S.P. and Moitra, A.(1996). Gymnosperms. New Age International (P) Ltd
2. Publishers, NewDelhi, India.
3. Dublish, P.K. & Agarwal, D.K.: An Introduction to Gymnosperms, Kedarnath Ramnath,Meerut.
4. Esau, K. Anatomy of Seed Plants. John Wiley, New York. 550 pp. 1977.
5. Ray, F.E. and S.E.Eichhorn. Esau’s Plant Anatomy: Meristems, Cells and Tissues of the Plant Body: their Structure, Function and Development. 3 rd Ed. Wiley-Lis. 624 pp. 2006.
6. Steeves, T.A. and I. M. Sussex. Patterns in Plant Development. 2 nd Ed. Cambridge Univ. Press, Cambridge. 408 pp. 1989.

Bot.221 **Plant Systematics** **3+1**

LEARNING OBJECTIVES:

The primary objective of this course is:

- To provide the convenient method of identification of plants.
- To describe all the characteristics of the identified species.

LEARNING OUTCOMES:

This course will enable the students to understand:

- The principle of general taxonomy and they can use nomenclature rules of plants.
- Historical development of taxonomy.
- The importance of nomenclature rules in botany.

THEORY (45 Hours)

UNIT –I: Introduction to Systematics (16Hours)

Plant identification, Classification, Nomenclature. Evidences from palynology, cytology, phytochemistry and molecular data, Functions of Herbarium; Important herbaria and botanical gardens of the world and India. Angiosperm-origin and evolution some examples of primitive angiosperms; Angiosperm taxonomy, brief history, aims and functional components (taxonomy, holotaxonomy,) identification keys, taxonomic literature; botanical nomenclature, principles and rules, taxonomic ranks (Taxonomic hierarchy), type concept, principle of priority.

UNIT –I I: Classification (8Hours)

Major contributions of Theophrastus, Linnaeus, Hutchinson, Takhtajan; Classification salient feature of the systems proposed by Bentham and Hooker (upto series) and Engler and Prantl (upto series)

UNIT –III: Taxonomical Evidences (3 Hours)

Major contribution of cytology, phytochemistry and taximetrics to taxonomy;

UNIT –IV: Diversity ofFlowering Plants (18 Hours)

Study of diversity of flowering plants as illustrated by members of the families- Brassicaceae, Malvaceae, Rutacae, Fabaceae (Faboideae), Apiaceae, Apocynaceae. Asclepiadaceae, Solanaceae, Lamiaceae, Euphorbiaceae, and Poaceae.

PRACTICAL (30 Hours)

1. Morphology of leaf: Leaf attachment, Stipules, Patterns of leaf, Phyllotaxy, Shapes of leaflamina,bases, margins and tips, Venation.This list is only indicative. Teachers may select plant available in their locality.
2. Study of inflorescence, flower in the following families: **Brassicaceae**- Brassica, Alyssum, Iberis, Coromopus; **Malvaceae**- Hibiscus, Abutilon; **Rutaceae**- Murraya, Citrus; **Fabaceae**- Lathyrus, Cajanus, Melilotus, Trigonella,**Apiaceae**-Coriandrum, foeniculum, Anethum **Apocynaceae**- Vinca, Thevetia, Neruim; **Asclepiadaceae**- calotropis; **Solanaceae-**Solanum, Whithania, Datura; **Lamiaceae-**Ocimum, Salvia; **Euphorbiaceae-**Euphorbia, Phyllanmthus ;and**Poaceae-**Avena, Triticum, Hordenum, Poa Sorghum

SUGGESTED READINGS:

1. Simpson, M.G. (2006). *Plant Systematics.* Elsevier Academic Press, San Diego, CA, U.S.A.
2. Singh, G. (2012).*Plant Systematics:* theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rdedition.
3. Cronquist A (1981). An integrated system of classification of flowering plants. ColumbiaUniversity Press.

Bot.311 **Cell Biology** **3+1**

LEARNING OBJECTIVES:

- The objective of the present course content is to provide a foundation and background in cellular and acellular entities of plants
- To provide knowledge regarding cell structure in relation to functions, eukaryotic genome structure (including nuclear and organellar), and regulatory mechanisms.

LEARNING OUTCOMES:

This course will enable the students to understand:

- About the components of endo-membrane systems and mechanisms governing intracellular trafficking in plant cells
- About the role of plant cytoskeleton and accessory proteins in major cellular processes of plants
- About the various components of the eukaryotic nuclear and organellar genome, with special reference to their regulatory role

THEORY (45 Hours)

UNIT –I: Techniques in Biology (6 Hours)

Principles of microscopy; Light Microscopy; Phase contrast microscopy; Sample Preparation for light microscopy; Electron microscopy (EM)- Scanning EM and Scanning Transmission EM (STEM); Sample Preparation for electron microscopy

UNIT 2: Cell as a unit of Life (6 Hours)

The Cell theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components

UNIT 3: Cell Organelles (15 Hours)

Mitochondria: Structure and function. Chloroplast:Structure and function ER, Golgi body: Structures and roles. Peroxisomes, Glyoxisomes and vacuole: Structures, composition, functions in animals and plants Nucleus: Nuclear Envelope- structure of nuclearpore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure (brief).Chromosome organization: Morphology, centromere and telomere, chromosome alternation, deletions, duplications, translocations, inversions. variation in chromosome number, aneuploidy, polyploidy.

UNIT 4: Cell Membrane and Cell Wall (6 Hours)

The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Faces of the membranes; Selective permeability of the membranes; Cell wall.

UNIT 5: Cell Cycle (6 Hours)

Overview of Cell cycle, Mitosis and Meiosis

UNIT 6: Regulation of gene expression (6 Hours)

Prokaryotes: Lac operon and Tryptophan operon; and in Eukaryotes.

PRACTICAL(30 Hours)

1. To study prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light and electron micrographs.
2. Study of the photomicrographs of cell organelles
3. To study the structure of plant cell through temporary mounts.
4. Study of mitosis and meiosis (temporary mounts and permanent slides).
5. Study the effect of temperature, organic solvent on semi permeable membrane.
6. Study of plasmolysis and deplasmolysis on Rhoeo leaf.
7. Measure the cell size (either length or breadth/diameter) by micrometry.
8. Study the structure of nuclear pore complex by photograph (from Gerald Karp)Study of special chromosomes (polytene & lampbrush) either by slides or photographs.
9. Study DNA packaging by micrographs.
10. To study cell structure from onion leaf peels.
11. Demonstration of staining and mounting method.
12. Comparative study of cell structure in onion cells, Hydrilla and Spirogyra
13. Study of electron micrograph of viruses, bacteria, cyanobacteria and eukaryotic cells for comparative cellular organization.

SUGGESTED READINGS:

1. Karp,G.2010.CellandMolecularBiology:ConceptsandExperiments.6thEdition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis,E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Bot.321 Economic Botany 3+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To explain the importance of plants and their role in human biological development and in ecosystem conservation and sustainability.
- To give an opportunity for students to learn the impact of plants on society for their use as a major food source, as medicine, and in the industrial and recreational world.

LEARNING OUTCOMES:

This course will enable the students to understand:

- The botanical aspects and origins of important food, medicinal and economically important plants.
- Evaluate the importance of plants and their different roles.
- Analyze the plant structures and interactions with hands on field experiments.

THEORY (45 Hours)

UNIT – I: Origin of Cultivated Plants **(2Hours)**

Concept of centres of origin, their importance w.r.t. Vavilov's work.

UNIT – I1: Cereals **(5Hours)**

A brief account of the origin, botany, cultivation and uses of food crops (Rice, wheat, maize)

UNIT – II1: Legumes **(5 Hours)**

General account with special reference to Gram

UNIT – IV: Spices **(5 Hours)**

General account with special reference to Clove

UNIT – VI: Beverages **(5 Hours)**

General description with special reference to Tea (Morphology, processing and uses)

UNIT – VI1: Oils and Fats **(5 Hours)**

General description with special reference to mustard

UNIT – VII1: Fibre Yielding Plants **(5 Hours)**

General description with special reference to Cotton (Botanical name, family, part used, morphology and uses)

UNIT – IX: Plants of Utility **(13 Hours)**

General account of sources of firewood, timber, medicinal plants. Name, family, distribution and uses of important commercial timbers of India (Teak, Sal, Chir, Kail, Deodar, Sisham, Kikar). List of important fuel woods, trees for avenues, pollution control and aesthetics.
A brief account of the following: (i) Gums (ii) Resin (iii) Tannins (iv) Dyes (v) Rattans (vi) Raw materials for Paper Industry (vii) Bamboos (viii) Wild Fruits.
Name, family, plant part yielding active principle and uses of the following
(i) Aromatic Plants: Mentha, rosa, Jasminum, cymbopogon, Lavender, Hops, Camphor.
(ii) Spices and Condament: Ginger, Turmeric, Cinnamon, Cloves, Cardamom, Chillies, Pepper

PRACTICAL (30 Hours)

1. Study of the morphology, structure and simple micro chemical tests of the food storing tissues in rice, wheat, maize,
2. Microscopic examination of starch in rice, wheat, maize.
3. Study of cotton flowers, sectioning of the cotton ovules/ developing seeds to trace the origin and development of cotton fibres.
4. Microscopic study of cotton and test for cellulose.
5. Tests for lignocelluloses.
6. Study of hand sections of mustard.
7. Staining of oil drops by Sudan III and Sudan Black.
8. Field visits to study sources of firewood (10plants), timber-yielding trees (10) and preparation of their list mentioning special features.
9. Examination and brief description of hand section of clove.
10. Preparation of an illustrated inventory of 10 medicinal plants used in indigenous systems of medicine or allopathy along with their botanical and common names, part used and diseases/ disorders for which they are prescribed.

11. Study of the characteristic structural features of tea leaves.

SUGGESTED READINGS:

1. Pandey, B.P. 1978. Economic Botany. S Chand publishing.
2. Conway, G. 1999. The Doubly Green Revolution. Food for All in the 21st Century, Penguin Books.
3. Conway, G. and Barbier, E. 1990. After the Green Revolution, Earthscan Press, London.
4. Conway, G. and Barbier, E. 1994. Plant, Genes and Agriculture, Jones and Bartlett Publishers, Boston.
5. Council of Scientific and Industrial Research, (1948-76). The Wealth of India.
6. Kochhar, (201 I). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi.4th edition.

DISCIPLINE ELECTIVE COURSES:

Bot.212 **Ecology** **3+1**

LEARNING OBJECTIVES:

The primary objective of this course is:

- To enable the students to the concept of ecology and ecosystem and introduce them to various interactions among organisms and environment.
- To provide knowledge of dynamics of ecosystems in relation to human life.

LEARNING OUTCOMES:

This course will enable the students to understand:

- The process that shapes the distribution and abundance of organisms from the micro-habitat to the globe.
- Recognize that the distribution of organisms is a product of positive and negative interactions within and across the trophic levels including competition, mutualism, predation, and parasitism.
- The evolution of organism form and function influences ecological interactions and habitat tolerance

THEORY (45 Hours)

UNIT 1: Plants and environment **(7 Hours)**

Ecological factors: Atmosphere (gaseous composition). Water (properties of water and water cycle), light (global radiation, photosynthetically active radiation), temperature, soil (development, soil profiles, physico-chemical properties), and biota.

UNIT 2: Ecological adaptations **(6 Hours)**

Morphological, anatomical and physiological responses of plants to water (hydrophytes and xerophytes), temperature (thermoperiodictity and vernalization), light (photoperiodism, heliophytes and sciophytes) and salinity.

UNIT 3: Population ecology **(8 Hours)**

Definition, Population characteristics, population dynamics & regulation, ecotypes, ecads.

UNIT 4: Community ecology (8 Hours)

Definition**,** Community characteristics, Biological spectrum, Ecological succession.

UNIT 5: Ecosystems (10 Hours)

Structure (biotic and abiotic components) ecological pyramids, and function of ecosystems; food chain, food web, energy flow; biogeochemical cycles of carbon, nitrogen and phosphorus.

UNIT 6: Biogeographical regions of India (6 Hours)

General account of biogeographical regions of India, Vegetation types of India: Forests and grasslands

PRACTICAL(30 Hours)

1. Determination of minimum quadrat size for the study of herbaceous vegetation/animals through species area curve method.
2. Quantitative analysis of herbaceous vegetation for frequency and comparison with Raunkiaer's frequency distribution law.
3. Study of instruments used to measure microclimatic variables: soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
4. Determination of pH, porosity and moisture content of soil of minimum three different habitats.
5. To estimate transparency, pH and temperature of different water bodies.
6. To estimate dust holding capacity of the leaves of different plant species.

SUGGESTED READINGS:

1. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4thedition.
2. Sharma,P.D.(2010)EcologyandEnvironment.RastogiPublications,Meerut,India.8thedition.
3. Simpson, M.G. (2006). *Plant Systematics.* Elsevier Academic Press, San Diego, CA, U.S.A.
4. Singh,G.(2012).*PlantSystematics:* theory andPractice.Oxford & IBH Pvt.Ltd., New Delhi. 3rdedition.

Bot.213 Genetics 3+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To understand the concepts and details of heredity and variation at molecular and cellular levels.
- Deals with more recent development which have taken place in the field of genetics besides providing introduction to methods of plant breeding of improvement of crop plants with respect to:
- Genetics of prokaryotic and eukaryotic organelles, Chromatin organization
- Structural and Numerical alterations in chromosomes, Mutation
- DNA damage and repair mechanism. Cytogenetics of aneuploids and structural heterozygotes

LEARNING OUTCOMES:

This course will enable the students to understand:

- About inheritance of qualitative and quantitative traits, allelic and genotypic frequencies, and their partitioning between and among populations.
- Elucidate factors governing the genetic structure of populations: significance, implications, and applications.
- Will enable to learn about- mapping genes in bacteria, functional allelism, gene regulation in prokaryotes: the components and the mechanisms.
- Provide knowledge about the use of linkage and recombination frequencies to map genes, molecular markers, types, development, and applications

THEORY(45 Hours)

UNIT-I: (12 Hours)

Introduction to Genetics and Heredity: Mendel'swork on transmission of traits, Principles of inheritance, Chromosome theory of inheritance, Incomplete dominance and co-dominance,Multiplealleles,Lethalalleles,Epistasis,Pleiotropy,Molecular basis of Genetic Information.

UNIT-II: (15 Hours)

Mutations and Chromosomal Aberrations: Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy; Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations; structural and numerical alteration of chromosomes.

UNIT-III: (12 Hours)

Linkage, Crossing Over, Chromosomal Mapping and Human Genetics: Linkage, crossing over; one, two or three point crossovers, chromosomal mapping, Interference and coincidence, chromosomal and genetic disorders; genetic code and Wobble’s hypothesis.

UNIT-IV: (6 Hours)

Sex Determination: Chromosomal mechanisms, sex linkedinheritance, extra-chromosomal inheritance, dosage compensation.

PRACTICAL (30 Hours)

1. Study of Linkage, recombination, gene mapping using charts.
2. Meiosis through temporary squash preparation.
3. Mendel’s laws through seed ratios. Laboratory exercises in probability and chi-square. Chromosome mapping using point test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex-linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Blood Typing: ABO groups & Rh factor. Study of aneuploidy: Down’s, Klinefelter’s and Turner’s syndromes.
7. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.

8. Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red-green Colour blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached ear lobe.

SUGGESTED READINGS:

1. Russel P. J. (2010). Genetics- A Molecular Approach, Pearson Education Inc.
2. Gardner E. J., Simmons M. J., Snustad D. P. (1991). Principles of Genetics, John Wiley & Sons.
3. Strickberger M.W. (2008). Genetics, Pearson (Prentice Hall).
4. Acquaah G (2007). Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd. USA.
5. Allard R. W. (1999). Principles of Plant Breeding, John Wiley and Sons.
6. Singh R. J. (2002). Plant Cytogenetics, CRC Press.
7. Hartwell L. H., Hood L., Goldberg M. L., Reynolds A. E., Silver L. M., Veres R. C. (2006). Genetics-From Genes to Genomes, McGraw Hill
8. Lewin B. (2008). Genes IX, Jones and Barlett Publishers.
9. Hartl D. L. and Jones E. W. (2007). Genetics-Analysis of Genes and Genomes, Jones and Barlett publishers.

Bot.222 Biochemistry 3+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To educate student on concepts of proteins, and enzymes
- To introduce the basic knowledge of cellular metabolism in plants

LEARNING OUTCOMES:

This course will enable the students to understand:

- Students will be taught about proteins, and their biosynthesis,
- The course will also teach about catalytic mechanistic of enzymes, its inhibitors and regulation
- The course will strengthen the basic ideas about metabolism of carbohydrates, proteins, and lipids

THEORY (45 Hours)

UNIT-I: Elementary Idea of Analytical and Separation Techniques (6 Hours)

Ultracentrifugation, electrophoresis, and chromatography

UNIT-II: Chemical Nature of Protoplasm (6 Hours)

Chemistry of carbohydrates, proteins, lipids, and nucleic acids

UNIT-III: Enzymes and Co-Enzymes (15 Hours)

Definition, nature, functions; Specificity and classification of enzymes and co-enzymes, enzyme action; high energy compound: phosphagens, phosphate bonding, formation of ATP, energy release and oxidation mechanism.

UNIT-IV: Carbohydrate Metabolism **(6 Hours)**

Glycolysis, Kreb's Cycle, Pentose phosphate pathway, Gluconeogenesis,Glycogen metabolism,Review of electron transport chain

UNIT-V: Lipid Metabolism **(6 Hours)**

Oxidation of fatty acids; fate of glycerol

UNIT-VI: Protein Metabolism **(6 Hours)**

Transamination, Deamination and Ornithine Cycle.

PRACTICAL(30 Hours)

1. Qualitative and quantitative tests for carbohydrates
2. Estimation of reducing and non-reducing sugars
3. Qualitative and quantitative tests for amino acids
4. Separation of amino acids by paper chromatography
5. Qualitative and quantitative tests for lipids
6. Qualitative and quantitative tests for proteins
7. Estimation of proteins
8. Determination of pH and use of pH meter.
9. Study of metabolism through charts.

SUGGESTED READINGS:

1. Tortora, G.J. and Derrickson, B.H. (2009). Principles of Anatomy and Physiology, XII Edition, John Wiley & Sons, Inc.
2. Guyton, A.C. and Hall, J.E.(2011). Textbook of Medical Physiology, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
3. Modern's Zoology. Biochemistry and Mammalian physiology by – Sabharwal and Sabharwal.
4. Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
5. Talwar, G.P. & Srivastava, M. Textbook oj Biochemistry and Human Biology, 3rd Ed. PHI Learning.

Bot.223 **Introduction toPlant Physiology** **3+1**

LEARNING OBJECTIVES:

This course aims:

- to educate student on concepts of plant physiology including water and nutrient uptake, photosynthesis, photorespiration, translocation, nitrogen metabolism, phytohormones and their role. The course further deals with proteins, enzymatic system, aerobic and anaerobic respiration.

LEARNING OUTCOMES:

- Students will be taught about catalytic mechanism of enzymes, its inhibitors and regulation mechanisms.

- The students will be learning about the various mechanisms such as channel or transport proteins involved in nutrient uptake in plants.
- During the course students will gain knowledge about various components of photosynthesis such as pigments, carotenoids, photosystems, oxygen evolving complex, and electron carriers. Additionally, the fixation of photo-assimilatory products in the dark phase of photosynthesis.

.

THEORY (45 Hours)

UNIT I: Plant-water relation **(8 Hours)**

Importance of water to plant life, physical properties of water, diffusion and osmosis, absorption, transportation of water and transpiration, physiology of stomata.

UNIT II: Mineral nutrition **(6 Hours)**

Essential macro and micro-elements and their role, mineral uptake, deficiency and toxicity symptoms.

UNIT III: Transports of organic substances **(4 Hours)**

Mechanism of phloem transport, source-sink relationship, factors affecting translocations.

UNIT IV: Photosynthesis **(8 Hours)**

Significance, historical aspects, photosynthetic pigments, action spectra and enhancement effect, concept of two photo systems, z-scheme, photophosphorylation, Calvin cycle, C-4 pathway, CAM plants, photorespiration.

UNIT V: Respiration **(6 Hours)**

ATP-The biological energy currency, aerobic and anaerobic respiration, Krebs cycle, electron transport mechanism (chemiosmotic theory), redox-potential, oxidative phosphorylation,

UNIT VI:Nitrogen metabolism **(4 Hours)**

Nitrogen metabolism: Biology of nitrogen fixation, importance of nitrate reductase and its regulation, ammonium assimilation

UNIT VI: Growth and development **(9 Hours)**

Definitions; phases of growth and development, kinetics of growth; seed dormancy, seed germination and factor of their regulation; concept of photoperiodism; physiologyof flowering; florigen concept; physiology of senescence, fruit ripening, plant hormones-auxins, gibberellins, cytoknins, abscisic acid and ethylene history of their discovery, bio-synthesis, and mechanism of action; photo morphogenesis; phytochromes,discovery physiological role and mechanism of action.

PRACTICAL (30 Hours)

1. To study the permeability of plasma membrane using different concentrations of organic solvents;
2. To study the effect of temperature on permeability of plasma membrane;
3. To study preparation of standard curve of protein and determine the protein content in unknown samples.
4. To study the enzyme activity of catalase and peroxidase as influenced by pH and temperature;

5. Comparison of the rate of respiration of various plant parts.
6. Separation of chloroplast pigments by solvent method;
7. Determination of osmotic potential of vacuolar sap by plasmolytic method.
8. Determining of water potential of any tuber.
9. Separation of amino-acids in the mixture of paper chromatography and their identification by comparison with standards.
10. Bioassay of auxin, cytokinin, GA, ABA and ethylene using appropriate plant material.

SUGGESTED READINGS:

1. Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.

Bot.322 Medicinal Botany and Ethnobotany 3+1

LEARNING OBJECTIVES:

- To focus on the conservation, cultivation, research, and educational activities related to plant species known for medicinal purpose.
- Proper documentation of indigenous knowledge about medicinal plants and to train people and students for utilization and conservation of plants.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Recognize and describe plant characteristics (plant composition, function, and diversity) and the use of plants by humans.
- Study the origins of human-plant relationships to understand the use of plants through history to current day.
- Describe how the use of plants as medicines contribute to human well-being and survival
- Analyze global issues and potential solutions from a multidisciplinary perspective using plants, and describe how different societies respond to such issues

THEORY (45 Hours)

UNITI: History, Scope, and Importance of Medicinal Plants (15 Hours)

Indigenous Medicinal Sciences; Definition and Scope-Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants used in ayurvedic treatments,Siddha:Origin of Siddha medicinal systems, Basis of Siddhasystem, plants used in Siddha medicine.Unani:History,concept: Umoor-e-tabiya, tumorstreatments/therapy, polyherbal formulations.

UNIT 2: Conservation of endangered and endemic medicinal plants (15 Hours)

Definition: endemic and endangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacred groves, National Parks; Ex situ conservation: Botanic Gardens, Ethnomedicinal plant Gardens. Propagation of Medicinal Plants: Objectives ofthe nursery, its classification, important components of anursery, sowing, pricking, use of green house for nursery production, propagation through cuttings, layering, grafting and budding.

UNIT 3: Ethnobotany and Folk medicines (15 Hours)

Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. Folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases-Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases.

PRACTICAL (30 Hours)

To visit botanical garden/herbal garden/medicinal plant repositories for the identification of ethno-medicinal plants.

1. Field visit to different tribal regions to gain ethno botanical knowledge and the inter-relation between plant and people
2. Collection and preparation of herbarium specimen of medicinal and aromatic plants
3. Identification of medicinal and aromatic plants
4. Identification and collection of locally used ethnobotanicals.
5. To study harvesting, drying, grading, storage, processing, and value addition techniques for medicinal and aromatic plants.
6. To study the propagation and nursery techniques of medicinal and aromatic plants.

SUGGESTED READINGS:

1. Trivedi PC, 2006. Medicinal Plants: Ethnobotanical Approach, Agrobios, India.
2. Purohit and Vyas, 2008. Medicinal Plant Cultivation: A Scientific Approach, 2ndedition. Agrobios, India

Bot.323 Reproductive Biology 3+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To learn about their general development in angiosperms.
- Emphasis will be given at their embryological studies.

LEARNING OUTCOMES:

This course will enable the students to understand:

- About the floral feature of Angiosperm.
- Learn about the reproductive tissues of Angiosperms

Understanding the importance of pollination and fertilization.

THEORY (45 Hours)

UNIT I: Structural Organization of Flower (9 Hours)

Flower: A modified shoot, structure and varieties of flower, function,

UNIT II: Gametophyte Development (9 Hours)

Microsporangium and megasporangium development, the male and female gametophytes development, Structure, and types of ovules; Types of embryo sacs.

UNIT II: Pollination **(9 Hours)**

Types of pollination, attraction, and rewards for pollinators.

UNIT III: Fertilization **(9 Hours)**

Pollen pistil interaction, self-incompatibility; double fertilization: fruit development and maturation, formation of seed, significance of seed.

UNIT IV: Embryo and Endosperm **(9 Hours)**

Endosperm and embryo, endosperm types, embryo endosperm relationship, Apomixis and Embryony: Definition, types, and practical application.

PRACTICAL (30 Hours)

1. Examination of a wide range of flowers available in the locality and methods of their pollination;
2. Structure of anther, microsporogenesis (using slides) and pollen grains (using whole mounts),
3. Germination of non-dormant seeds.
4. Structure of ovule and embryo sac development (using serial sections).
5. Nuclear and Cellular endosperm.
6. Embryo development in monocots and dicots (using slides/ dissections).

SUGGESTED READINGS:

1. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
2. Bhojwani, S.S. &Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas
3. Publication House Pvt. Ltd. New Delhi. 5thedition.
4. Eames, A.J. Morphology of Angiosperms. McGraw – Hill Inc., New York. 518 pp. 1961
5. Sporne, K.R. The Morphology of Angiosperms. B.I. Publication, Bombay, Calcutta, Delhi. 207 pp. 1986.

HIGHER LEVEL DISCIPLINE SPECIFIC COURSES:

Bot.411 **Phycology** **3+1**

LEARNING OBJECTIVES:

- To impart knowledge about Algae on various aspects like Classification, Life cycles, Thallus organization and Reproduction in various groups; Evolution,
- To study Habitats and Economic importance of algae.

LEARNING OUTCOMES:

- Students will be taught about the diversity of microorganisms, their classification, structure and growth
- The students will be learning about the theoretical and practical knowledge of algal microbes.

- During the course students will gain knowledge about basic components of photosynthesis such as algal pigments, carotenoids, photosystems, oxygen evolving complex, and electron carriers.

THEORY (45 Hours)

UNIT-I **(9 Hours)**

Criteria for algal classification (pigments, reserve food, flagella, chloroplasts, pyrenoids, eye spots, endoplasmic reticular membrane etc.); Comparative account of important systems of classification (Fritsch, Round, Chapman and Lee).

UNIT-II **(9 Hours)**

Salient features: Cell structure, thallus organization, reproduction and broad classification of i) Cyanophyta ii) Xanthophyta iii) Bacillariophyta iv) Dinophyta.

UNIT-III **(9 Hours)**

Salient features: Cell structure, thallus organization, reproduction and broad classification of v) Chlorophyta vi) Phaeophyta vii) Cryptophyta and viii) Rhodophyta.

UNIT-IV **(9 Hours)**

Diversity in algal habitats (terrestrial, freshwater and marine). Thallus organization in algae including evolutionary trends. Reproduction (vegetative, asexual and sexual), origin and evolution of sex, life cycles. Current concepts and relationships of protochlorophycean algae.

UNIT-V **(9 Hours)**

Rhythms and bioluminescence in dinoflagellates. Economic importance of algae (algal biofertilizers, algal blooms, algae as food and feed, uses in industries etc.) Algae in Biotechnology.

PRACTICAL(30 Hours)

1. Algal collections from different habitats and their identification.
2. Morphology and reproductive stages of following genera:Cyanophyta: Chroococcus, Microcystis, Oscillatoria, Lyngbya, Nostoc, Anabaena, Gloetrichia, Cylindrospermum, Scytonema.

Chlorophyta: Volvox, Hydrodictyon, Chlorella, Pediastrum, Scenedesmus, Oedogonium, Bulbochaete, Cosmarium, Closterium, Zygnema, Sphaeroplea, Cladophora, Pithophora, Spirogyra, Caulerpa, Codium, Valonia, Halimeda, Acetabularia, Chara, Nitella, Coleochaete, Dreparnaldia.

Xanthophyta: Vaucheria, Botrydium. Bacillariophyta: Pinnularia, Synedra, Navicula, Cyclotella. Phaeophyta: Ectocarpus, Fucus, Laminaria, Dictyota, Desmortestia, Sporochnus, Sargassum.Rhodophyta: Erythrotrichia, Porphyra, Nemalion, Batrachospermum, Corallina, Gelidium, Polysiphonia

SUGGESTED READINGS:

1. Chapman, V.J. and D.J. Chapman. The Algae. ELBS and Macmillan, NY. 1977.
2. Lee, R. E., Phycology, Cambridge University Press, Cambridge, 2008
3. VanDen Hock, C., Mann, D.G. and Jahns, H. M. Algae: An Introduction to Phycology, Cambridge University Press, Cambridge, 1995.

4. Ahluwalia, A.S., (Ed.) Phycology: Principles, Processes and Applications, Daya Publishing House, New Delhi, 2003
5. Kumar, H.D., Introductory Phycology, East West Press, New Delhi, 1999

Bot.412 Bryology 3+1

LEARNING OBJECTIVES:

- To impart knowledge about Bryophytes on various aspects like Classification, structural organization and developmental studies of gametophyte and sporophyte in various groups; Ecology, Water relations, Chemistry, Cytology, Fossil bryophytes,
- To strengthen the knowledge of origin and evolution, Experimental studies, and Economic Importance of Bryophytes.

LEARNING OUTCOMES:

- The course will strengthen the concept that how the organ formation occurs in the early land plants.
- The course will deal with Ecological and Economic Importance of bryophytes.
- The course will help to understand their role in ecosystem functioning

THEORY (45 Hours)

UNIT-I (10 Hours)

General characteristics of Bryophytes: systems of classification with salient features of Anthcerotophyta, Marchantiophyta and Bryophyta. Structure and development of sex organs in Bryophytes. Economic and ecological importance of Bryophytes.

UNIT-II (12 Hours)

Comparative structural organization of gametophyte and sporophyte; Asexual reproductive structures; distribution of sex organs; protective structures associated with archegonia and developing sporogonia; spore and elaters / peristome teeth; spore dispersal mechanisms and spore germination in Hornworts (Anthocerotales), Liverworts (Jungermanniales, Marchantiales, and Sphaerocarpales.)

UNIT-III (10 Hours)

Mosses (Sphagnopsida, Andreaeopsida, Archidiopsida, and Peristomiopsida). Experimental studies: Effect of various factors on protonemal differentiation and bud formation; Apogamy and Apospory.

UNIT-IV (10 Hours)

Chemistry of Bryophytes: A brief account of distribution of various organic compounds in different groups of Bryophytes; Chemistry in relation to taxonomy. Cytological studies in Bryophytes: Chromosome numbers in major groups of Bryophytes, Polyploidy in brief, m-chromosomes and sex-chromosomes, Cytology in relation to taxonomy.

UNIT-V (3 Hours)

Fossil Bryophytes (A brief account), Origin of Bryophytes.

PRACTICAL (30 Hours)

1. Structural details of Marchantia, Asterella, Plagiochasma, Targionia, Pellia, Frullania, Porella, Notothylas, Anthoceros, Sphagnum, Pogonatum, Barbula, Bryum and Entodon and Thuidium.
2. Study of diagnostic features of following genera: Dumortiera, Athalamia, Conocephalum, Cryptomitrium, Reboulia, Riccia, Riccardia, Metzgeria, Blasia, Sewardiella, Plagiochila, Fissidens, Atrichum, Mnium and Thuidium.
3. Field trips to familiarize with natural habitats, growth forms and diversity of bryophytes.
4. To study permanent slides / photographs of m-Chromosomes and Sex- chromosomes.

SUGGESTED READINGS:

1. Goffinet, B. and Shaw, A.J. Bryophyte Biology. Cambridge University Press, Cambridge, pp. 476, 2000.
2. Richardson, D. H. S. Biology of Mosses, Blackwell Scientific Publications, Oxford, pp. 220, 1981.
3. Schofield, W.B. Introduction to Bryology, Macmillan Publishing Company, New York, pp. 431, 1985.
4. Kashyap, S.R. Liverworts of Western Himalayas and the Punjab plains. Vols I II. Research co. Publications, New Delhi. 1932
5. Kumar, S.S. An approach towards Phylogenetic Classification of Mosses. Jour. Hattori Bot.Lab. Nichinan, Japan. 1984.
6. Rashid, A. An Introduction to Bryophyta. Ist Ed. Vikas Publishing House Pvt. Ltd., New Delhi. 298 pp. 1998.

Bot.413 Mycology and Microbiology 3+1

LEARNING OBJECTIVES:

- To provide knowledge about Classification, Mycelium, Reproduction in various groups of Fungi.; Nomenclature, Classification, Structure, reproduction, importance of Bacteria,
- Information about Viruses, MLOs, Spiroplasmas, Viroids, Mycoviruses; Translocation and distribution in host plants, infection, replication, and transmission of plant viruses.

LEARNING OUTCOMES:

- The students will be learning about the role of edible fungi in strengthening the commercial sector.
- It helps the students to understand and appreciate role of microbes in their life.
- The course provides Develop theoretical and technical skills of basic microbiology (sterilize, isolate, culture, preserve microbes).

THEORY (45 Hours)

UNIT-I (9 Hours)

Recent trends in the classification of Fungi. General account of Myxomycota, Oomycota and Chytidriomycota

UNIT-II (6 Hours)

General account of Zygomycota, Ascomycota, Basidiomycota and anamorphic fungi.

UNIT-III **(9 Hours)**

Tissue systems in Fungi. Types of Centrum development in Ascomycota. Heterokaryosis and Parasexuality. Mycorrhizal application in agriculture and plant growth.

UNIT-IV **(12 Hours)**

Nomenclature, classification, morphology, translocation and distribution in host plants, infection, replication and transmission of plant viruses. Nomenclature, classification, structure, reproduction, nutrition and economic importance of Eubacteria.

UNIT-V **(9 Hours)**

General account of Archaebacteria. Brief account of MLOs, Spiroplasma, Viroids and Mycoviruses.

PRACTICAL (30 Hours)

1. Study of morphological and reproductive structures of following genera: MYXOMYCOTA: Stemonitis, Physarum. OOMYCOTA: Saprolegnia, Albugo, Peronospora, Phytophthora, Bremia. CHYTIDRIOMYCOTA: Synchitrium, Allomyces, Blastocladia. ZYGOMYCOTA: Mucor, Rhizopus, Pilobolus. ASCOMYCOTA: Protomyces, Aspergillus, Penicillium, Claviceps, Phyllactinia, Xylaria, Morchella, Peziza BASIDIOMYCOTA: Puccinia, Melampsora, Agaricus, Ustilago, Polyporus, Ganoderma, Cyathus, Hydnum, Geasterum. ANAMORPHIC FUNGI: Fusarium, Cercospora, Colletotrichum, Alternaria, Helminthosporium.
2. Preparation of media to isolate fungi, bacteria and other microbes.
3. Isolation of Rhizobium from legume root nodules. 4. Sensitivity tests of bacteria using different antibiotics.

SUGGESTED READINGS:

1. Alexopolous, C.J., C.W. Mims and M. Blackwell. Introductory Mycology. 4 th Ed. John Wiley & Sons, New York. 880 pp. 2007.
2. Webster, J. and Webes R. Introduction to Fungi. Cambridge University Press, Cambridge 3rd Edition, 2007.
3. Bos, L. Introduction to Plant Virology. Longman, New York. 160 pp. 1992

Bot.421 **Pteridophytes** **3+1**

LEARNING OBJECTIVES:

The primary objective of this course is:

- To familiarize students with the diversity of Pteridophytes (both ferns and fern allies), their evolutionary history and origin, economic importance, classification, detailed study on the representative ferns of major families with reference to their morphology, anatomy, and reproduction.
- Exposure of students to fern flora in the surrounding areas and botanical garden

LEARNING OUTCOMES:

This course will enable the students to understand:

- Understand general characters of Pteridophytes and stellar evolution among them, Structure, reproduction, life cycle and systematic position
- Study and impart knowledge about the occurrence, distribution, structure, and life history of lower plants
- They will learn phylogeny and evolutionary concepts in lower group of organisms

THEORY (45 Hours)

UNIT-I: **(5 Hours)**

Origin and evolution of Pteridophytes, Economic importance of Pteridophytes, Diversity and distribution of Pteridophytes in India.

UNIT-II: **(15 Hours)**

Classification of Pteridophytes with special reference to ferns, Criteria for classification of ferns. General characteristics of some living fern families. A brief account of generas of major fern families especially Marattiaceae (Marattia), Ophioglossaceae (Ophioglossum), Osmundaceae (Osmunda), Dryopteridaceae (Dryopteris), Pteridaceae (Adiantum), Marsileaceae (Marsilea), Salviniaceae (Salvinia), Azollaceae (Azolla), Aspleniaceae (Asplenium) and Polypodiaceae (Platycerium). Telome theory and evolution of stelar system in Pteridophytes.

UNIT-III: **(10 Hours)**

Types, structure and germination pattern of spores in Pteridophytes. Structure, types and development of fern prothalli. Antheridium-inducing substances in ferns.

UNIT-IV: **(15 Hours)**

Apogamy and apospory in pteridophytes (types and inductions), heterospory and its significance. Role of ferns in phytoremediation, ferns as hyperaccumulators of arsenic, mechanism of uptake, transfer and tolerance. Chromosome numbers and polyploidy in Pteridophytes.

PRACTICAL(30 Hours)

1. Study of the morphology, anatomy, and reproductive structures of the representatives of the fern families mentioned in the theory part.
2. Taxonomical characters of ferns for generic identification and characterization of families.
3. Studies on the fern spores and their morphology.

SUGGESTED READINGS:

1. Khullar, S.P. An Illustrated Fern Flora of West Himalayas (Vols. I and 2), International Book Distributors, Dehradun, 2000.
2. Rashid, A. An Introduction to Pteridophyta, Vikas Publishers, New Delhi, 1999.
3. Sporne, K.R. The Morphology of Pteridophytes, B.I., Publications, Bombay, Delhi, Madras, 1982.

Bot.422 **Gymnosperms** **3+1**

LEARNING OBJECTIVES:

The primary objective of this course is:

- Involve detailed study about the vegetative and reproductive morphology of various gymnosperms specimens and their economic importance.
- Understanding of systematic position along with evolutionary aspects

LEARNING OUTCOMES:

This course will enable the students to understand:

- Students would be able to undertake project work about most of the aspects covered concerning gymnosperms specimens, their distribution and economic importance.
- Students will be confident in identifying the immense diversity and cultural conditions of these species.
- They would be able to identify vast diversity amongst the different plant species among gymnosperms.

THEORY (45 Hours)

UNIT-I: **(15 Hours)**

Current trends in the classification of Gymnosperms. General characteristic features of Gymnosperms and their affinities with pteridophytes and angiosperms. Distribution of Gymnosperms with special reference to Indian members and emphasis on their distribution in the Himalayas.

UNIT-II: **(15 Hours)**

Vegetative morphology and reproductive organs only (excluding developmental stages) of Indian representatives of: Living Coniferopsida: Pinaceae, Taxodiaceae, Cupressaceae, Podocarpaceae, Cephalotaxaceae, Araucariaceae. Range and form of structure in the leaves of Coniferales.

UNIT-III: **(10 Hours)**

Vegetative morphology and reproductive organs only (excluding developmental stages) of Indian representatives of: (a) Gnetopsida: Ephedraceae, Gnetaceae, and Welwitschiaceae. (b) Ginkgopsida:Ginkgoaceae.

UNIT-IV: **(5 Hours)**

Economic importance of Gymnosperms. Cytological studies in Gymnosperms. Comparative of analysis of various gymnosperm taxa on the basis of their distribution, morphology and reproductive structures

PRACTICAL(30 Hours)

Wood Anatomy in *Cedrus, Ginkgo, Ephedra* and *Gnetum*

1. Leaf Anatomy in Cedrus, Abies, Picea, Podocarpus Cryptomeria, Cephalotaxus.
2. Male cones (external morphology) & microsporophylls in Cedrus, Abies, Cephalotaxus, Podocarpus, Cryptomeria, Cupressus, Thuja and Juniperus.
3. Female cones in Cedrus, Abies, Picea, Taxodium, Auraucaria, Cunninghamia. Seed scale complex in Cryptomeria, Cupressus, and Thuja.

SUGGESTED READINGS:

1. Beck, C. E. (1985). Gymnosperm Phylogeny, Bot.Rev., 51: 176-294.
2. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International Limited, New Delhi,
3. Sharma, O.P. ad Dixit, S. (2001). Gymnosperms. Pragati Prakashan, Meerut.
4. Bierhorst, D.W. (1971). Morphology of Vascular Plants, The Macmillan and Co., New York,
5. Rothwell, G.W. (1985). The Role of Comparative Morphology and Anatomy in Interpreting the Systematics of Fossil Gymnosperms, Bot.Rev., 51: 318-327.

Bot.423 Embryology 3+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To impart knowledge about various biological aspects of reproduction in Angiosperms like structure of male and female Gametophyte, Palynology, Pollen-pistil interaction, Self incompatibility, Apomixis, Fertilization, Endosperm, Embryo and Seed formation.
- To acquaint the students about the structure of various parts of flowers and pollination mechanisms.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Students will able to differentiate reproductive organs at Morphological, Anatomical, Physiological and Biochemical level.
- This knowledge will be help to apply in agriculture for reproduction of hybrids.
- The allergic problems in Humans can be justified on the basis of pollens.

THEORY (45 Hours)

UNIT-1: (5 Hours)

Introduction, History and scope. Flower: Structure and Development; Induction of Flowering, Photoperiodism, Vernalization.

UNIT-2: (15 Hours)

Anther and Ovule, Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure,; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia. Structure of the Ovule; Types; Special structures– endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of Polygonum type); Organization and ultrastructure of mature embryo sac.

UNIT-3: (15 Hours)

Pollination, fertilization and Seed Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization. Embryo Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor:

structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in Paeonia. Seed structure, importance and dispersal mechanisms.

UNIT-4: (10 Hours)

Self incompatibility, Polyembryony and apomixis Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Polyembryony and Apomixis: Introduction; Classification; Causes and applications.

PRACTICAL(30 Hours)

Study of microsporogenesis and gametogenesis in sections of anthers.

1. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, Cannabis sativa, Crotolaria, Tradescantia, Brassica, Petunia,Solanum melongena etc.)
2. Tests for pollen viability using stains and in vitro germination. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture.
3. Study of ovules in cleared preparations; study of monosporic, bisporic and tetrasporic types of embryo sac development and embryos through examination of permanent stained serial sections
4. Field study of several types of flowers with different pollination mechanisms (Wind pollination, Bee / butterfly pollination, Bird pollination).

SUGGESTED READINGS:

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
2. Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.
3. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH PublishingCo. Pvt. Ltd. Delhi.
4. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands

HIGER & APPLIED AREA MINOR COURSES:

Bot.414 Cytogenetics 3+1

LEARNING OBJECTIVES:

The primary objective of this course is -

- The very purpose of this course is to acquaint the students with cell cycle and architecture of chromosome in prokaryotes and eukaryotes and their gene regulation
- This course aims to impart knowledge of various mechanisms of cell functioning.

LEARNING OUTCOMES:

This course will enable the students to:

- Get well acquaint with the concept of cell and related functioning and its genetics.

THEORY(45 Hours)

UNIT I: (15 Hours)

Chromosome Organization:Structure of chromosomes, DNA packaging and Metaphase chromosomes, centromere, kinetochore, telomere and its importance, Heterochromatin and euchromatin, Chromosome banding, Polytene and lampbgrush chromosomes.Sex chromosomes, sex determination and dosage compensation in Drosophila and human.Structure and functions of cell and its organelles (Nucleus, plasma membrane, mitochondria, Golgi bodies, endoplasmic reticulumn, ribosomes and lysosomes).

UNIT II: (15 Hours)

Mendelian and non-Mendelian Inheritance:Mendelian inheritance and its modification, Maternal effect, Epigenetic inheritance,Extranuclear inheritance,Variation chromosome structure and number. Genetic linkage mapping using molecular markers,cell cycle and its regulation;Protein sorting in ER, Golgi and targeting of proteins to Mitochondria, secretory and endocytotic pathway;Cell-Cell signalling: Cell surface receptors, Second messenger system, MAP kinase pathways, Signalling from plasma membrane to nucleus.

UNIT III: (15 Hours)

Brief description of gene expression:Genetic code, Transcription and translation in prokaryotes and eukaryotes, Regulation of gene expression, Gene mutation and DNA repair: Consequences of mutations Occurrence

PRACTICAL(30 Hours)

1. Demonstration of SEM and TEM and study of different micrographs
2. Study of Problems based on Genetics
3. Study of permanent histological slides of testis and ovaries of insects/ mice/rat.
4. Basis of reaction and demonstration of the sites of proteins, nucleic acids, lipids & carbohydrates in ovaries of insects/rat/mice through slides and photographs.
5. Study of stages of mitosis and meiosis from permanent slides from animal and plant materials through slides/charts/photographs.

SUGGESTED READINGS:

1. Cell Biology and Molecular Biology by D.Robertis, EDP & DE Robertis E.M.F, 8th ed., Saunders & Co. Philadelphia (1995).
2. Cell Biology by C.B. Powar, 3rd ed., Himalaya Pub., Bombay (1984).
3. Advances in Cell and Molecular Biology by Dupraw, E.J., eds. Academic Press, New York & London (1971).
4. Cell Biology. Pollard, Thomas, D.S.Earnshan, William C. Saunders. USA. (2002).
5. The Cell: A Molecular Approach by Cooper GM & H 5th edition (2009).
6. Molecular Biology of the Cell, 5th edition by Alberts, John Raff. Roberts & Walter (2008).
7. Cell and Molecular Biology: Concepts and Experiments 5th edition by Gerald Karp. John Wiley and Saunders. 8. Molecular Cell Biology by Lodish et. al. W.H. Freeman Co. New York (2008).

Bot.415 Advances in Plant Physiology 3+1

LEARNING OBJECTIVE:

- The study will provide depth understanding about Water relations of plants, Inorganic nutrition, Photosynthesis, Respiration, Nitrogen metabolism, and Phytohormones.
- It will help to add about Growth, Stress physiology, and the coordination growth under stress condition.

LEARNING OUTCOME:

- The students will be learning about the various mechanisms water and nutrient uptake in plants.
- During the course students will strengthen their knowledge about photosynthetic pigments, carotenoids, photosystems, oxygen evolving complex, and electron carriers.
- The course will deal with various phytohormones and their signalling pathways associated with growth and development.

THEORY (45 Hours)

UNIT-I (5 Hours)

Water Relations of Plants
Modern thermodynamic concepts of physical state of water in plant cells and tissues, movement of water in the Soil – Plant – Atmosphere Continuum. Transpiration, stomatal control and mechanism of guard cell movement.

UNIT-II (4 Hours)

Inorganic Nutrition and Translocation
Occurrence, availability and physiological roles of various elements, ion uptake and active and passive transport, Role of calmodulin, phloem transport.

UNIT-III (9 Hours)

Photosynthesis
Energy pathways in photosynthesis, Chloroplast as an energy transducing organelle, composition and characterization of photosystems I and II, electron flow through cyclic and non-cyclic photophosphorylation, pathway of CO2 Fixation, differences between C3 and C4 photosynthesis, different kinds of C4 pathways, CAM pathway – occurrence, biochemical events, and adaptive advantage. Regulation of photorespiration, Factors affecting photosynthesis, photorespiration and photophosphorylation.

UNIT-IV (4 Hours)

Respiration
Glycolysis, Krebs cycle and Electron Transport Chain (Cytochrome System), Gluconeogenesis, Factors affecting respiration.

UNIT-V (5 Hours)

Nitrogen Metabolism
Nitrogen fixation of free living and symbiotic organisms, mechanism of Nitrogen fixation, Soil nitrogen sources, nitrogen uptake and assimilation, nitrate reductase system and induction, Light

substrate-controlled induction, interrelationship between photosynthesis and nitrogen metabolism, transport of nitrogen in plants.

UNIT-VI (9 Hours)

Phytohormones
Auxins, gibberellins, cytokinins, abscissins and ethylene: their transport, biosynthesis, physiological roles and mechanism of action; phenols, synthetic regulators, retardants and inhibitors.

UNIT-VII (4 Hours)

Growth
Process, phases and dynamics of growth. External and internal factors affecting growth, growth and yield analysis, Source – Sink relationship, photoperiodism, phytochrome, endogenous rhythms, tropisms. Seed and bud dormancy and germination.

UNIT-VIII (5 Hours)

Stress Physiology
Mechanism of plant response to water (low and high), temperature (low and high), Salt (Salinity and Alkalinity) and biotic stresses (Pathogens and insects).

PRACTICAL (30 Hours)

1. Experiments pertaining to photosynthesis, respiration and water relations.
2. Determination of water potential by various methods.
3. Determination of Chlorophyll a and Chlrophyll b ratio in C3 and C4 plants.
4. Spectroscopic determination of Chrophyll a, Chlorophyll b, Carotenoids and Anthocyanin under varied environmental conditions.
5. Experimental study of hormonal effects in plant material.
6. Bioassays of hormones.
7. Study of seed germination as effected by different factors.
8. Experimental study of stress physiology.

SUGGESTED READINGS:

1. Malik, C.P. Plant Physiology. 3rd Ed. Kalyani Publishers India. 2002.
2. Noggle, G.R. and G.J. Fritz. Introductory Plant Physiology. 2nd Ed. Prentice Hall of India Pvt. Ltd., New Delhi. 1991.
3. Salisbury, F.B. and C.Ross. Plant Physiology.4 th Ed. CBS Publisher and Distributors.682 pp. 1992.
4. Wilkins, M.B., Advanced Plant Physiology, Pitman, New York, 1984.
5. Taiz, L. and Zeiger, E. Plant Physiology, (5th Edition), Sinauer Associates, Inc., Massachusetts, USA, 2010.
6. Hopkins, W.G. Introduction to Plant Physiology, John Wiley & Sons, Inc., N.Y., USA, 1999.

Bot.424 Biotechnology and Bioinformatics 3+1

LEARNING OBJECTIVES:

Acquaint students to the principles, practices andwith various approaches of conducting genetic engineering and their applications in biological research as well as in biotechnology industries.

LEARNING OUTCOMES:

On completion of this course, students should be endowed with strong theoretical knowledge of biotechnology and bioinformatics and is able to take up biological research with better understanding.

THEORY (45 Hours)

UNIT – I (15 Hours)

Basic biomolecular concepts: central dogma; DNA replication semi-conservative, Transcription and RNA Processing in Eukaryotic Cells, Expression of genetic information: from Transcription to Translation - Genetic code, Decoding the codons: the role of transfer RNAs. Genetic Engineering: Enzymes useful in molecular cloning: Restriction endonuclease, DNA ligases, polynucleotide kinase, klenow enzyme, DNA Polymerase- I, reverse transcriptase, alkaline phosphatase, terminal nucleotidyltransferase; Molecular markers - Restriction based and PCR based: RFLP, RAPD, AFLP, ISSR, SNP, SSR; Marker-assisted selection - strategies for introducing genes of biotic and abiotic stress resistance in plants: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; Cloning Vectors - Plasmids (pBR 322, pUC), Vectors for Plant and Animal Cells, Shuttle Vectors, YAC Vectors, Expression Vectors Recombinant DNA technology; Labeling nucleic acids and blotting techniques (Southern, Northern, Western, Zooblot); transformation; Polymerase Chain Reaction and its applications;DNA fingerprinting-principles and applications.

UNIT – II (12 Hours)

Genetic engineering: Gene transfer methods-Biological, physical, chemical;Agrobacterium-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation; characterization of transgenics; concept of plants as biofactories

UNIT – III (12Hours)

Transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species; Vaccinology: history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.

UNIT – IV (6 Hours)

Overview of genomics – definition, complexity, and classification; need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype; genome projects and bioinformatics resources for genome research – databases; overview of forward and reverse genetics for assigning function for genes
RNAi, CRISPR-CAS; History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for *in vivo* genome

engineering for genetic studies, promise of the technology as a next generation therapeutic method.

PRACTICAL(30 Hours)

1. Introduction to Instruments used in Molecular Biology /GELaboratory
2. Preparation of Buffers.
3. DNA isolation and DNA quantitation
4. Polymerase Chain Reaction and analysis by agarose gel electrophoresis
5. Transformation of *E.coli* with standard plasmids and calculation of transformation efficiency
6. Confirmation of the insert by Colony PCR and Restriction mapping
7. Explore different softwares of bioinformatics analysis

SUGGESTED READINGS:

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
4. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
5. Umesha, S. (2013). *Plant Biotechnology.* The Energy And Resources.

RESEARCH/PROJECT/SEMINAR:

Bot.391 **Seminar** **0+1**

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Identify and compare technical and practical issues related to the area of course specialization.
- Outline annotated bibliography of research demonstrating scholarly skills.
- Prepare a well-organized report employing elements of technical writing and critical thinking.
- Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

LEARNING OUTCOMES:

At the end of this course, students will be able to:

- Establish motivation for any topic of interest and develop a thought process for technical presentation.
- Organize a detailed literature survey and build a document with respect to technical publications.
- Analysis and comprehension of proof-of-concept and related data.
- Effective presentation and improve soft skills.
- Make use of new and recent technology for creating technical reports

- Will be able to present themselves in front of an audience. It will help them to develop skills like speaking ability, gain and express knowledge in different fields and presentation capability. They will also learn to defend themselves in front of a panel of Seminar Committee.

Bot.491 Pre-Research 0+4

LEARNING OBJECTIVES:

The primary aim of this course is to:
- Identifying the Research Problem.
- Performing a Literature Review & Writing a Theoretical/Conceptual/experimental Framework.
- Researching the methods/experiments/Design or Approach to the Problem.

LEARNING OUTCOMES:

At the end of Research Proposal, students will be able to:
- Outline the literature on as Specific research problem.
- Construct objectives and motivations of research problem to be carried out.
- Explain the nuts and bolts of the theoretical concepts of the problem (experimental or theoretical) to be carried out.
- Making research proposal for further research.

Student will prepare a research proposal based on literature review and extensive student-mentor interactions involving discussions, meetings and presentations. Each student will submit a research/dissertation proposal of the research work planned for the research dissertation with origin of the research problem, literature review, hypothesis, objectives, and methodology to carry out the planned research work, expected outcomes and bibliography. Research projects can be taken up in collaboration with industry from within the discipline or across the discipline

Bot.492 Research 0+8

LEARNING OBJECTIVES:

The prime aim of this course is to:
- Collecting and Analyzing the Data and/or Designing and Validating the methods/experiments/Design
- Drawing Conclusions and Giving Recommendations
- Prepare dissertation/thesis/report on the proposed research work

LEARNING OUTCOMES:

At the end of Dissertation students will be able to:
- Demonstrate an in-depth knowledge of scientific research pertaining to the area of study
- Demonstrate experimental/theoretical research capabilities based on rigorous hands-on training
- Critically analyze, interpret and present the data in light of existing scientific knowledge to arrive at specific conclusions

- Develop higher order thinking skills required for pursuing higher studies (Ph.D.)/research-oriented career options in respective fields.

Students will carry out their research work under the supervision of a faculty member. Students will interact with the supervisors through meetings and presentations on a regular basis. After completion of the research work, students will complete the dissertation under the guidance of the supervisor. The dissertation will include literature review, hypothesis, objectives, methodology, results, discussion, and bibliography.

Bot.493 Academic Project 0+4

LEARNING OBJECTIVES:

The primary aim of this course is to:

- review the Research in the subject area.
- Analyse data and other research findings.
- Report research findings in written form.

LEARNING OUTCOMES:

After completion of course, students will have hand on experience of

- Literature survey on advanced research topics in Botany and its allied discipline
- Planning and designing the experiment of the research Problem
- Analysis and evaluation of the experimental data/ theoretical & computational modeling
    - Deduction and systematic presentation of the results
- Compilation of the results / information to produce written document
- Defending the results of the project in an open viva–voice through power point presentation

All the Botany honours students will do a supervised Botany Project as an important culmination of training in Botany learning and research. This project shall be a supervised collaborative work in Botany and its allied discipline The project will aim to introduce student to the basics and methodology of research in Botany, which is done via theory, computation, and experiments either all together or separately by one of these approaches. It is intended to give research exposure to students.

Zoology
(DISCIPLINE – B)

DISCIPLINE SPECIFIC COURSES:

Zoo.111 Diversity of Non-Chordates 3+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To introduce the learner about the existence of different life forms on the earth and appreciate the diversity of animal life.

- To make the students aware about the characteristic morphological and anatomical features of diverse animals

LEARNING OUTCOMES:

This course will enable the students to understand:

- Learn about the importance of systematics, taxonomy, and structural organization of non-chordates.
- Appreciate the diversity of non-chordates living in varied habits and habitats
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities
- Critically analyse the organization, complexity, and characteristic features of non-chordates.
- Recognize the life functions and the ecological roles of the animals belonging to different phyla.

THEORY (45 Hours)

UNIT – I: (15 Hours)

Introduction to non-chordates, Protozoa: General characters and classification up to classes; Study of reproduction in *Paramecium*, Life cycle of *Plasmodium vivax,* Porifera: General characters and classification up to classes; Canal system in *Sycon.* Cnidaria: General characters and classification up to classes; Polymorphism in hydrozoa and coral reefs.

UNIT – II: (15 Hours)

Platyhelminthes: General characters and classification up to classes; Life history of *Taenia solium*, Nemathelminthes: General characters and classification up to classes; Life history of *Ascaris lumbricoides* and its parasitic adaptations, Annelida: General characters and classification up to classes; Metamerism in Annelida, Excretion in Annelida

UNIT – III: (15 Hours)

Arthropoda: General characters and classification up to classes; Vision in Arthropoda, Metamorphosis in Insects. Mollusca: General characters and classification upto classes; Torsion and detorsion in gastropoda; Foot in mollusca and Pearl formation. Echinodermata: General characters and classification up to classes; Water vascular systemin Asteroidea.

PRACTICAL (30 Hours)

1. Study of the following specimens:Amoeba, Euglena, Plasmodium,Paramecium,Sycon,Hyalonema,Euplectella, Obelia, Physalia, Aurelia, Tubipora, Metridium, Taenia solium, Male and female Ascaris lumbricoides, Aphrodite, Nereis, Pheretima, Hirudinaria, Palaemon, Cancer, Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Apis, Chiton, Dentalium, Pila, Unio, Loligo, Sepia, Octopus, Pentaceros, Ophiura, Echinus, Cucumaria and Antedon, Balanoglossus
2. Study of the following permanent slides:
    - (i) T.S. and L.S. of *Sycon*, Study of life history stages of *Taenia* and *Fasciola,* T.S. of Male and female *Ascaris.*

3. An "animal album" containing photographs, cut outs, with appropriate write up about the above mentioned Taxa. Differenttaxa/topics may be given to different students for this purpose.

SUGGESTED READINGS:

1. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders, International Edition.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002).The, Invertebrates: A New Synthesis, III Edition, Blackwell Science
3. Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
4. Dhami, J. K.& Dhami P. S. Invertebrate Zoology: A Text Book for B. Sc. Students of Indian Universities. R. Chand & Company, 1979

Zoo.121 Diversity of Chordates 3+1

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- The course aims to impart in-depth knowledge about the diverse life forms from the taxonomic positions of Protochordates and Agnatha to Mammalia.
- It will help the students to identify the body plan types of complex chordates and their systematic organization based on evolutionary relationships, structural and functional affinities.
- The course will help the students to understand the characteristic morphological, adaptive and anatomical features of diverse animals.

LEARNING OUTCOMES:

This course will enable the students to:

- Correlate the importance of systematics, taxonomy, and structural organization of chordates.
- Recognize the diversity of chordates living in varied ecological habitats.
- Critically analyse the organization, complexity and characteristic features of chordates.

THEORY(45 Hours)

UNIT – I: (15 Hours)

Introduction to Chordates: Origin of chordates; characteristic features of chordates. Protochordates: General features and classification. Agnatha: General features of Agnatha and classification of cyclostomes up to classes; Ammocoete larva.

UNIT – II (15 Hours)

Pieces: General characteristics of Chondrichthyes and Osteichthyes; Classification up to order; Osmoregulation in Fishes, Scales in fishes; Migration of fishes Amphibians:General features and Classification up to orders, Parental care in amphibians.

UNIT – III (15 Hours)

Reptiles: General features and Classification up to orders; Mesozoic reptiles; Poisonous and non-poisonous snakes, Poison apparatus and biting mechanism in snakes. Aves: General features and Classification up to orders; Flight adaptations and mechanism in birds Mammals: General features and Classification up to orders; Origin of mammals.

PRACTICAL(30 Hours)

1. Study of the following specimens:Herdmania, Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo, Labeo, Exocoetus, Anguilla, Ichthyophis/ Ureotyphlus, Salamandra, Bufo, Hyla, Chelone, Hemidactylus,Chamaeleon,Draco,Vipera,Naja,Crocodylus,Gavialis.Any six common birds from different orders; Sorex, Bat, Funambulus, Loris,Lemur,Primates
2. Types of scales of fishes
3. An "animal album" containing photographs, cut outs, with appropriate write up about the above-mentioned Taxa. Different taxa/ topics may be given to different students for this purpose.

SUGGESTED READINGS:

1. Young, J. Z. (2004). *The Life of Vertebrates*. III Edition. Oxford university press.
2. Modern Text Book of Zoology-Vertebrates by-R.L. Kotpal, Rastogi Publications
3. Modern’sZoology Vol. I- Vertebrate Zoology by –Ashok Sabharwal and Dr. S.K. Malhotra
4. Young, J.Z. (2004). The Life of Vertebrates. III Edition, Oxford University Press.
5. Parker T.J. and Haswell W.A. (1972). Text book of Zoology Vertebrates. VII Edition, Volume II.

Zoo.211 Animal Physiology 3+1

LEARNING OBJECTIVES:

The primary objective of this course is -

- The course will provide a thorough understanding of the normal body function and helps to determine the cause of disease.
- It will enable the development of new and more effective treatments and guidelines for maintaining good health.
- It will equip the students with an ability to pursue career in medical and healthcare sector, pharmaceuticals, and other related areas.

LEARNING OUTCOMES:

This course will enable the students to:

- Appreciate human physiology and have its enhanced knowledge.
- Recognize and identify principal tissue structures and functions
- Understand the functions of important physiological systems including the nervous system, muscular system, endocrine and reproductive system
- Learn an integrative approach to understand how these separate systems interact to yield integrated physiological responses to maintain homeostasis in the body along with feedback mechanisms.

THEORY(45 Hours)

UNIT – I: (15 Hours)

Nutrition, Digestion and Absorption:Nutritional requirements, composition, function and regulation of salivary, gastric, pancreatic, hepatic and intestinal juices. Mechanism of digestion and absorption.
Circulation: Composition and function of blood and lymph, haemopoiesis, blood groups, Rh factor, blood coagulation, structure and function of haemoglobin, structure, origin and conductance of heart beat, pace maker system, cardiac cycle, blood pressure, electrocardiogram.

UNIT – II (15 Hours)

Respiration: Mechanism and control of breathing; transport of oxygen and carbon dioxide, oxygen dissociation curves of Haemoglobin and Myoglobin, Bohr’s effect and chloride shift. Excretion: structure of kidney and nephron, Nitrogenous wastes, urine formation and water balance.
Muscles: Types of muscles, structure of skeletal muscle cell, mechanical and biochemical basis of muscle contraction, muscle fatigue.

UNIT – III (15 Hours)

Nervous System: Structure of neuron, nature, origin and propagation of nerve impulse, synaptic junctions, myoneural junctions. Skeletal System: Bone and their types, ossification; joints and articulation
Endocrine system and Reproduction: Detailed structure of pituitary glands, nature and functions of pituitary hormones, feedback relationships with other endocrines; Gonadal hormones, estrous cycle, implantation, parturition, lactation.

PRACTICAL (30Hours)

1. Estimation of the haemoglobin and blood cell (RBC and WBC) counts.
2. Study of endocrine glands of rat.
3. Histology of mammalian pituitary, parathyroid, thyroid, pancreas, ovary, testes and adrenal gland.
4. Study of permanent slides of spinal cord, duodenum, liver, lung, kidney, bone, cartilage.
5. Study of human salivary activity in relation to pH and temperature.
6. Study of metabolism through charts.
7. Study of Human systems through charts.

SUGGESTED READINGS:

1. Tortora, G.J. and Derrickson, B.H. (2009). Principles of Anatomy and Physiology, XII Edition, John Wiley & Sons, Inc.
2. Guyton, A.C. and Hall, J.E.(2011). Textbook of Medical Physiology,XIIEdition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
3. Widmaier E, Raff H and Strang K. (2013). Vander’s Human Physiology: The Mechanism of Body Functions. XIIIth Edition, McGraw-Hill Education.
4. Kesar, S. and Vashisht, N. (2007) Experimental Physiology. Heritage Publishers.
5. Prakash, G. (2012) Lab Manual on Blood Analysis and Medical Diagnostics. S. Chand and Company Ltd.
6. Prosser, C.L. and Brown, F.A. comparative Animal Physiology 2nd Ed. W.B. Sunders, Philadelplina.

Zoo.221 Animal Genetics 3+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To apprise students with the basic principles of Genetics and Molecular Biology and its applications in living systems

LEARNING OUTCOMES:

This course will enable the students to understand:

- understand the fundamentals of Mendelian inheritance and non-Mendelian inheritance.
- describe the concepts of linkage and crossing over and their usage in constructing genetic maps.
- gain knowledge about chromosomal aberrations and mutations.
- become familiar with structure and function of nucleic acids with reference to replication, transcription and translation.

THEORY(45 Hours)

UNIT-I: (12Hours)

Mendel's principles of inheritance; chromosomal theory of inheritance; incomplete dominance and co-dominance; multiple allelism; lethal alleles (dominant and recessive lethals); deviations of Mendelian dihybrid ratio (Epistatic interactions-Dominant, Recessive, Duplicate Dominant, Duplicate Recessive, Duplicate Gene Interaction, Dominant - Recessive); polygenic inheritance; numericals based on above; extrachromosomal inheritance (Chloroplast Inheritance: Variation in Four O` clock plant; Mitochondrial inheritance: petite mutants in yeast); Maternal effect (shell coiling in snails).

UNIT-II: (15 Hours)

Classical and molecular concept of gene Mutations and Chromosomal Aberrations: Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy; Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations; structural and numerical alteration of chromosomes,Central Dogma.

UNIT-III: (12 Hours)

Linkage, Crossing Over, Chromosomal Mapping and Human Genetics: Linkage, crossing over; one, two or three point crossovers, chromosomal mapping, Interference and coincidence, chromosomal and genetic disorders; genetic code and Wobble's hypothesis, sex linkage (eye color in *Drosophila*; colour blindness and haemophilia in humans, dosage compensation.

UNIT-IV: (6 Hours)

Haploidy, polyploidy, autopolyploidy (examples: banana, watermelon), allopolyploidy (ancestry of wheat) and aneuploidy (Down's, Turner's and Klinefelter's syndromes); Deletion; Duplication (Bar eye in *Drosophila*); Inversion (paracentric and pericentric); Translocation (*Rhoeo, Oenothera;* Robertsonian translocation, Familial Down Syndrome and cancer).

PRACTICAL (30 Hours)

1. Study of Linkage, recombination, gene mapping using charts.

2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square. Chromosome mapping using point test cross data.
3. Pedigree analysis for dominant and recessive autosomal and sex-linked traits.
4. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
5. Blood Typing: ABO groups & Rh factor. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
6. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
7. Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red-green Colour blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached ear lobe.

SUGGESTED READINGS:

1. Russel P. J. (2010). Genetics- A Molecular Approach, Pearson Education Inc.
2. Gardner E. J., Simmons M. J., Snustad D. P. (1991). Principles of Genetics, John Wiley & Sons.
3. Strickberger M.W. (2008). Genetics, Pearson (Prentice Hall).
4. Acquaah G (2007). Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd. USA.
5. Allard R. W. (1999). Principles of Plant Breeding, John Wiley and Sons.
6. Singh R. J. (2002). Plant Cytogenetics, CRC Press.
7. Hartwell L. H., Hood L., Goldberg M. L., Reynolds A. E., Silver L. M., Veres R. C. (2006). Genetics-From Genes to Genomes, McGraw Hill
8. Lewin B. (2008). Genes IX, Jones and Barlett Publishers.
9. Hartl D. L. and Jones E. W. (2007). Genetics-Analysis of Genes and Genomes, Jones and Barlett publishers.

Zoo.311 Comparative Anatomy of Vertebrates 3+1

LEARNING OBJECTIVES:

The primary objective of this course is -

- The course will provide a thorough understanding of the different vertebrate structures and their functions
- It will enable the student to study animal physiology in more details

LEARNING OUTCOMES:

This course will enable the students to:

- Make comparison among different systems of the vertebrates

THEORY (45 Hours)

UNIT I: (15 Hours)

Integumentary System: Structure, function and development of its derivatives.
Skeletal System: Evolution of visceral arches.
Digestive System: Brief account of alimentary canal and digestive glands in vertebrates, Structure of stomach in cattle.

UNIT-II: **(15 Hours)**

Circulatory System: Evolution of heart and aortic arches and visceral arches
Respiratory System:Respiratory system in birds and mammals, Accessory respiratory organs
Urino Genital System: Evolution and succession of kidney and genital ducts

UNIT-III: **(15 Hours)**

Nervous System: Evolution of brain, cerebral hemispheres and cerebellum in vertebrates
Sense Organs Types of receptors, Eye, Ear comparative account in vertebrates

PRACTICAL (30 Hours)

1. Comparative study of digestive system vertebrates studied in theory through charts.
2. Comparative study of Heart of vertebrates studied in theory through charts.
3. Comparative study of kidney of vertebrates studied in theory through charts.
4. Comparative study of brain of vertebrates studied in theory through charts.
5. To study the sections of eye in vertebrates
6. Comparative study of Accessory respiratory organs

SUGGESTED READINGS:

1. Kardong, K.V. (2005) *Vertebrates 'Comparative Anatomy, Function and Evolution*. IV Edition. McGraw-Hill Higher Education.
2. Kent,G.C. and Carr R.K. (2000). *Comparative Anatomy of the Vertebrates*. IX Edition. The McGraw-Hill Companies.
3. Modern Text Book of Zoology-Vertebrates By- R.L. Kotpal, Rastogi Publications
4. Modern's Zoology Vol. I- Vertebrate Zoology By –Ashok Sabharwal and Dr. S.K. Malhotra

Zoo.321 **Applied Zoology** **3+1**

LEARNING OBJECTIVES:

The primary objective of this course is -

- It deals with the application of zoological knowledge for the benefit of mankind by understanding the economy, health and welfare of humans.
- It includes culturing organisms for mass production for human use and to control or eradicate harmful ones.
- It will bring to the fore the multidisciplinary nature of Economic Zoology as it includes sericulture, apiculture, aquaculture, pisciculture and insect pests of agriculture.

LEARNING OUTCOMES:

This course will enable the students to:

- Understand different parasites and their life cycles
- Understand agriculturally important insect pests based on their morphological characteristics/structures.
- develop a critical understanding of the contribution of organisms to the welfare of society.
- examine the diversity of insect pests of different orders in the agro-ecosystem and sustainable pest management strategies.

THEORY(45 Hours)

UNIT-I: (15 Hours)

Introduction to Host-Parasite Relationship: Host, Definitive host, Intermediate host, Parasitism, Symbiosis, Commensalism, Reservoir, Zoonosis. Epidemiology of Diseases: Brief account of arthropods as direct agents of diseases-malaria, filiariasis and plague; Epidemic diseases such as typhoid, cholera and small pox, their occurrence and eradication programmes.

UNIT-II: (15 Hours)

Protozoans and Helminthes: Brief account of diseases caused by:
Pathogenic protozoa: *Entamoeba, Trypanosoma, Leishmania, Giardia, Trichomonas.*
Pathogenic helminthes: *Fasciolopsis, Schistosomiasis, Echinocccus, Ancylostoma, Trichinella, Wuchereria, Dracunculus* and *Oxyuris*.
Insects of Economic Importance: Biology, Control and damage caused by *Helicoverpaarmigera, Pyrillaperpusilla* and *Papilio demoleus, Callosobruchus chinensis, Sitophilus oryzae and Triboliumcastaneum*

UNIT-III (15 Hours)

Insects of Medical Importance: Medical importance and control of *Pediculus humanus corporis, Anopheles, Culex, Aedes, Xenopsyllacheopis.*
Toxicity and Pest Management: Definition of toxicity, classification of toxicants, toxic agents and their modes of action; study and identification of major crop pest, common house hold pest, stored grain pests, common plant protection appliances and pest control
Economic Zoology: Brief account of sericulture, lac culture, poultry farming, apiculture and pisciculture.

PRACTICAL (30 Hours)

1. Study of histopathological slides, pathogenic protozoans and parasitic helminthes and their life stages through permanent slides/photomicrographs or specimens.
2. Study of arthropod vectors associated with human diseases.
3. Study of insect damage to different plant parts/stored grains through damaged products/photographs.
4. Identification of cultivable prawns, crabs, lobsters, food fishes, ornamental and exotic fishes.
5. Study of different stages of silkworm and honey bee from egg to adult stage.
6. Visit to poultry farm or animal breeding centre/ apiary. Submission of visit report.
7. Maintenance of fresh water aquarium.

SUGGESTED READINGS:

1. Park, K.(2007).*Preventive and Social Medicine*. XVI Edition. B.B Publishers.
2. Arora, D.R and Arora B. (2001). *Medical Parasitology*. II Edition. CBS Publications and Distributors.
3. Atwal, A.S. (1986). Agricultural Pests of India and South East Asia, Kalyani Publishers.
4. Hafez, E. S. E. (1962). *Reproduction in Farm Animals*. Lea & Fabiger Publisher
5. Economic Zoology by Shukla and Upadhyay, Merrut, India.

DISCIPLINE SPECIFIC ELECTIVE COURSES:

Zoo.212 Ecology 3+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To enable the students to the concept of ecology and ecosystem and introduce them to various interactions among organisms and environment.
- To provide knowledge of dynamics of ecosystems in relation to human life.

LEARNING OUTCOMES:

This course will enable the students to understand:

- The process that shape the distribution and abundance of organisms from the micro-habitat to the globe.
- Recognize that the distribution of organisms is a product of positive and negative interactions within and across the trophic levels including competition, mutualism, predation and parasitism.
- The evolution of organism form and function influences ecological interactions and habitat tolerance

THEORY (45 Hours)

UNIT 1: Plants and environment (7 Hours)

Ecological factors: Atmosphere (gaseous composition). Water (properties of water and water cycle), light (global radiation, photosynthetically active radiation), temperature, soil (development, soil profiles, physico-chemical properties), and biota.

UNIT 2: Ecological adaptations (6 Hours)

Morphological, anatomical and physiological responses of plants to water (hydrophytes and xerophytes), temperature (thermoperiodictity and vernalization), light (photoperiodism, heliophytes and sciophytes) and salinity.

UNIT 3: Population ecology (8 Hours)

Definition, Population characteristics, population dynamics & regulation, ecotypes, ecads.

UNIT 4: Community ecology (8 Hours)

Definition**,** Community characteristics, Biological spectrum, Ecological succession.

UNIT 5: Ecosystems (10 Hours)

Structure (biotic and abiotic components) ecological pyramids, and function of ecosystems; food chain, food web, energy flow; biogeochemical cycles of carbon, nitrogen and phosphorus.

UNIT 6: Biogeographical regions of India (6 Hours)

General account of biogeographical regions of India, Vegetation types of India: Forests and grasslands

PRACTICAL(30 Hours)

1. Determination of minimum quadrat size for the study of herbaceous vegetation/animals through species area curve method.
2. Quantitative analysis of herbaceous vegetation for frequency and comparison with Raunkiaer's frequency distribution law.
3. Study of instruments used to measure microclimatic variables: soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
4. Determination of pH, porosity, and moisture content of soil of minimum three different habitats.
5. To estimate transparency, pH, and temperature of different water bodies.
6. To estimate dust holding capacity of the leaves of different plant species.

SUGGESTED READINGS:

1. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4thedition.
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8thedition.
3. Simpson, M.G. (2006). *Plant Systematics.* Elsevier Academic Press, San Diego, CA, U.S.A.
4. Singh, G.(2012).*Plant Systematics:* theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rdedition.

Zoo.213 Basic Cell biology 3+1

LEARNING OBJECTIVES:

The primary objective of this course is -

- The very purpose of this course is to acquaint the students with basics of cell and its organelles and the basic processes of the cell.
- This course aims to impart knowledge of various mechanisms of cell functioning.

LEARNING OUTCOMES:

This course will enable the students to:

- Get well acquaint with the concept of cell and related functioning and its working

THEORY(45 Hours)

UNIT –I (15 Hours)

Techniques in Biology: Principles of microscopy; Light Microscopy; Phase contrast microscopy; Sample Preparation for light microscopy; Electron microscopy (EM)- Scanning EM and Scanning Transmission EM (STEM); Sample Preparation for electron microscopy; Cell as a unit of Life: The Cell theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components.

UNIT – II (15 Hours)

Cell Organelles:Mitochondria: Structure and function. ChloroplastStructure and function.

ER, Golgi body: Structures and roles.
Peroxisomes, Glyoxisomes and vacuole: Structures, composition, functions in animals and plants
Nucleus: Nuclear Envelope- structure of nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure (brief).

UNIT – III **(15 Hours)**

Cell Membrane and Cell Wall: The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Selective permeability of the membranes; Cell wall. Cell Cycle: Overview of Cell cycle, Mitosis and Meiosis. Replication, transcription, and translation in prokaryotes; Regulation of gene expression: Prokaryotes: Lac operon and Tryptophan operon

PRACTICAL (30 Hours)

1. To study prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light and electron micrographs.
2. Study of the photomicrographs of cell organelles
3. To study the structure of animal cell through temporary mounts.
4. Study of mitosis and meiosis (temporary mounts and permanent slides).
5. Prepare the slide of bar body in human cheek cells.
6. Measure the cell size (either length or breadth diameter) by micrometry.
7. Study the structure of nuclear pore complex by photograph (from Gerald Karp) Study of special chromosomes (polytene & lamp brush) either by slides or photographs.
8. Study DNA packaging by micrographs.
9. To study cell structure from onion leaf peels.
10. Demonstration of staining and mounting methods
11. Study of electron micrograph of viruses, bacteria, cyanobacteria and eukaryotic cells for comparative cellular organization.

SUGGESTED READINGS:

1. Cell Biology and Molecular Biology by D. Robertis, EDP & DE Robertis E.M.F, 8th ed., Saunders & Co. Philadelphia (1995).
2. Cell Biology by C.B. Powar, 3rd ed., Himalaya Pub., Bombay (1984).
3. Advances in Cell and Molecular Biology by Dupraw, E.J., eds. Academic Press, New York & London (1971).
4. Cell Biology. Pollard, Thomas, D.S. Earnshan, William C. Saunders. USA. (2002).
5. The Cell: A Molecular Approach by Cooper GM & H 5th edition (2009).
6. Molecular Biology of the Cell, 5th edition by Alberts, John Raff. Roberts & Walter (2008).
7. Cell and Molecular Biology: Concepts and Experiments 5th edition by Gerald Karp. John Wiley and Saunders. 8. Molecular Cell Biology by Lodish et. al. W.H. Freeman Co. New York (2008).

Zoo.222 **Biochemistry** **3+1**

LEARNING OBJECTIVES:

The primary objective of this course is:

- To educate student on concepts of proteins, and enzymes
- To introduce the basic knowledge of cellular metabolism in animals

LEARNING OUTCOMES:

This course will enable the students to understand:

- Students will be taught about proteins, and their biosynthesis,
- The course will also teach about catalytic mechanistic of enzymes, its inhibitors and regulation
- The course will strengthen the basic ideas about metabolism of carbohydrates, proteins and lipids

THEORY (45 Hours)

UNIT-I: Elementary Idea of Analytical and Separation Techniques (6Hours)

Ultracentrifugation, electrophoresis and chromatography

UNIT-II: Chemical Nature of Protoplasm (6Hours)

Chemistry of carbohydrates, proteins, lipids and nucleic acids

UNIT-III: Enzymes and Co-Enzymes (15Hours)

Definition, nature, functions; Specificity and classification of enzymes and co-enzymes, enzyme action; high energy compound: phosphagens, phosphate bonding, formation of ATP, energy release and oxidation mechanism.

UNIT-IV: Carbohydrate Metabolism (6Hours)

Glycolysis, Kreb's Cycle, Pentose phosphate pathway, Gluconeogenesis, Glycogen metabolism, Review of electron transport chain

UNIT-V: Lipid Metabolism (6Hours)

Oxidation of fatty acids; fate of glycerol

UNIT-VI: Protein Metabolism (6 Hours)

Transamination, Deamination and Ornithine Cycle.

PRACTICAL (30 Hours)

1. Qualitative and quantitative tests for carbohydrates
2. Estimation of reducing and non-reducing sugars
3. Qualitative and quantitative tests for amino acids
4. Separation of amino acids by paper chromatography
5. Qualitative and quantitative tests for lipids
6. Qualitative and quantitative tests for proteins
7. Estimation of proteins
8. Determination of pH and use of pH meter.
9. Study of metabolism through charts.

SUGGESTED READINGS:

1. Tortora, G.J. and Derrickson, B.H. (2009). Principles of Anatomy and Physiology, XII Edition, John Wiley & Sons, Inc.

2. Guyton, A.C. and Hall, J.E.(2011). Textbook of Medical Physiology, XIIEdition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
3. Modern's Zoology. Biochemistry and Mammalian physiology by – Sabharwal and Sabharwal.
4. Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
5. Talwar, G.P. & Srivastava, M. Textbook of Biochemistry and Human Biology, 3rd Ed. PHI Learning.

Zoo.223 Evolutionary Biology 3+1

LEARNING OBJECTIVES:

The primary objective of this course is -

- To provide comprehensive overview of Concept of Evolution.
- To explore salient features of various theories of evolution comprising of Lamarckism, Darwinism and Neo-Darwinism
- To develop comprehensive knowledge regarding various Sources of Variations and their role in evolution.

LEARNING OUTCOMES:

This course will enable the students to:

- After successful accomplishment of the course, the students will be able to learn most of the essential aspects of Evolutionary Biology in detail which will help them in acquiring better understanding regarding the subject.
- Understand the Phylogenetic Trees and highlight their construction along with interpretation.
- Learner will have descriptive knowledge regarding Origin and Evolution of Man.

THEORY (45 Hours)

UNIT-I: (15 Hours)

Concept and Theories of Organic Evolution: Concept and evidences of organic evolution; Origin of Prokaryotes and Eukaryotes; Theories of organic evolution: Lamarckism, Darwinism, mutation, and synthetic theory; Origin of life.

UNIT-II: (15 Hours)

Fossils and Processes of Evolutionary Change: Types of fossils, Incompleteness of fossil record, Dating of fossils, Phylogeny of horse and human; Organic variations; Isolating Mechanisms; Natural selection (Example: Industrial melanism); Types of natural selection (Directional, Stabilizing, Disruptive), Artificial selection. Population Genetics: Hardy-Weinberg Law & Genetic Drift

UNIT-III (15 Hours)

Species Concept: Biological species concept (Advantages and Limitations); Modes of speciation (Allopatric, Sympatric), Study of Phylogenetic Trees
Realms and Adaptations: A brief account of zoo-geographical regions; adaptations and adaptive radiations.

PRACTICAL (30 Hours)

1. Adaptive modifications in the beaks and feet of birds and mouth parts of insects.
2. Study of fossil evidences from plaster cast models and pictures.
3. Study of homology and analogy from suitable specimens/ pictures.
4. Phylogeny of horse with diagrams/ cut outs of limbs and teeth of horse ancestors.
5. Phylogeny of human being with diagrams/models.
6. Project report on chromosomal and genetic disorders.

SUGGESTED READINGS:

1. Hall, B. K. and Hallgrimsson, B. (2008). Evolution. IV Edition. Jones and BartlettPublishers.
2. Text book of evolution by Bir Bala Rastogi

Zoo.322 Developmental Biology 3+1

LEARNING OBJECTIVES:

The primary objective of this course is -

- The course will provide the students a complete comprehension about the essential vertebrate developmental biology
- The course will help the students to understand the conundrum of the different levels of biological complexity by tracing them back to events at the level of genes and genomes

LEARNING OUTCOMES:

This course will enable the students to:

- Know the evolution of different concepts in developmental biology.
- Be able to understand the process of gamete formation from stem cell population to mature ova and sperm. The students will know the differences between Spermatogenesis and Oogenesis.
- Be able to comprehend the sequence of steps leading to the fusion of gametes and learn the contribution of sperm and ova to zygote formation
- Be able to understand how polyspermy is avoided in animal kingdom.
- Learn the methods and tools related to developmental biology help to understand different processes of embryogenesis

THEORY(45 Hours)

UNIT-I: (15 Hours)

Introduction to developmental Biology, Historical perspective including contributions by eminent scientists and landmark experiments in the field of Developmental Biology, Early Development, Blastulation and Gastrulation: Types of eggs, gametogenesis; spermatogenesis and oogenesis; process offertilization, Fast and slow blocks to Polyspermy

UNIT-II: (15 Hours)

Cleavage and its types, Process of blastulation and gastrulation in *Amphioxus*, frog and chick; Fate map construction in frog and chick; Metamorphosis in frog

UNIT-III: (15 Hours)

Extra Embryonic Membranes and Placentation: Embryonic and extra embryonic membranes in birds and mammals; Placenta in mammals, Implantation, Parturition and Lactation

PRACTICAL (30 Hours)

1. Frog - Study of developmental stages - whole mounts and sections through permanent slides - cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages.
2. Chick-13-18 hrs, 24-33 hrs, 36-48 hrs, 48-72 hrs.
3. Studyofthedifferenttypesofplacenta-histologicalsectionsthroughpermanentslidesor photomicrographs.
4. Examination of gametes-Frog/Rat- sperm and ova through permanent slides or photomicrographs.

SUGGESTED READINGS:

1. Gilbert, S.F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.
3. Freeman and Bracegirdle (1975, 2nd Edition) "An Atlas of Embryology", Published by Heinmann.
4. Kalthoff Klaus (2001) Analysis of Biological Development, 2nd ed. Boston, MA: Mc Graw-Hill, ISBN: 0071180788
5. Wolpert, L & Tickle, C (2011) Principles of Developmental Biology (4th edition). Oxford University Press, ISBN: 9780198792918
6. Carlson, Bruce M (1996). Patten's Foundations of Embryology, McGraw Hill, Inc. ISBN: 9780070634275

Zoo.323 Aquatic Biology 3+1

LEARNING OBJECTIVES:

The primary objective of this course is –

- This course offers a comprehensive knowledge on life in freshwater and marine environments; lakes; stream and their characteristics, adaptations of organisms, water resource management; nutrient cycling; major threats to aquatic systems, pollution, and eutrophication.
- To impart knowledge and understanding of basic laboratory equipment and practice of water quality analysis, to study of aquatic plants.
- To introduce various freshwater and marine ecosystems and its components.
- To understand the biodiversity and productivity of freshwater and marine environments.

LEARNING OUTCOMES:

This course will enable the students to:

- Be acquainted with the physico-chemical environment, and its role in aquatic ecosystem.
- Learn about adaptations unveiled by organisms to survive in these distinctive conditions.

- well-versed with the laws governing the use of freshwater systems, as well as the local, state, federal, and international agencies that enforce these laws to protect endangered and vulnerable species.
- Understand and apply relevant scientific principles in the area of aquatic biology and educate others or work to conserve our natural resources.
- Realize impact of human activities on aquatic organisms.

THEORY(45 Hours)

UNIT-I: (15 Hours)

Aquatic Biomes: Brief introduction of the aquatic biomes: Freshwater ecosystem (lakes, wetlands, streams andrivers),estuaries,intertidalzones,oceanicpelagiczone,marine benthic zone and coral reefs.

UNIT-II: (15 Hours)

Freshwater Biology: Lakes: Origin and classification, Lake as an Ecosystem, Lakemorphometry, Physico-chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Nutrient Cyclesin Lakes-Nitrogen, Sulphur and Phosphorous.
Streams: Differentstagesofstreamdevelopment, Physico-chemical environment, Adaptation of hill-stream fishes.

UNIT-II: (15 Hours)

Marine Biology: Salinity and density of Seawater, Continental shelf, Adaptations of deep-seaorganisms, Seaweeds. Management Of Aquatic Resources. Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation(legislations), Sewage treatment Water quality assessment-BOD and COD.

PRACTICAL (30 Hours)

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the importantmacrophytes,phytoplanktonsandzooplanktons present in a lake ecosystem.
3. Study of aquatic organisms - prawns, oysters, and fishes (any three) through museum specimens in the laboratory with details on their classification, distribution, and specialized features.
4. Determine the amount of Turbidity/transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates&bicarbonates) in water collected from a nearby lake/waterbody.
5. Instruments used in limnology (Secchidisc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.
6. A Project Report on a visit to a Sewage treatment plant/Marinebio- reserve/Fisheries Institutes.

SUGGESTED READINGS:

1. Anathakrishnan: Bioresources Ecology3rdEdition
2. Goldman: Limnology, 2ndEdition
3. Odum and Barrett: Fundamentals of Ecology, 5th Edition
4. Pawlowski: Physicochemical Methods for Water and Waste water Treatment, 1st Edition
5. Trivedi and Goya: Chemical and biological methods for water pollution studies

HIGHER LEVEL DISCIPLINE SPECIFIC COURSES:

Zoo.411 **Immunology** **3+1**

LEARNING OBJECTIVES:

The primary objective of this course is -

- The very purpose of this course is to acquaint the students with components of immune system
- This course aims to impart knowledge of various mechanisms of immune responses.

LEARNING OUTCOMES:

This course will enable the students to:

- Get well acquaint with the concept of immunology and related functioning and its mechanisms.

THEORY (45 Hours)

UNIT-I **(10 Hours)**

Overview of the Immune System: Introduction to basic concepts in immunology, components of immune system, principles of innate and adaptive immune system.

UNIT-2 **(20 Hours)**

Cells and Organs of the Immune System: Haematopoeisis, Cells of immune system and organs (primary and secondary lymphoid organs) of the immune system. Antigens: Basic properties of antigens and antibodies, Structure, classes and function of antibodies, monoclonal antibodies, B and T cell epitopes, haptens and adjuvants, hypersensitivity.

UNIT-3 **(15 Hours)**

Working of the Immune System and its role in Health: Structure and functions of MHC, exogenous and Endogenous pathways of antigen presentation and processing, Basic properties, and functions of cytokines, Complement system: Components and pathways. Gell and Coombs' classification and brief description of various types of hypersensitivities, Introduction to concepts of autoimmunity and immunodeficiency, vaccines, and its types.

PRACTICAL (30 Hours)

1. Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/ photographs.
3. Preparation of stained blood film to study various types of blood cells.
4. ABO blood group determination.
5. Study different immunological techniques

SUGGESTED READINGS:

1. Kindt,T.J.,Goldsby,R.A.,Osborne,B.A.andKuby,J(2006).Immunology,VIEdition.W.H.Freeman and Company.

2. David, M., Jonathan, B., David, R.B. and Ivan R. (2006). Immunology, VII Edition, Mosby, Elsevier, Publication.
3. Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology. Vth Edition. Saunders Publication.
3. Immunology by J.P. Bellanti
4. Fundamentals of Immunology by W.E. Paul
5. Essential Immunology by J.M. Roitt
6. Immunology by E.S. Golub
7. Immunology by E. Benjamini, R. Coico and G. Sunshine

Zoo.412 Entomology 3+1

LEARNING OBJECTIVES:

The primary objective of this course is –

- To make student aware about the insects their classification and societies and also their structure and economic importance.

LEARNING OUTCOME:

- To impart knowledge to students on ecological and physiological aspects of Insects, which dominate in number among all living organisms.
- To make the students understand the adaptations of these animals to their environment and theconcept of insect societies.

THEORY (45 Hours)

UNIT- I (15 Hours)

General features of insects. Distribution and success of insects on the earth; structure and physiology of digestive and nervous systems, sensory receptors, and reproductive system. Insects as mechanical and biological vectors, brief discussion on houseflies and mosquitoes as important insect vectors.

UNIT- II (15 Hours)

Basis of insect classification; classification of insects up to orders, Salient features of different orders of insects, Preservation techniques. Growth and metamorphosis. External features; head, eyes, types of antennae. Mouth parts of insects with respect to their feeding habits. Thorax: wings and wing articulation, types of Legs adapted to diverse habitat. Abdominal appendages.

UNIT- III (15 Hours)

Insect Societies: Origin of sociality in insects, Ant society with reference to general habits including- caste system, nest construction, communication, brood care, thermoregulation, swarming, feeding, foraging and defense.

PRACTICAL(30 Hours)

1. Study of one specimen from each insect order
2. Study of different kinds of antennae, legs and mouth parts of insects
3. Study of head and sclerites of any one insect
4. Study of insect wings and their venation.

5. Methodology of collection, preservation and identification of insects through powerpoint.
6. Morphological studies of various castes of Apis, Camponotus and Odontotermes
7. Study of any three insect pests and their damages
8. Study of any three beneficial insects and their products
9. Field study of insects and submission of a project report on the insect diversity

SUGGESTED READINGS:

1. Mani, M.S. (1990) General Entomology, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, Calcutta, Bombay.
2. Chapman, R.F. (2013) The Insects, Structure & Function (eds; Simpson, S.J. and Douglass, A. E.) 5th ed., Cambridge University Press.
3. Richards, O. W. and Davies R. G. Imms (1997) General Text Book of Entomology, 10th ed., (reprint) B.I. Publications Pvt Ltd. New Delhi.
4. Wigglesworth, V.B. (2011) Insect Physiology, BiblioBazaar.
5. Imms, A.D. (1977). A General Text Book of Entomology. Chapman & Hall, U.K. ISBN No-9780412152306
6. Chapman, R.F. (2012). The Insects: Structure and Function. V Edition, Cambridge University Press, UK. ISBN No- 9780521113892
7. Snodgrass, R. E. (1993). Principles of Insect Morphology. Cornell Univ. Press, USA. ISBN No- 9780801481253
8. Borror, D. J., Triplehorn, C. A., and Johnson, N. F., M (2004) Introduction to the Study of Insects. Saunders College Publication, USA. ISBN No.: 978-0030968358
9. Wilson, E. O. (1971). The Insect Societies. Harward Univ. Press, UK. ISBN No. 9780674454903
10. Bernays, E. A., and Chapman, R. F. (1994).Host Selection by Phytophagous Insects. New York, USA. ISBN No. 9780585304557
11. Klowden, M. J. (2013). Physiological System in Insects. Academic Press, USA.ISBN No.: 9780124159709.
12. Nation, J. L. (2008). Insect Physiology and Biochemistry. CRC Press, USA. ISBN No. 78-1420061772

Zoo.413 Aquaculture and Fisheries 3+1

LEARNING OBJECTIVES:

The primary objectives of this course are:

- To introduce the basic concept of fisheries and aquaculture.
- Various Techniques of aquaculture

LEARNING OUTCOMES:

- The course will enable the students to understand different types of aquaculture system
- The course will enable the students to understand the steps for aquaculture
- Identification of various aquaculture species

THEORY (45 Hours)

UNIT-1 (15 Hours)

Principles of Aquaculture: Basics of aquaculture, definition and scope, history of aquaculture.Systems of aquaculture: pond culture, pen culture, cage culture, running water culture a zero-water exchange system, Extensive, semi-intensive, intensive, and super intensive aquaculture. Major candidate species for aquaculture: Fresh water, brakish and marine. Monoculture, polyculture, and integrated culture system.

UNIT –II (15 Hours)

Taxonomy of fish: Definition, component, importance, stages of taxonomy, Zoological nomenclature. Classification of Fishes

UNIT -III (15 Hours)

Fresh water aquaculture resources-ponds, tanks, lakes, reservoirs etc. Nursery, rearing and grow out ponds preparation and management – control of aquatic weeds and algal blooms, predatory and weed fish, liming fertilization and manuring. Water quality management. Transportation and acclimatization and seed.Composite fish culture system. Integration of aquaculture with agriculture/horticulture. Integration of aquaculture with livestock.

PRACTICAL(30 Hours)

Component of aquaculture farm, Water quality in relation to fish production, Practical's on pre-stocking and post stocking management. Preparation and management of nursery, rearing and grow out pond. Collection, identification and control of aquatic weeds, insects, predatory fish. Estimation of planktons. Identification of fresh water fishes. Identification of brackish and marine fishes

SUGGESTED READINGS:

1. Jayaram K.C. (2010). Fish Taxonomy. NPH
2. Jhingran V.G. fish and fisheries of India. Hindustan publication Corpn. (India) Delhi
3. Rath R. K. Fresh water aquaculture. Scientific publishers, Jodhpur 342001 India
4. Arumugam N. Aquaculture and Fisheries. Sara Publication

Zoo.421 Parasitology 3+1

LEARNING OBJECTIVES:

The primary objectives of this course are:

- To introduce the basic concept of host parasite interactions.
- To acquaint the students with important arthropod vectors.

LEARNING OUTCOMES:

- To enable the students to classify and study the variation in morphology, life cycle and pathogenesis of important parasites causing diseases in animals and human beings.

THEORY (45 Hours)

UNIT- I (15 Hours)

Brief introduction of Parasitism, Parasite, Parasitoid and Vectors (mechanical and biological vector). Host parasite relationship; Parasitic Protists; Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Entamoeba histolytica, Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani, Plasmodium vivax*

UNIT- II **(15Hours)**

Parasitic Platyhelminthes; Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Fasciola hepatica, Schistosoma haematobium, Taenia soliumand Hymenolepis nana*

UNIT- III **(15Hours)**

Parasitic Nematodes; Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides, Ancylostoma duodenale, wuchereria bancrofti* and *Trichinella spiralis*. Study of structure, life cycle and importance of *Meloidogyne* (root knot nematode), *Pratylencus* (lesion nematode); Parasitic Arthropoda Biology, importance and control of ticks, mites, *Pediculus humanus* (head and body louse), *Xenopsyll acheopis* and *Cimex lectularius* Parasitic Vertebrates A brief account of parasitic vertebrates; Cookicutter Shark, Candiru, Hood Mockingbird and Vampire bat.

PRACTICAL (30 Hours)

1. Study of life stages of Entamoeba histolytica, Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani and Plasmodium vivax through permanent slides/micro photographs.
2. Study of adult and life stages of *Fasciola hepatica, Schistosoma haematobium, Taenia solium and Hymenolepis nana* through permanent slides/micro photographs.
3. Study of adult and life stages of Ascaris lumbricoides, Ancylostoma duodenale, Wuchereria bancrofti and Trichinella spiralis through permanent slides/micro photographs.
4. Study of plant parasitic root knot nematode, *Meloidogyne* from the root and soil samples.
5. Study of Pediculus humanus (Head louse and Body louse), *Xenopsyll cheopis* and *Cimex lectularius* through permanent slides/ photographs.

6. Study of nematode/cestode parasites from the intestines of sheep/goat.
   [Intestine can be procured from poultry/market as a byproduct]

7. Submission of a brief report on vertebrate parasites.

SUGGESTED READINGS:

1. Arora, D. R and Arora, B. (2001). Medical Parasitology. II Edition. CBS Publications and
2. Distributors. ISBN No.- 8123915497
3. Noble, E.R. and Noble, G.A. (1982). Parasitology: The Biology of Animal Parasites. V
4. Edition, Lea &Febiger. ISBN-No.-0812111559;
5. Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007). Biology of Disease. Taylor and Francis Group. ISBN No.- 9780748772100
6. Parija, S. C. Textbook of Medical Parasitology, Protozoology & Helminthology (Text and
7. colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers,
8. Chennai, Delhi. ISBN No.-8180040437.
9. Rattan Lal Ichhpujani and Rajesh Bhatia. Medical Parasitology, III Edition, Jaypee Brothers
10. Medical Publishers (P) Ltd., New Delhi. ISBN No.- 9350250454

11. Meyer, Olsen & Schmidt's. Essentials of Parasitology, Murray, D. Dailey, W.C. Brown Publishers. ISBN No.-0697159833
12. Chatterjee, K. D. (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBS Publishers & Distributors (P) Ltd. ISBN No.-8123918100

Zoo.422 Human Physiology 3+1

LEARNING OBJECTIVES:

This course offers:

- an overview of the concepts of normal biological functions in the human body. The fundamentals of human physiology and histological structures will be correlated.
- The concept of homeostasis in response to changes in the external environment will be introduced.
- Further, students will be provided with knowledge that can be applied in everyday life.
- The students will be encouraged to pursue further studies in physiology and related fields as well as multidisciplinary subjects that require an understanding of the physiology of humans.

LEARNING OUTCOMES:

Upon completion of the course, students will be able to:

- Understand the principles of normal biological function in the human body.
- Outline basic human physiology and correlate it with histological structures.
- Understand the homeostasis in animals in response to changes in their external environment.

THEORY (45 Hours)

UNIT- I (15 Hours)

Types of Tissues; Structure and Function of Epithelial, Connective, Muscular and Nervous tissues. Nutrition and digestion: Vitamins, minerals and their role, Structure and function of digestive system; Digestion and absorption of carbohydrates, fats and proteins, Coordination and control of digestion Ultrastructure of a skeletal muscle, Differences between skeletal, cardiao and smooth muscle,Mechanism of contraction of skeletal muscle (Sliding filament theory); Generation of action potential; Neurotransmitters: Molecular mechanism of acetylcholine, catecholamine, serotonin- amino butyric and glycine; Structure of retina; Retinal rod cell excitation and visual cycle; colour vision; Mechanisms of auditory and olfactory responses.

UNIT- II (15 Hours)

Structure and function of respiratory tract and lungs; Ventilation, External and Internal respiration; Transport of oxygen and carbon dioxide in blood; Distribution and physiology of respiratory pigments, Carbon monoxide poisoning; Buffer systems: bicarbonate buffer system, phosphate buffer system, Protein buffer system; Respiratory regulation of acid base balance; Respiratory Quotient; Structure of heart, Composition of blood; Hematopoiesis and its molecular regulation; Biochemical interconversions during blood coagulation; Cardiac cycle and its regulatory mechanisms; factors influencing blood pressure and its related disorders.

UNIT- III (15 Hours)

Structural and functional organization of pituitary gland, Hormones secreted by thyroid, parathyroid, adrenal gland, pancreas, and their functions. Feedback inhibition, Hormonal regulation of mineral and electrolyte concentration; Functional anatomy of human kidney and its renal unit, Ultrafiltration, absorption and secretion mechanisms in urine formation, Kidney in acid base balance, Role of antidiuretic hormone and aldosterone; Histophysiology of mammalian gonads (Testis, Ovary), Hormones secreted by gonads Spermatogenesis and Oogenesis. Hormones and metabolism

PRACTICAL (30 Hours)

1. To prepare blood smear and perform DLC.
2. Preparation of haemin crystals.
3. Haemoglobin estimation using Sahli's haemoglobinometer.
4. Determination of ABO Blood group.
5. Recording of blood pressure using a Sphygmomanometer.
6. To study the effect of exercise on cardiovascular and respiratory system.
7. Examination and detailed study of permanent histological sections of human Stomach, Duodenum, Liver, Lung, Kidney, Pancreas, Testis, Ovary, muscle (skeletal, smooth, cardiac) and nerve.

SUGGESTED READINGS:

1. Tortora, G.J. and Derrickson, B.H. (2012). Principles of Anatomy and Physiology. XIIIth Edition, John Wiley and Sons, Inc.
2. Widmaier E, Raff H and Strang K. (2013). Vander's Human Physiology: The Mechanism of Body Functions. XIIIth Edition, McGraw-Hill Education.
3. Guyton, A.C. and Hall, J.E. (2011) Textbook of Medical Physiology. XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
4. Kesar, S. and Vashisht, N. (2007) Experimental Physiology. Heritage Publishers.
5. Prakash, G. (2012) Lab Manual on Blood Analysis and Medical Diagnostics. S. Chand and Company Ltd.
6. Prosser, C.L. and Brown, F.A. comparative Animal Physiology 2nd Ed. W.B. Sunders, Philadelplina.
7. Karpati, G., Jones, D.H. and Griggs. R.C. Disorders of Voluntary Muscle, 7th Edn, Cambridge University Press.
8. Turner, C.D. General Endocrinology, 4th Ed. W.B. Saunders, Philadelphia London.
9. Prosser, C.L., Comparative Animal Physiology, W.B. Saunders, Toppen Publication.

Zoo.423 Principles of Ecology 3+1

LEARNING OBJECTIVES:

The primary aim of this course is

- to develop a scientific understanding of the diverse aspects of the field of ecology.
- The students will be familiarized with the interactions between the organisms and their physical environment.
- Additionally, various attributes of populations and communities with help of theoretical concepts and field examples will be discussed.
- It provides a platform to understand the varied forces that lead to variations among populations of a species.

LEARNING OUTCOMES:

Upon completion of the course, the students should be able to:

- Demonstrate an understanding of the basic concepts of the subject
- Explain the characteristics, dynamics, and growth of populations
- Understand the characteristics of the community, ecosystem development and climax theories
- Gain knowledge about the relationship of the evolution of various species and the environment they live in.
- Design basic field studies, collect data and interpret it
- Carry out population and community studies

THEORY (45 Hours)

UNIT- I **(15 Hours)**

Autecology and Synecology, Laws of limiting factors, Study of physical factors: Temperature and Light.Unitary and Modular populations; Unique and group attributes of population: density, natality,
mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal, and dispersion; Exponential and logistic growth, equations and patterns, *r* and *k* strategies; Intraspecific population regulation: density-dependent and independent factors.

UNIT- II **(15 Hours)**

Types of species interactions, Interspecific competition: Lotka-Volterra model of competition, Gause's Principle with laboratory and field examples, Niche concept; Predation: Lotka-Volterra equations, Functional and numerical responses; Predation: Predator-Prey interaction, Role of predation in nature, predator defense mechanisms, Resource partitioning. Community characteristics: species richness, dominance, diversityconcepts and levels, role of biodiversity in ecosystem functions and stability, speciation and categories of threat, distribution, and global patterns, Terrestial biodiversity hot spots, abundance, guilds, ecotone and edge effect; Ecological succession with examples and types.

UNIT- III **(15 Hours)**

Types of Ecosystems: Terrestrial ecosystem, vertical stratification in tropical forest; Food chain: detritus and grazing food chains, linear and Y-shaped food chains, food web; Energy flowthrough the ecosystem; Ecological pyramids and Ecological efficiencies; global biogeochemical cycles, mineral cycles in terrestrial and aquatic ecosystems. Ecology in wildlife conservation and management, Protected areas: National Parks, Biospherereserves and Sanctuaries; Restoration ecology, Principles of Environmental impact assessment.

PRACTICAL (30 Hours)

1. Determination of population density in a natural or a hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index.
2. Study of an aquatic ecosystem:
    a) Phytoplankton and zooplankton
    b) Measurement of temperature, turbidity/penetration of light, determination of pH
    c) Dissolved oxygen content (Winkler's method), chemical oxygen demand
    d) Free carbon dioxide and alkalinity
3. Study of ten endemic animals of India with slides/pictures/videos.

4. Report on a visit to a National Park/Biodiversity Park/Wildlife Sanctuary.

SUGGESTED READINGS:

1. Odum, E.P. and Barrett G. W. (2008). Fundamentals of Ecology. Indian Edition (5th). Publisher: Brooks/Cole.
2. Smith T. M. and Smith R. L. (2015). Elements of Ecology. 9th International Edition. Publisher: Benjamin Cummings.
3. Saha G.K. and Mazumdar S. (2020) Wildlife Biology, An Indian Perspective. Publisher: PHI Learning Private Limited
4. Zimmer C. and Emlen D. J., (2013) 1st Edition. Evolution: Making Sense of Life, Roberts & Co.
5. Futuyma, Douglas and Mark, Kirkpatrick (2017) 3rd Edition. Evolutionary Biology, Oxford University Press

HIGHER & APPLIED AREA MINOR COURSES:

Zoo.414 Cytogenetics 3+1

LEARNING OBJECTIVES:

The primary objective of this course is -

- The very purpose of this course is to acquaint the students with cell cycle and architecture of chromosome in prokaryotes and eukaryotes and their gene regulation
- This course aims to impart knowledge of various mechanisms of cell functioning.

LEARNING OUTCOMES:

This course will enable the students to:

- Get well acquaint with the concept of cell and related functioning and its genetics.

THEORY (45 Hours)

UNIT I: (15 Hours)

Chromosome Organization: Structure of chromosomes, DNA packaging and Metaphase chromosomes, centromere, kinetochore, telomere and its importance, Heterochromatin and euchromatin, Chromosome banding, Polytene and lampbgrush chromosomes. Sex chromosomes, sex determination and dosage compensation in Drosophila and human. Structure and functions of cell and its organelles (Nucleus, plasma membrane, mitochondria, Golgi bodies, endoplasmic reticulumn, ribosomes and lysosomes).

UNIT II: (15 Hours)

Mendelian and non-Mendelian Inheritance: Mendelian inheritance and its modification, Maternal effect, Epigenetic inheritance, Extranuclear inheritance, Variation cbromosome structure and number. Genetic linkage mapping using molecular markers, cell cycle and its regulation; Protein sorting in ER, Golgi and targeting of proteins to Mitochondria, secretory and endocytotic pathway; Cell-Cell signalling: Cell surface receptors, Second messenger system, MAP kinase pathways, Signalling from plasma membrane to nucleus.

UNIT III: (15 Hours)

Brief description of gene expression: Genetic code, Transcription and translation in prokaryotes and eukaryotes, Regulation of gene expression, Gene mutation and DNA repair: Consequences of mutations Occurrence

PRACTICAL (30 Hours)

1. Demonstration of SEM and TEM and study of different micrographs
2. Study of Problems based on Genetics
3. Study of permanent histological slides of testis and ovaries of insects/ mice/rat.
4. Basis of reaction and demonstration of the sites of proteins, nucleic acids, lipids & carbohydrates in ovaries of insects/rat/mice through slides and photographs.
5. Study of stages of mitosis and meiosis from permanent slides from animal and plant materials through slides/charts/photographs.

SUGGESTED READINGS:

1. Cell Biology and Molecular Biology by D. Robertis, EDP & DE Robertis E.M.F, 8th ed., Saunders & Co. Philadelphia (1995).
2. Cell Biology by C.B. Powar, 3rd ed., Himalaya Pub., Bombay (1984).
3. Advances in Cell and Molecular Biology by Dupraw, E.J., eds. Academic Press, New York & London (1971).
4. Cell Biology. Pollard, Thomas, D.S. Earnshan, William C. Saunders. USA. (2002).
5. The Cell: A Molecular Approach by Cooper GM & H 5th edition (2009).
6. Molecular Biology of the Cell, 5th edition by Alberts, John Raff. Roberts & Walter (2008).
7. Cell and Molecular Biology: Concepts and Experiments 5th edition by Gerald Karp. John Wiley and Saunders.
8. Molecular Cell Biology by Lodish et. al. W.H. Freeman Co. New York (2008).

Zoo.415 Wildlife and its Conservation 3+1

LEARNING OBJECTIVES:

The primary objectives of this course are:

- To acquaint the students with varied aspects of wildlife conservation, including its importance, major threats, and management of their habitats and populations.
- The emphasis will be on developing interest and invoking a sense of responsibility among students towards wildlife conservation.
- The course also explores different techniques, perspectives, and approaches to both identify and achieve wildlife management goals.
- To motivate students to pursue a career in the field of wildlife conservation and Management

LEARNING OUTCOMES:

By studying this course, students will be able to:

- To enable the students to understand the importance of wildlife and different laws of wildlife protection.
- Appreciate wildlife in general and realize its conservation and management in particular.

- Better understand the application of the principles of ecology and animal behaviour to formulate strategies for the management of wildlife populations and their habitats.
- Understand the management practices required to achieve a healthy ecosystem for wildlife population along with emphasis on conservation and restoration.

THEORY (45 Hours)

UNIT- I (15 Hours)

Values of wildlife/Wildlife and its scope in India/Types of wildlife and their status/ Wildlife depletion and its causes. Wildlife corridors, Wildlife legislation, Wildlife Protection Act, 1972, Wildlife trade, Wildlife Safari, Wild animal's projects, Wildlife and tribal welfare, Wildlife research in India and world

UNIT- II (15Hours)

Wildlife education/ India's wildlife/ Wildlife conservation, Importance of wild animals and their conservation, Wild animals and artificial insemination and captive breeding, Wildlife sanctuaries, National Parks, Biosphere reserves/Germplasm stations, seed banks and pollen banks/ Zoological Gardens in India/ Western Ghats/Eastern Ghats/ Himalayan Biodiversity/Government Institutions involved in wildlife research and conservation/NGO's involved in wildlife research and conservation

UNIT- III (15Hours)

ICUN List of endangered animals, critically endangered species, vulnerable species, Ramsar wetlands/ Mega biodiversity centres/ Biodiversity hotspots/ Biodiversity heritage sites.Protected area network/ Biodiversity mapping and prospecting/Wildlife census, techniques, and biodiversity index

PRACTICAL (30 Hours)

1. To prepare report on the Himalayan biodiversity of wild animals,
2. To study bird fauna of Himachal.
3. To visit Zoo/ national park/safari
4. To study wildlife fauna through photographs.
5. To study the different endangered, critically endangered animals
6. To study project tiger, project elephant
7. Demonstration of basic equipment needed in wildlife studies- use, care and
8. maintenance (Compass, Binoculars, Spotting cope, Range Finders, Global Positioning System, Various types of Cameras and lenses).
9. Familiarization and study of animal evidences in the field: Identification of animalsthrough pugmarks, hoof marks and scats.
10. Trail/ transect monitoring for abundance and diversity estimation of mammals andbird (direct and indirect evidences).
11. Identification of Big cats: Lion, Tiger, Cheetah, Leopard and Jaguar.

SUGGESTED READINGS:

1. Hudson, P.J., Rizzoli, A., Grenfell, B.T. Heestrbeek, H. and Dobson, A.P. (2002) The Ecology of Wildlife Diseases. Oxford University Press, Oxford.
2. Banerjee, K. (2002) Biodiversity Conservation in Managed and Protected Areas. Agrobios, India.
3. Kenneth Anderson (2000) The Kenneth Anderson Omnibus Vol I. Rupa Publications.

4. Jim Corbett. (2017) Man Eaters of Kumaon. Om Books International.
5. Saha, G.K. and Mazumdar, S. (2017) Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd. ISBN: 8120353137, 978-812035313.
6. Sinclair, A.R.E., Fryxell, J.M. and Caughley, G. (2006) Wildlife Ecology, Conservation and Management. Wiley-Blackwell, Oxford, UK.
7. Singh, S.K. (2005) Text Book of Wildlife Management. IBDC, Lucknow

Zoo.424 Biotechnology and Bioinformatics 3+1

LEARNING OBJECTIVES:

- Acquaint students to the principles, practices andwith various approaches of conducting genetic engineering and their applications in biological research as well as in biotechnology industries.

LEARNING OUTCOMES:

- On completion of this course, students should be endowed with strong theoretical knowledge of biotechnology and bioinformatics and is able to take up biological research with better understanding.

THEORY (45 Hours)

UNIT-I (15 Hours)

Basic biomolecular concepts: central dogma; DNA replication semi-conservative, Transcription and RNA Processing in Eukaryotic Cells, Expression of genetic information: from Transcription to Translation - Genetic code, Decoding the codons: the role of transfer RNAs. Genetic Engineering: Enzymes useful in molecular cloning: Restriction endonuclease, DNA ligases, polynucleotide kinase, klenow enzyme, DNA Polymerase- I, reverse transcriptase, alkaline phosphatase, terminal nucleotidyltransferase; Molecular markers - Restriction based and PCR based: RFLP, RAPD, AFLP, ISSR, SNP, SSR; Marker-assisted selection - strategies for introducing genes of biotic and abiotic stress resistance in plants: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; Cloning Vectors - Plasmids (pBR 322, pUC), Vectors for Plant and Animal Cells, Shuttle Vectors, YAC Vectors, Expression Vectors Recombinant DNA technology; Labeling nucleic acids and blotting techniques (Southern, Northern, Western, Zooblot); transformation; Polymerase Chain Reaction and its applications;DNA fingerprinting-principles and applications.

UNIT-II (12 Hours)

Genetic engineering: Gene transfer methods-Biological, physical, chemical; Agrobacterium-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation; characterization of transgenics; concept of plants as biofactories

UNIT – III (12Hours)

Transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species; Vaccinology: history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.

UNIT – IV **(6 Hours)**

Overview of genomics – definition, complexity, and classification; need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype; genome projects and bioinformatics resources for genome research – databases; overview of forward and reverse genetics for assigning function for genes
RNAi, CRISPR-CAS; History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for *in vivo* genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.

PRACTICALS (30 Hours)

1. Introduction to Instruments used in Molecular Biology /GE Laboratory
2. Preparation of Buffers.
3. DNA isolation and DNA quantitation
4. Polymerase Chain Reaction and analysis by agarose gel electrophoresis
5. Transformation of E.coli with standard plasmids and calculation of transformation efficiency
6. Confirmation of the insert by Colony PCR and Restriction mapping
7. Explore different softwares of bioinformatics analysis

SUGGESTED READINGS:

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: An Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
4. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
5. Umesha, S. (2013). *Plant Biotechnology.* The Energy and Resources.

RESEARCH/PROJECT/SEMINAR:

Zoo.391 **Seminar** **0+1**

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Identify and compare technical and practical issues related to the area of course specialization.
- Outline annotated bibliography of research demonstrating scholarly skills.
- Prepare a well-organized report employing elements of technical writing and critical thinking.
- Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

LEARNING OUTCOMES:

At the end of this course, students will be able to:

- Establish motivation for any topic of interest and develop a thought process for technical presentation.
- Organize a detailed literature survey and build a document with respect to technical publications.
- Analysis and comprehension of proof-of-concept and related data.
- Effective presentation and improve soft skills.
- Make use of new and recent technology for creating technical reports
- Will be able to present themselves in front of an audience. It will help them to develop skills like speaking ability, gain and express knowledge in different fields and presentation capability. They will also learn to defend themselves in front of a panel of Seminar Committee.

Zoo.491 Pre-Research 0+4

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Identifying the Research Problem.
- Performing a Literature Review & Writing a Theoretical/Conceptual/experimental Framework.
- Researching the methods/experiments/Design or Approach to the Problem.

LEARNING OUTCOMES:

At the end of Research Proposal, students will be able to:

- Outline the literature on as Specific research problem.
- Construct objectives and motivations of research problem to be carried out.
- Explain the nuts and bolts of the theoretical concepts of the problem (experimental or theoretical) to be carried out.
- Making research proposal for further research.

Student will prepare a research proposal based on literature review and extensive student-mentor interactions involving discussions, meetings and presentations. Each student will submit a research/dissertation proposal of the research work planned for the research dissertation with origin of the research problem, literature review, hypothesis, objectives, and methodology to carry out the planned research work, expected outcomes and bibliography. Research projects can be taken up in collaboration with industry from within the discipline or across the discipline

Zoo.492 Research 0+8

LEARNING OBJECTIVES:

The prime aim of this course is to:

- Collecting and Analyzing the Data and/or Designing and Validating the methods/experiments/Design
- Drawing Conclusions and Giving Recommendations

- Prepare dissertation/thesis/report on the proposed research work

LEARNING OUTCOMES:

At the end of Dissertation students will be able to:

- Demonstrate an in-depth knowledge of scientific research pertaining to the area of study
- Demonstrate experimental/theoretical research capabilities based on rigorous hands-on training
- Critically analyze, interpret and present the data in light of existing scientific knowledge to arrive at specific conclusions
- Develop higher order thinking skills required for pursuing higher studies (Ph.D.)/research-oriented career options in respective fields.

Students will carry out their research work under the supervision of a faculty member. Students will interact with the supervisors through meetings and presentations on a regular basis. After completion of the research work, students will complete the dissertation under the guidance of the supervisor. The dissertation will include literature review, hypothesis, objectives, methodology, results, discussion, and bibliography.

Zoo.493 Academic Project 0+4

LEARNING OBJECTIVES:

The primary aim of this course is to:

- review the Research in the subject area.
- Analyse data and other research findings.
- Report research findings in written form.

LEARNING OUTCOMES:

After completion of course, students will have hand on experience of

1. Literature survey on advanced research topics in Zoology and its allied discipline
2. Planning and designing the experiment of the research Problem
3. Analysis and evaluation of the experimental data/ theoretical & computational modeling Deduction and systematic presentation of the results
4. Compilation of the results / information to produce written document
5. Defending the results of the project in an open viva–voice through power point presentation

All the Zoology honours students will do a supervised Zoology Project as an important culmination of training in Zoology learning and research. This project shall be a supervised collaborative work in Zoology and its allied discipline The project will aim to introduce student to the basics and methodology of research in Zoology, which is done via theory, computation, and experiments either all together or separately by one of these approaches. It is intended to give research exposure to students.

CHEMISTRY
(DISCIPLINE – C)

DISCIPLINE SPECIFIC COURSES:

Chem.111 Atomic Structure & Chemical Bonding 3+1

LEARNING OBJECTIVES:

Objectives of the course are:

- To review the structure of the atom, as it is a necessary pre-requisite in understanding the nature of chemical bonding in compounds.
- To discuss the periodicity in properties with reference to the s and p block, this is necessary in understanding their group chemistry.
- To provide basic knowledge about different types of bonding present between atoms or ions.

LEARNING OUTCOMES:

The students will be able to:

● Solve the conceptual questions related to quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p, and d orbitals, and periodicity in atomic radii, ionic radii, ionization enthalpy and electron affinity of elements.
● Predict the geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).
● Understand the concept of lattice energy using Born-Landé and Kapustinskii equation.
● Calibrate the apparatus used in titrimetric analysis and prepare standard solutions for titration.
● Understand the theory and application of various acid-base and redox titrations.

THEORY (45 Hours)

UNIT-I: Atomic Structure (15 Hours)

Recapitulation of concept of atom, Bohr's theory& its limitations, atomic spectrum of hydrogen atom.de Broglie concept of dual nature of matter, Heisenberg's Uncertainty Principle, and its significance. Postulates of wave mechanics, Time independent Schrödinger's wave equation, well behaved wave function, significance of ψ and ψ^2. Quantum mechanical treatment of H- atom, Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial function plots, radial probability distribution plots, angular distribution curves. Shapes of *s*, *p*, and *d* orbitals, Relative energies of orbitals. Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity, Aufbau principle and its limitations.

UNIT- II: Periodic properties of Elements & Periodic Trends (6 Hours)

Brief discussion of the following properties of the elements, with reference to *s*- &*p*-block and their trends:

a) Effective nuclear charge, shielding or screening effect and Slater's rules
b) Atomic and ionic radii
c) Ionization enthalpy (Successive ionization enthalpies)

d) Electron gain enthalpy
e) Electronegativity, Pauling's scale of electronegativity. Variation of electronegativity with bond order and hybridization.

UNIT- III: Ionic bond (12 Hours)

General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Lattice energy, Born-Landé equation with derivation, Madelung constant, importance of Kapustinskii equation for lattice energy. Born-Haber cycle and its applications.
Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

UNIT- IV: Covalent bond (12 Hours)

Valence shell electron pair repulsion (VSEPR) theory, shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCl_3, PCl_5, SF_6, ClF_3, I_3^-, BrF_2^+, PCl_6^-, ICl_2^+, ICl_4^- and SO_4^{2-}. Application of VSEPR theory in predicting trends in bond lengths and bond angles. Valence Bond theory (*Heitler-London* approach). Hybridization, equivalent and non-equivalent hybrid orbitals, Bent's rule.Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. Molecular orbital diagrams of homo & hetero diatomic molecules [N_2, O_2, C_2, B_2, F_2, CO, NO] and their ions; HCl (idea of s-p mixing and orbital interaction to be given).

PRACTICALS (30 Hours)

1. **Titrimetric Analysis:**
(i) Calibration and use of apparatus.
(ii) Preparation of solutions of different Molarity/Normality.
2. **Acid-Base Titrations:** Principles of acid-base titrations are to be discussed.
(i) Estimation of oxalic acid using standardized NaOH solution.
(ii) Estimation of sodium carbonate using standardized HCl.
(iii) Estimation of carbonate and hydroxide present together in a mixture.
(iv) Estimation of carbonate and bicarbonate present together in a mixture.
3. **Redox Titration:** Principles of oxidation-reduction titrations to be discussed.
(i) Estimation of oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
(iii) Estimation of oxalic acid and sodium oxalate in a given mixture.

SUGGUESTED READINGS:

1. Lee, J.D. (2010), Concise Inorganic Chemistry, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), Concepts and Models of Inorganic Chemistry, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
5. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons.
6. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5th Edition, Pearson.
7. Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited.
8. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.

9. Shiver, D.; Weller, M.; Overton, T.; Rourke, J.; Armstrong, F. (2014), Inorganic Chemistry, 6th Edition, Freeman & Company
10. Das, A. K.; Das, M. (2014), Fundamental Concepts of Inorganic Chemistry, 1st Edition, Volume CBS Publishers & Distributors Pvt. Ltd.
11. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.
12. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis*,* 9th Edition, Freeman and Company

Chem.121 Basic Concepts and Aliphatic Hydrocarbons 3+1

LEARNING OBJECTIVES:

Objectives of the course are:

- To recapitulate of fundamental concepts of organic chemistry and their application in different organic compounds like alkanes, alkenes, alkynes etc.
- To introduce the students to the concept of visualizing the organic molecules in a three-dimensional space.

LEARNING OUTCOMES:

The students will be able to:

- Understand and explain the electronic displacements and reactive intermediates and their applications in basic concepts.
- Formulate the mechanistic route of organic reactions by recalling and correlating the fundamental concepts.
- Identify and comprehend mechanism for free radical substitution, electrophilic addition, nucleophilic substitution, and elimination reactions.
- Understand the fundamental concepts of stereochemistry.

THEORY (45 Hours)

UNIT I: (9 Hours)

Basic Concepts of Organic Chemistry:
Electronic displacements and their applications: inductive, electrometric, resonance and mesomeric effects and hyperconjugation. Dipole moment, acidity and basicity.
Homolytic and heterolytic fissions with suitable examples. Types, shape and relative stability of carbocations, carbanions, carbenes and free radicals.
Electrophiles & nucleophiles, and introduction to types of organic reactions: addition, elimination and substitution reactions.

UNIT II: (18 Hours)

Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. specific rotation; Configuration and projection formulae: Newman, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration.
Racemic mixture and their resolution. Relative and absolute configuration: D/L and R/S designations (CIP rules).
Geometrical isomerism: *cis-trans*, *syn-anti* and *E/Z* notations.

Conformational Isomerism: Alkanes (Conformations, relative stability and energy diagrams of Ethane, Propane and butane). Relative stability of cycloalkanes (Baeyer strain theory), Cyclohexane conformations with energy diagram. Conformations of monosubstituted cyclohexanes.

UNIT III: (18 Hours)

Aliphatic Hydrocarbons Alkanes: Preparation, Halogenation of alkanes, Concept of relative reactivity v/s selectivity.
Alkenes and Alkynes: Methods of preparation of alkenes using Mechanisms of E_1, E_2, E_1cb reactions, Saytzeff and Hoffmann eliminations. Electrophilic additions, mechanism with suitable examples, (Markownikoff/Anti-markownikoff addition), *syn* and *anti*-addition; addition of H_2, X_2, oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, hydroxylation, reaction with NBS, Reactions of alkynes; acidity, Alkylation of terminal alkynes, electrophilic addition: hydration to form carbonyl compounds, Relative reactivity of alkenes and alkynes, 1,2-and 1,4-addition reactions in conjugated dienes, Diels Alder reaction (excluding stereochemistry)

PRACTICAL (30 Hours)

1. Calibration of a thermometer and determination of the melting points of the organic compounds using any one of the following methods-Kjeldahl method, electrically heated melting point apparatus and BODMEL).
2. Concept of melting point and mixed melting point.
3. Concept of recrystallisation using alcohol/water/alcohol-water systems (Any two).
4. Determination of boiling point of liquid compounds (boiling point lower than and more than 100 °C by distillation, capillary method and BODMEL method)
5. Separation of a mixture of two amino acids/sugars by radial/ascending paper chromatography.
6. Separation of a mixture of *o*-and *p*-nitrophenol or *o*-and *p*-aminophenol by thin layer chromatography (TLC).
7. Detection of extra elements.

SUGGUESTED READINGS:

1. Morrison, R.N., Boyd, R.N., Bhattacharjee, S.K. (2010), Organic Chemistry, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
2. Finar, I.L. (2002), Organic Chemistry, Volume 1, 6th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
3. Eliel, E.L., Wilen, S.H. (1994), Stereochemistry of Organic Compounds; Wiley: London.
4. Mann, F.G., Saunders, B.C. (2009), Practical Organic Chemistry, 4th Edition, Pearson Education.
5. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
6. Furniss, B.S., Hannaford, A.J., Smith, P.W.G.; Tatchell, A.R (2004), Vogel's Textbook of Practical Organic Chemistry, Pearson.
7. Leonard, J., Lygo, B., Procter, G. (2013) Advanced Practical Organic Chemistry, 3rd Edition, CRC Press.
8. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi

Chem.211 States of Matter and Chemical Kinetics 3+1

LEARNING OBJECTIVES:

The objective of this course is

- to develop understanding of basic and advanced concepts regarding gases, liquids and solids.
- to study the similarity and differences between the different states of matter and reasons responsible for these.
- to develop skills for working in physical chemistry laboratory.

LEARNING OUTCOMES:

By the end of the course, the students will be able to:

- Derive mathematical expressions for different properties of gas and liquid and understand their physical significance.
- Apply the concepts of gas equations and liquids while studying other chemistry courses and everyday life.
- Handle stalagmometer and Ostwald viscometer properly.
- Determine the density of aqueous solutions.

THEORY (45 Hours)

UNIT – I (24 Hours)

Gaseous state

Kinetic Theory of gases- postulates and derivation of kinetic gas equation, Maxwell distribution of molecular velocities and its use in evaluating average, root mean square and most probable velocities and average kinetic energy. Definition, expression, applications and temperature and pressure dependence of each one of the following properties of ideal gases: Collision frequency, Collision diameter, Mean free path. Coefficient of viscosity, definition, units and origin of viscosity of gases, relation between mean free path and coefficient of viscosity, temperature and pressure dependence of viscosity of a gas, calculation of molecular diameter from viscosity

Barometric distribution law, its derivation and applications, alternative forms of barometric distribution law in terms of density and number of molecules per unit volume, effect of height, temperature and molecular mass of the gas on barometric distribution

Behaviour of real gases- Compressibility factor, Z, Variation of compressibility factor with pressure at constant temperature *(plot of Z vs P)* for different gases (H_2, CO_2, CH_4 and NH_3), Cause of deviations from ideal gas behaviour and explanation of the observed behaviour of real gases in the light of molecular interactions

van der Waals equation of state,Limitations of ideal gas equation of state and its modifications in the form of derivation of van der Waal equation, Physical significance of van der Waals constants, application of van der Waal equation to explain the observed behaviour of real gases.

Isotherms of real gases- Critical state, relation between critical constants and van der Waals constants, correlation of critical temperature of gases with intermolecular forces of attraction, Continuity of states, Limitations of van der Waals equation, Reduced equation of state and law of corresponding states (statement only).

Virial equation of state-Physical significance of second and third virial coefficients, van der Waals equation expressed in virial form, Relations between virial coefficients and van der Waals constants

UNIT – II **(6 Hours)**

Liquid state

Nature of liquid state, qualitative treatment of the structure of the liquid state

Physical properties of liquids-vapour pressure, its origin and definition, Vapour pressure of liquids and intermolecular forces, and boiling point

Surface tension, its origin and definition, Capillary action in relation to cohesive and adhesive forces, determination of surface tension by (i) using stalagmometer (drop number and drop mass method both) and (ii) capillary rise method, Effects of addition of sodium chloride, ethanol and detergent on the surface tension of water and its interpretation in terms of molecular interactions, Role of surface tension in the cleansing action of detergents

Coefficient of viscosity and its origin in liquids, Interpretation of viscosity data of pure liquids (water, ethanol, ether and glycerol) in the light of molecular interactions, Effects of addition of sodium chloride, ethanol and polymer on the viscosity of water, relative viscosity, specific viscosity and reduced viscosity of a solution, comparison of the origin of viscosity of liquids and gases, effect of temperature on the viscosity of a liquid and its comparison with that of a gas.

UNIT – III **(6 Hours)**

Solids: Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography- Law of constancy of interfacial angles, Law of rational indices. Miller indices. X-Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

UNIT – IV **(9 Hours)**

Chemical Kinetics: The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half-life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

PRACTICAL (30 Hours)

1. Surface tension measurements using stalagmometer
    a. Determine the surface tension of a liquid by drop number method.
    b. Determine the surface tension of a liquid by drop weight method.
2. Viscosity measurement using Ostwald's viscometer
    a. Determination of co-efficient of viscosity of unknown aqueous solution.
    b. Study the variation of viscosity with different concentration of sugar solutions.
    c. Study the effect of the addition of solutes such as (i) polymer (ii) ethanol (iii) sodium chloride on the viscosity of water at room temperature and explain the observations in terms of molecular interactions
    d. Study the variation of viscosity of water with the amounts of a solute and calculate the intrinsic viscosity at room temperature.
3. **Study the kinetics of the following reactions:**
    a. Acid hydrolysis of methyl acetate with hydrochloric acid.
    b. Saponification of ethyl acetate.
    c. Compare the strengths of HCl / H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

SUGGUESTED READINGS:

1. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
2. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.
4. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 6th Edition, McGraw Hill Education.
5. Moore, W.J. (1972), Physical Chemistry, 5th Edition, Longmans Green & Co. Ltd.
6. Glasstone, S. (1948), Textbook of Physical Chemistry, D. Van Nostrand company, New York.
7. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
8. Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.
9. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York

Chem.221 Chemistry of s-and p-Block Elements 3+1

LEARNING OBJECTIVES:

The objectives of this course are as follows:

- To develop the general principles of metallurgy and s-, p-block elements.
- To introduce the terms minerals, ores, concentration, benefaction, calcination, roasting, refining, etc. and explain the principles of oxidation and reduction as applied to the extraction procedures.
- To make students ware of different methods of purification of metals, such as electrolytic, oxidative refining, VanArkel-De Boer process and Mond's process are discussed and applications of thermodynamic concepts like that of Gibbs energy and entropy to the extraction of metals.
- To familiarize students with the patterns and trends exhibited by s- and p-block elements and their compounds with emphasis on synthesis, structure, bonding and uses.
- To impart information about the fundamentals of internal and external redox indicators, and iodometric/iodimetric titrations.

LEARNING OUTCOMES:

By studying this course, students will be able to:

- Learn the fundamental principles of metallurgy and understand the importance of recovery of by-products during extraction.
- Applications of thermodynamic concepts like that of Gibbs energy and
- entropy to the principles of extraction of metals.
- Learn about the characteristics of s- and p- block elements as well as the synthesis, structure, bonding, and uses of their compounds
- Understand the concept and use of internal and external redox indicators
- Comprehend the theory and application of iodometric and iodimetric titrimetric analysis

THEORY (45 Hours.)

UNIT-I: General Principles of Metallurgy (6 Hours)

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, Van Arkel-De Boer process, Zone refining. Brief discussion of metals and alloys used in ancient and medieval India.

UNIT- II: Chemistry of s- Block Elements (15 Hours)

General characteristics: melting point, flame colouration, reducing nature, diagonal relationships and anomalous behavior of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water.

Common features such as ease of formation, thermal stability, energetics of dissolution, and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates.

Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium. Solutions of alkali metals in liquid ammonia and their properties

UNIT-III: Chemistry of p-Block Elements (9 Hours)

Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Catenation, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behaviour of first member of each group.

UNIT – IV: Compounds of p-Block Elements (15 Hours)

Acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat on the following:Hydrides of Group 13 (only diborane), Group 14, Group 15 (EH3 where E = N, P,As, Sb, Bi), Group 16 and Group 17. Oxoacids of phosphorus, sulphur and chlorine, Interhalogen and pseudohalogen compound, Clathrate compounds of noble gases, xenon fluorides (MO treatment of XeF_2).

PRACTICAL (30 Hours)

1. **Redox Titrations**
   (i) Estimation of Fe(II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.
   (ii) Estimation of Fe(II) with $K_2Cr_2O_7$ using N-phenyl anthranilic acid as internal indicator.
   (iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using external indicator.
2. **Iodo/Iodimetric Titrations**
   (i) Estimation of Cu(II) using sodium thiosulphate solution.
   (ii) Estimation of $K_2Cr_2O_7$using sodium thiosulphate solution.
   (iii) Estimation of antimony in tartaremetic iodimetrically.
   (iv) Estimation of Iodine content in iodized salt.

SUGGUESTED READINGS:

THEORY

1. Lee, J. D.; (2010), Concise Inorganic Chemistry, Wiley India.
2. Huheey, J. E.; Keiter, E. A.; Keiter; R.L.; Medhi, O.K. (2009), Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.

3. Atkins, P. W.; Overton, T. L.; Rourke, J. P.; Weller, M. T.; Armstrong, F. A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
4. Miessler, G. L.; Fischer P. J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.
5. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5thEdition, Pearson.
6. Canham, G. R., Overton, T. (2014), Descriptive Inorganic Chemistry, 6th Edition, Freeman and Company.
7. Greenwood, N. N.; Earnsaw, A., (1997), Chemistry of Elements, 2nd Edition, Elsevier.

PRACTICAL

1. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denney, R. C. (1989), Vogel's Text book of Quantitative Chemical Analysis, John Wiley and Sons.
2. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company.
3. Day, R. A.; Underwood, A. L. (2012), Quantitative Analysis, 6th Edition, PHI Learning Private Limited.

Chem.311 Chemistry of Functional Groups 3+1

LEARNING OBJECTIVES:

The objectives of this course are as follows:

- To teach the students about fundamental chemical reactions of organic compounds.
- To provide information about synthesis of various useful organic compounds and their derivatives.

LEARNING OUTCOMES:

By the end of this course, students will be able to:

- Understand the differential behaviour of organic compounds.
- Formulate the mechanism of organic reactions by correlating the fundamental properties of reactants.

THEORY (45 Hours)

UNIT-I: (8 Hours)

Alkyl and Aryl Halides:

Alkyl Halides(Upto 5 Carbons)Types Nucleophilic Substitution(SN_1andSN_2) reactions. and SNi) reactions.

Preparation: from alkenes and alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides**:** Preparation: (Chloro, bromo and iodo-benzene): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).

Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

UNIT-II: (14 Hours)

Alcohols, Phenols and Ethers (Upto 5 Carbons): Alcohols: Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.
Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation. Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.
Phenols: (Phenol) Preparation: Cumene hydroperoxide method, from diazonium salts.
Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben– Hoesch Condensation, Schotten – Baumann Reaction.
Ethers (aliphatic and aromatic): Cleavage of ethers with HI.
Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde)
Preparation: from acid chlorides and from nitriles.
Reactions – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

UNIT-III: (6 Hours)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.Carboxylic acids and their derivatives: Carboxylic acids (aliphatic and aromatic) Preparation: Acidic and Alkaline hydrolysis of esters.Reactions: Hell – Vohlard - Zelinsky Reaction.
Carboxylic acid derivatives (aliphatic): (Upto 5 carbons):
Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion.
Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky
Reaction, Perkin condensation.

UNIT- IV: (7 Hours)

Amines and Diazonium Salts: Amines (Aliphatic and Aromatic): (Upto 5 carbons)
Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann
Bromamide reaction.
Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2,Schotten – Baumann Reaction. Electrophilic substitution (aniline): nitration, bromination, sulphonation.
Diazonium salts: Preparation: from aromatic amines.
Reactions: conversion to benzene, phenol, dyes.

UNIT-V: (10 Hours)

Amino Acids, Peptides and Proteins:
Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.
Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.
Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation,
N-terminal and C–terminal (thiohydantoin and with carboxypeptidase enzyme).
Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

PRACTICAL (30 Hours)

1. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.
2. Organic Synthesis:
   (i) Preparation of Iodoform.
   (ii) Preparation of p-bromoacetanilide from acetanilide.
   (iii) Preparation of glucosazone.
   (iv) Preparation of aspirin.
3. Thin Layer Chromatography
   (i) Determination of R_f value and purity of organic compounds by use of thin layer chromatography.
   (ii) To analyze the organic compounds by thin layer chromatography.

SUGGUESTED READINGS:

1. Principles of Physical Chemistry by Puri, Sharma and Pathania.
2. Physical Chemistry by S.C. Khetarpal, G.S, Sharma and R.K. Kalia.
3. Moderns Approach to Physical Chemistry by S. Kiran.
4. A text Book of Physical Chemistry by K.K.Sharma and I.K. Sharma
5. Physical Chemistry by P.N.Kapil and S.K.Guglani.
6. Elements of Physical Chemistry by Puri, Sharma and Pathania.
7. Advance Organic Chemistry Reaction Mechanism and Structure by Jerry March.
8. Organic Chemistry by SM Mukherji, SP Singh and RP Kapoor, Vol. I, II & III, New Age International Publishers
9. Organic Chemistry (Volume II) by I. L Finar

Chem.321 Chemical Thermodynamics and Electrochemistry 3+1

LEARNING OBJECTIVES:

The learning objectives: of this course are as follows:

- To provide basic knowledge about the heat changes taking place during various chemical and physical changes.
- To familiarise the students about the basic concepts of electrical conductivity.

LEARNING OUTCOMES:

By the end of this course, students will be able to:

- apply the fundamental concepts of energy changes taking place in the universe
- Understand the phenomena involved in conductance measurements and its applications.

UNIT-I: (10Hours)

Chemical Thermodynamics: Review of thermodynamics First Law of Thermodynamics, statement, definition of internal energy and enthalpy. Heat capacity, heat capacities at constant volume and pressure and their relationship. Joule's law, Joule-Thomson coefficient, and inversion temperature. Calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.

Thermochemistry: Standard state, standard enthalpy of formation- Hess's Law of heat summation and its applications. Heat of reaction at constant pressure and at constant volume. Enthalpy of neutralization. Bond dissociation energy and its calculation from thermo-chemical data, temperature dependence of enthalpy. Kirchhoff's equation.
Thermodynamics-II: Second law of thermodynamics: Need for the law, different statements of the law. Carnot cycle and its efficiency. Carnot theorem. Thermodynamic scale of temperature. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

UNIT-II: (8 Hours)

Chemical Equilibrium: Equilibrium constant and free energy. Thermodynamic derivation of law of mass action. Le Chatelier's principle Reaction isotherm and reaction isochore- Clapeyron equation and Clausius – Clapeyron equation, applications.

UNIT-III: (12Hours)

Ionic Equilibria: Strong, moderate, and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts, applications of solubility product principle.

UNIT-IV: (6 Hours)

Conductance: Conductivity, equivalent and molar conductivity, and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.
Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

UNIT-V: (9 Hours)

Electrochemistry: Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

PRACTICAL (30 Hours)

1. **Thermochemistry**
   i) Determination of Water Equivalent of a thermos flask.
   ii) Determination of heat of solution of KNO3 and KCl.
   iii) Determine the enthalpy of neutralization between strong acid and strong base.
   iv) Determine the enthalpy of neutralization between strong acid and weak base.
   v) Determine the enthalpy of hydration of CuSO4.
   vi) Determine the enthalpy of neutralization of a weak acid/weak base versus strong base/strong acid
2. pH measurements
   Preparation of buffer solutions:
   i) Sodium acetate-acetic acid
   ii) Ammonium Chloride and Ammonium Hydroxide

3. **Conductance:**
   i) Determination of cell constant
   ii) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
   iii) Perform the following conductometric titrations:
   iv) Strong acid vs. strong base
   v) Weak acid vs. strong base

SUGGUESTED READINGS:

1. Principles of Physical Chemistry by Puri, Sharma and Pathania.
2. Physical Chemistry by S.C. Khetarpal, G.S, Sharma and R.K. Kalia.
3. Modren's Approach to Physical Chemistry by S. Kiran.
4. A text Book of Physical Chemistry by K.K. Sharma and I.K. Sharma
5. Physical Chemistry by P.N. Kapil and S.K. Guglani.
6. Elements of Physical Chemistry by Puri, Sharma and Pathania.

DISCIPLINE ELECTIVE COURSES:

Chem.212 Basic Quantum Chemistry and Photochemistry 3+1

LEARNING OBJECTIVES:

The learning objectives: of this course are as follows:

- To familiarize the students about structure of atoms and molecules in light of quantum theory.
- To learn about interaction between light radiations and matter.

LEARNING OUTCOMES:

By the end of this course, students will be able to:
- Understand the basic phenomena associated with the formation of molecules.
- Have an insight into the phenomena of fluorescence, phosphorescence, chemiluminescence.

THEORY (45 Hours)

UNIT-I: (12 Hours)

Quantum Chemistry: Black-body radiation, Planck's radiation law, photoelectric effect, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect. de Broglie hypothesis, Heisenberg's uncertainty principle, Sinusoidal wave equation, Schrodinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one-dimensional box.

UNIT-II: (22 Hours)

Chemical bonding:Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.

UNIT-III: (11 Hours)

Photochemistry: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photo stationary states, chemiluminescence.

PRACTICAL (30 Hours)

1. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/ $K_2Cr_2O_7$ in a solution of unknown concentration.
2. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
3. Study the kinetics of iodination of propanone in acidic medium.
4. Determine the amount of iron present in a sample using 1,10-phenathroline.
5. Determine the dissociation constant of an indicator (phenolphthalein).
6. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

SUGGUESTED READINGS:

1. Fundamentals of Molecular Spectroscopy by Banwell, & McCash.
2. Introductory Quantum Chemistry by A. K. Chandra,
3. Principles of Physical Chemistry by Puri, Sharma and Pathania.
4. Physical Chemistry by S.C.Khetarpal, G.S, Sharma and R.K. Kalia.
5. Modren Approach to Physical Chemistry by S. Kiran.
6. A text Book of Physical Chemistry by K.K.Sharma and I.K. Sharma
7. Physical Chemistry by P.N.Kapil and S.K.Guglani.
8. Elements of Physical Chemistry by Puri, Sharma and Pathania.
9. Experimental Physical Chemistry by B.D Khosla
10. Selected experimental in Physical Chemistry, Vol. I by J N Gurtu and R Kapoor.
11. Experimental Physical Chemistry by J C Ghose.
12. Systematic Practical Chemistry for B.Sc 1st, 2ndand 3rd year by P.C Kamboj
13. Vogel's Quantitative Chemical Analysis, by J.Mendham.

Chem.213 Spectroscopy 3+1

LEARNING OBJECTIVES:

The Objectives of this course are as follows:

- To familiarize the student about different kinds of spectroscopic techniques.
- To provide the information about structure elucidation.

LEARNING OUTCOMES:

By the end of this course, students will be able to:

- Have an insight about the different spectroscopic techniques.
- Identify the different kinds of techniques for structure determination.

THEORY (45 Hours)

UNIT-I: (4 Hours)

Molecular Spectroscopy: Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

UNIT-II: (5 Hours)

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

UNIT-III: (10 Hours)

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

UNIT-IV: (4 Hours)

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

UNIT-V: (4 Hours)

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

UNIT-VI: (18 Hours)

Application of Spectroscopy to Simple Organic Molecules: Application of visible, ultraviolet and Infra-red spectroscopy in organic molecules. Electromagnetic radiations and electronic transitions, λ_{max}& ε_{max}, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λ_{max} of conjugated dienes and α, β – unsaturated compounds.

Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin- spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

PRACTICAL (30 Hours)

1. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.

3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.
4. Analyse the given vibration-rotation spectrum of HCl(g)

SUGGUESTED READINGS:

For Theory:

1. Fundamentals of Molecular Spectroscopy by Banwell, & Mc Cash.
2. Introductory Quantum Chemistry by A. K. Chandra,
3. Principles of Physical Chemistry by Puri, Sharma and Pathania.
4. Physical Chemistry by S.C. Khetarpal, G.S, Sharma and R.K. Kalia.
5. A text Book of Physical Chemistry by K.K. Sharma and I.K. Sharma
6. Physical Chemistry by P.N. Kapil and S.K. Guglani.
7. Elements of Physical Chemistry by Puri, Sharma and Pathania.

For Lab:

1. Experimental Physical Chemistry by B.D Khosla
2. Selected experimental in Physical Chemistry, Vol. I by J N Gurtu and R Kapoor.
3. Experimental Physical Chemistry by J C Ghose.
4. Systematic Practical Chemistry for B.Sc 1^{st}, 2^{nd} and 3^{rd} year by P.C Kamboj
5. Vogel's Quantitative Chemical Analysis, by J.Mendham.

Chem.222 Analytical Chemistry 3+1

LEARNING OBJECTIVES:

The learning objectives: of this course are as follows:

- To acquire basic knowledge of the analytical chemistry of important techniques that will provide the basis for their industrial production methods.
- To provide an adequate mastery of analytical methods used for the determination of commercial/domestic raw materials and finished product quality.

LEARNING OUTCOMES:

By the end of this course, students will be able to:

- understand the fundamental concepts of partition coefficients and their role in achieving separations across different types of chromatography.
- develop the core skills to parse existing chromatographic protocols and identify the key factors influencing a chromatography experiment.
- Understand the underlying assumptions of the most common chromatographic separation techniques and approaches to method validation.

THEORY (45 Hours)

UNIT – I: (6 Hours)

Qualitative and quantitative aspects of analysis: Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

UNIT-II: **(6 Hours)**

Optical methods of analysis: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.
UV-Visible Spectrometry*:* Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument.

UNIT-III:. **(6 Hours)**

Basic principles of quantitative analysis: Estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

UNIT – IV: Chromatography **(10 Hours)**

Classification of chromatographic methods: Principles of differential migration, description of chromatographic process, distribution coefficients, modes of chromatography, Column chromatography (elution time and volume) capacity factor, column efficiency and resolution, sample preparation.

UNIT – V: Paper Chromatography **(05 Hours)**

Experimental modifications, various modes of developments, nature of paper, detections of spots, retardation factors, factors that affect reproducibility of Rf values (due to paper, solvent system, sample, development procedures), selection of solvent, quantitative analysis, applications.

UNIT – VI: Thin Layer Chromatography **(06 Hours)**

Stationary phase, adsorbents, liquid phase support, plate preparation, mobile phase, sample application, development, saturation of chamber, detection of spot, R*f* values (effect of adsorbent, solvent, solute, development process), quantitative analysis, applications.

UNIT – VII: Solvent Extraction **(07 Hours)**

Distribution law, determination of distribution ratio, batch extraction, continuous extraction, discontinuous extraction, counter-current extraction.

PRACTICAL (30 Hours)

1. Separation and identification of amino acids present in the given mixture by ascendingpaper Chromatography.
2. Separation of ortho-nitrophenol & para-nitrophenol and *o*- and *p*-amino phenol by thin layer chromatography (TLC) and calculation of their R*f* values.
3. Separation of constituents of leaf pigments by thin layer chromatography and paper chromatography.
4. Separation of a mixture of compounds by solvent extraction.
5. Analysis of soil samples (*at least three soil samples to be collected for analysis*).
   i. Determination of pH of soil samples.
   ii. Determination of total soluble salts.
   iii. Determination of carbonate and bicarbonate.
   iv. Determination of calcium, magnesium and iron.
   v. Determination of conductance of the soil samples.

SUGGUESTED READINGS:

1. Fifield ,F. W.; Kealey, D. (2000), Principles and Practice of Analytical Chemistry, Wiley.
2. Harris, D. C. (2007), Exploring Chemical Analysis, W.H. Freeman and Co.

3. Harris, D. C. (2007), Quantitative Chemical Analysis, 6th Edition, Freeman
4. Mikes, O. (2000), Laboratory Handbook of Chromatographic methods, D.Van Nostrand Company Inc.

Chem.223 Organometallics, Heterocyclic and Polynuclear Hydrocarbons 3+1

LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

- To make the students learn about organometallic compounds, an interface between organic and inorganic chemistry.
- To learn about polynuclear hydrocarbons and heterocyclic compounds.

LEARNING OUTCOMES:

By the end of this course, students will be able to:
- Identify the different kinds of organometallic compounds, their structures and nature of bonding.
- Compare the stability of different compounds including metal carbonyls.
- Learn about relative stability, reactivity, and aromatic character of polynuclear hydrocarbons and heterocyclic compounds.

THEORY (45 Hours)

UNIT-I: (10 Hours)

Organometllic Compounds: Definition and Classification with appropriate examples based on nature of metal- carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding, and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach).

UNIT-II: (12 Hours)

Heterocyclic Compounds: Introduction to molecular orbital picture and aromatic characteristics of furan, pyrrole, thiophene, and pyridine.methods of synthesis and chemical reactions (mainly electrophilic substitution with mechanism). mechanism of nucleophilic substitution reactions in pyridine derivatives.comparison of basicity of pyridine, piperidine and pyrrole.

UNIT-III: (12 Hours)

Introduction to condensed five and six membered heterocyclic compounds. Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fischer Indole synthesis, Skraup synthesis and Bischler – Napieralski synthesis. Mechanism of electrophilic substitution reactions of Indole, Quinoline and Isoquinoline.

UNIT-IV: (6 Hours)

Polynuclear and heteronuclear aromatic compounds: Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine.

UNIT-V: (5Hours)

Active methylene compounds: Preparation: Claisen ester condensation. Keto-enol tautomerism. Reactions:Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon).

PRACTICAL (30 Hours)

1. Section A: Inorganic Chemistry
   Preparation of the of the following complexes.
   (i) tetraamminecarbonatocobalt (III) nitrate
   (ii) tetraamminecopper (II) sulphate
   (iii)potassium trioxalatoferrate (III) trihydrate
2. Section B: Organic Chemistry

Systematic Qualitative Organic Analysis of Organic Compounds possessing functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines, carbohydrates).

SUGGUESTED READINGS:

1. Modren Approach to Inorganic Chemistry for B.Sc 1st year by SP Jauhar.
2. Principles f Inorganic Chemistry By Puri, Sharma and Kalia.
3. Inorganic Chemistry by James E Huhee.
4. Advanced Inorganic Chemistry by F.A.Cotton and G Wilkinson.
5. Modren Approach to Organic Chemistry By B.Sc 1st year by Sahgal.
6. Stereo Chemistry by P.S. Kalsi.
7. Organic Chemistry by Paula Yurkanis Bruice.
8. Reaction Mechanism by O. P. Aggarwal.
9. Modren Organic Chemistry By M.K.Jain and S.C. Sharma.
10. Concise Inorganic Chemistry by J.D. Lee.
11. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

For Lab

1. Vogel's Text Book of Qualitative Inorganic analysis (revised) J. Bassett, R.C. Cdenney, G. H. Jettery and J. Mendhan, ELBS.
2. Standard Methods of Chemical Analysis by W. W. Scott.
3. Experimental inorganic Chemistry by W. G. Paimer.
4. Vogel's Text Book of Qualitative Organic analysis (revised) J. Bassett, R.C Cdenney, G H Jettery and J Mendhan, ELBS.
5. Laboratory Manual in Organic Chemistry, R K Bansal.
6. Experimental Organic Chemistry Vol. I & II, P R Singh, D S Gupta and K S Bajpai.

Chem.322 Chemistry of Polymers 3+1

LEARNING OBJECTIVES:

The learning objectives: of this course are as follows:

- To familiarize the students about the different kinds of polymeric compounds.
- To provide knowledge about different properties of polymers.

LEARNING OUTCOMES:

By the end of this course, students will be able to:

- Compare the structures, properties and uses of various polymers.
- Learn about the kinetic studies of polymers.

THEORY (45 Hours)

UNIT -I: (15 Hours)

Polymers: Introduction and history of polymeric materials:Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. Functionality and its importance: Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems

UNIT -II: (15 Hours)

Kinetics of Polymerization: Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.
Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers-Structure Property relationships.

UNIT -III: (14 Hours)

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties).
Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene).

PRACTICAL (30 Hours)

Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
2. Preparation of nylon 66
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight by viscometry:
    i. Polyacrylamide-aq.$NaNO_2$ solution
    ii. Poly vinyl proplylidine (PVP) in water
2. Determination of the viscosity-average molecular weight of poly (vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

SUGGUESTED READINGS:

1. M.P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed., Oxford University Press, 1999.
2. H.R. Allcock, F.W. Lampe & J.E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall (2003)
3. F.W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
4. J.R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
5. P. Munk & T.M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
6. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
7. M.P. Stevens, Polymer Chemistry: An Introduction 3rd ed. Oxford University Press (2005).
8. Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

Chem.323 Molecules of Life 3+1

LEARNING OBJECTIVES:

The learning objectives of this course are as follows:
• To teach the students about fundamental molecules essential for life.
• To provide information about different classes of organic compounds and their biological uses.

LEARNING OUTCOMES:

By the end of this course, students will be able to:
• Understand the structure and importance of organic compounds for the human beings.
• Gain insight into the mechanism of different biological processes taking place.

THEORY (45 Hours)

UNIT-I: (12 Hours)

Carbohydrates: Classification of carbohydrates, reducing and non-reducing sugars, General properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosachharides, structure of disachharides (sucrose, maltose, lactose) and polysachharides (starch and cellulose) excluding their structure elucidation.

UNIT-II: (13 Hours)

Amino Acids, Peptides, Proteins and Enzymes: Classification of Amino Acids, Zwitterion structure and Isoelectric point. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity),

UNIT-III: (20 Hours)

Nucleic Acids and Lipids: Components of Nucleic acids: Adenine, guanine, thymine and cytosine (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (types of RNA), Genetic code, Biological roles of DNA and RNA: Replication, Transcription and Translation.

Introduction to lipids,classification. Oils and fats: Common fatty acids present in oils and fats, omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

PRACTICAL (30 Hours)

1. Separation of amino acids by paper chromatography
2. Action of salivary amylase on starch
3. Effect of temperature on the action of salivary amylase on starch.
4. To determine the saponification value of an oil/fat.
5. To determine the iodine value of an oil/fat
6. Differentiate between a reducing/non reducing sugar.
7. Extraction of DNA from onion/ cauliflower
8. To synthesize aspirin by acetylation of salicylic acid
9. Comparison of aspirin with the ingredient of an aspirin tablet by TLC.

SUGGUESTED READINGS:

For Theory

1. Modren Approach to Organic Chemistry by Sehgal.
2. Organic Chemistry (Volume 1), by I. L Finar.
3. Organic Chemistry (Volume II), by I. L Finar.
4. Lehninger's Principles of Biochemistry 7th Ed. By D. L. Nelson, & M. M. Cox

For lab

1. Vogel's Textbook of Practical Organic Chemistry by B.S. Furniss, A.J. Hannaford, V. Rogers, P.W.G. Smith, A.R. Tatchell.
2. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia, & R. Aggarwal

HIGHER LEVEL DISCIPLINE SPECIFIC COURSES:

Chem.411 Group Theory and X-ray Crystallography 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- to disseminate the knowledge of symmetry and its applications in structure determination.
- to provide basic knowledge about symmetry elements, symmetry operations and properties of group multiplication tables.

LEARNING OUTCOMES:

The student will be able to

- to explain IR and Raman spectral features in terms of group theory.
- to apply the study of single crystal X-ray structure its applications to supramolecular chemistry.

THEORY (45 Hours)

UNIT-I: Symmetry and Group Theory (11 Hours)

Fundamentals: Introduction to symmetry and group theory, symmetry operations, symmetry elements, point groups, identification of point group in molecules of special symmetry (linear molecules and molecules with multiple axes) molecules of low symmetry, molecules of high symmetry, notation of point group, assignment of point group, definitions of group, subgroup, class, relation between orders of a finite group and its subgroup

UNIT-II: Applications of Group Theory (11 Hours)

Group multiplication tables, conjugacy relation and classes, Schoenflies symbols, representation of groups, character of a representation, reducible and irreducible representations, character tables, the method of finding the number of irreducible representation in a reducible representation, construction of character table, matrix representation of symmetry elements and point groups,normal mode analysis, internal coordinate method, IR and Raman activity

UNIT-III: X-ray Crystallography (12 Hours)

X-ray and their properties. Use of X-ray diffraction to find atomic arrangements. Point group, space group and unit cell. Combining waves to obtain an image: Elementary treatment of Structure factor and Fourier synthesis. Crystals and intensity data collection: Fundamental concepts. The phase problem in crystallography: Direct methods of relative phase determination. Patterson method and heavy atom method. R-Factor criterion. Structure completion in practice. Refinement of crystal structure: Mention of refinement by Fourier synthesis. The method of least squares. Goodness of fit parameter, weighting functions.

UNIT-IV: Applications of X-ray Crystallography (11 Hours)

a) Derived results and applications: Representation of structural results. Chirality and absolute structure. Packing in crystals. Thermal and Photo-chemical reactions in solid state. Topochemical principle. Conformation of polypeptides: Ramachandran plot.
b) Supramolecular Chemistry: Introduction to supramolecular chemistry: basics and concepts. Non-covalent interactions in supermolecules, their nature type and role in pre-organization andcomplementarity. Introduction to crystal Engineering and supramolecular synthons. Anion binding sites and anon receptors. Applications of supramolecular chemistry.

PRACTICAL (30 Hours)

1. **Volumetric Analysis:**
   (a)Potassium iodate titrations: Determination of iodide, hydrazine, antimony (III) and arsenic (III)
   (b)Potassium bromate titrations
   i) Determination of antimony (III) and arsenic (III) Direct Method)
   ii) Determination of aluminium, cobalt and zinc (by oxine method)
2. **EDTA titrations**
   i) Determination of copper, nickel, magnesium
   ii) Back titration
   iii) Alkalimetric titration
   iv) Titration of mixtures using masking and damasking agents
   v) Determination of hardness of water
3. **Commercial Analysis:**
   i) Determination of available chlorine in bleaching powder
   ii) Determination of Oxygen in hydrogen peroxide.
   iii) Determination of Phosphoric acid in commercial phosphoric acid.
   iv) Determination of Boric acid in borax.
   v) Analysis of Ores (Dolomite, Pyrolusite) and alloys (Coin, Brass, Bronze).

SUGGUESTED READINGS:

1. Hollas J.M., Symmetry in Molecules, Pubs: Chapman and Hall (1972).
2. Harris D.C. and Bortolucci M.D., Symmetry and Spectroscopy, Pubs: Oxford University Press (1978).
3. Pearson R.G., Symmetry Rules for Chemical Reactions, Pubs: John Wiley (1976).
4. Bishop D.M., Group theory and Chemistry, Pubs: Oxford University Press (1973).
5. Vincent Alan, Molecular Symmetry and Group theory A programmed introduction to Chemical Applications, Pubs:John Wiley & Sons Ltd., 1977 (Reprint 1998).
6. Cotton F. A.,Chemical applications of group theory, 3 rd Edition, Pubs: John Wiley New York, 1971 [Indian print by Wiley Eastern, 1999].
7. Jaffe H. H. and Orchin M., Symmetry in Chemistry, Pubs: John Wiley New York, 1965.
8. Stout G.H. and Jeansen L.H., X-ray structure determination a practical guide, Pubs: John Wiley & Sons, New York (1989).
9. Glusker J.P., Lewis M, Crystal structure analysis for chemists and biologists, Pubs: VCH Publisher inc., New York (1994).
10. Steed J. W. and Atwood J. L., Supramolecular Chemistry, John Wiley and Sons, Ltd, (2000)
11. A text Book of Quantitative Inorganic Analysis: A.I. Vogal.
12. Commercial Methods of Analysis: Shell & Biffen

Chem.412 Chemistry of Natural Products 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- to familiarize the students about different classes of natural products.
- to provide basic knowledge about applications of natural products and their derivatives.

LEARNING OUTCOMES:

The student will be able to

- to synthesize different kinds of compounds.
- to apply the study of natural products to prepare different derivatives.

THEORY (45 Hours)

UNIT-I Terpenoids and Carotenoids (11 Hours)

Classification, occurrence, isolation, general methods of structure determination. Biosynthesis and synthesis of citral, geraniol, α -terpineol, menthol, farnesol, zingiberene, santonine, longifolene, abietic acid, and vitamin A. Plant Pigments Occurrence, nomenclature, synthesis of Quercetin myrcetin cyanidine hirsutidin

UNIT-II Steroids (11 Hours)

Occurrence, basic skeleton, stereochemistry, structure determination of cholesterol by degradation experiments, synthesis and biosynthesis of cholesterol, bile acids, and testosterone, estrone(Vollhardt Synthesis), progesterone(Johnsons Synthesis), vitamin D, cortisone.

UNIT-III Alkaloids (11 Hours)

Occurrence, isolation, general method structure elucidtion, degradation, classification based on nitrogen heterocyclic ring structure, stereochemistry andsynthesis of ephedrine, Nicotine, atropine, quinine (Woodward and Storks synthesis), morphine, (±) Strychnine*, chloroquin and primaquin

UNIT-IV Vitamins (12 Hours)

Occurrence, deficiency, physiological effects and synthesis of B complex, E and K. Chemotherapy Antibiotics: General structure determination/elucidation of penicillin and terramycin. Synthesis of penicillin G and V (via APA). Introduction to the structure and function of antibiotics i.e. ampicillin, amoxycillin, chloramphenicol, cephalosporin, tetracycline and streptomycin. Mode of action of antibacterial agents. Sulpha drugs Prostaglandins Biosynthesis, Synthesis of PGE2 and PGF2α.

PRACTICAL (30 Hours)

1. **Qualitative Analysis:** Separation, purification, and identification of binary mixture of organic compounds by chemical tests.
2. **Organic Synthesis:**

Acetylation: - Acetylation of cholesterol and separation of cholesteryl acetate by column chromatography.
Oxidation: Adipic acid by chromic acid oxidation of cyclohexanol.
Grignard reaction: Synthesis of triphenyl methanol from benzoic acid.
Aldol condensation: Dibenzal acetone from benzaldehyde.

SUGGUESTED READINGS:

1. Finar l. L, Organic Chemistry, Vol.1, 2, Pubs: ELBS (1994).
2. Nicolaou K.C. and Sorensen E.J., Classics in Total Synthesis, Pubs: VCHN.Y.(1986).
3. Nicolaou K.C. and Synder, S.A.Classics in Total Synthesis II, Pubs: VCH N.Y.(2003).
4. Akhrem, A.A.Total Steroids Synthesis, Pubs: Plenum Press, New York, (1970)
5. Solomon T.W.G. and Fryhle C.B., Organic Chemistry, 7thEdn., Pubs: John. Wiley & Sons Inc. N.Y. (2000).
6. Manitto P., Biosynthesis of Natural Products, Pubs: Horwood Ltd.(1981).
7. Padwa, A. Org. Lett. 2007, 9(2), 279-282
8. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C.Heath.
9. Systematic Qualitative Organic Analysis, H.Middleton, Adward Arnold.
10. Handbook of Organic Analysis-Qualitative and Quantitative, H.Clark, Adward Arnold.
11. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
12. Experiments and Techniques in Organic Chemistry, D.Pasto, C. Johnson and M.Miller, Prentice Hall.

Chem.413 Statistical Thermodynamics and Quantum Chemistry 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- to teach the fundamental concepts of statistical thermodynamics and quantum chemistry.
- to provide basic knowledge about applications of quantum chemistry

LEARNING OUTCOMES:

The student will be able to

- to understand the concepts of quantum chemistry
- to apply knowledge gained through the course to fundamental structure of atoms and molecules.

THEORY (45 Hours)

UNIT-I **(11 Hours)**

Statistical Thermodynamics:Basic Terminology: probability, phase space, micro and macro states, thermodynamic probability, statistical weight,
assembly, ensemble, The most probable distribution: Maxwell-Boltzmann distribution, quantum statistics: The Bose-Einstein statistics and Fermi- Dirac Statistics. Thermodynamic probability (W) for the three types of statistics. Lagrange's undetermined multipliers. Stirling's approximation, Molecular partition function and its importance.
Applications to ideal gases: The molecular partition function and its factorization. Evaluation of translational, rotational and vibrational partition functions, the electronic and nuclear partition functions for monatomic, diatomic and polyatomic gases.

UNIT-II **(11 Hours)**

Quantum Mechanics: black-body radiation, heat capacities, photoelectric and Compton effects, atomic and molecular spectra, particle diffraction, wave-matter duality.Foundation of Quantum theory Postulates of quantum mechanics. Uncertainty Principle Schrodinger equation and its interpretation.Hermitian operators and their properties. Commutation relations. Linear harmonic oscillator and its solution in terms of ladder operators(factorization method). Selection rules, expectation values.

UNIT –III **(11 Hours)**

Virial theorem. Hydrogen atom and its complete solution (including solution of the radial equation using factorization method). Spherical harmonics as wave functions of a rigid rotor. Total wave function of the hydrogen like atoms, shapes of atomic orbitals, Radial distribution function.Angular momentum, Spin. Coupling of angular momenta; spin-orbit coupling. Molecular term symbols.

UNIT-IV **(12 Hours)**

Approximate Methods: Time-Independent (Non-degenerate, degenerate states) perturbation theory. Application of time-dependent perturbation theory. The variation method. Comparison of perturbation and variation method. Valence-bond and molecular orbital approaches, their comparison and equivalence limit. The pi-electron approximation. Huckel theory of conjugated systems. Applications to ethylene, butadiene and benzene.

PRACTICAL (30 Hours)

1. **Refractive Index (RI) Measurements:** Refractive index measurements of pure solvents and analysis of solvent mixtures in terms of composition from the calibration plot.
2. **Conductometric Measurements:** Determination of cell constant, limiting molar conductance of simple electrolytes in water, verification of Ostwald, dilution law for week acetic acid.
3. **Thermochemistry:** Determination of water equivalent of thermos flask, and estimation of heat of neutralization for strong acid strong base, weak acid strong base or vice – versa, heat of hydration and solution of salts.

SUGGUESTED READINGS:

1. Atkins P.W. and Friedman R.S., Molecular Quantum Mechanics, 4th edition, Pubs: Oxford University Press, (2004).
2. McQuarrie D., Quantum Chemistry, 2nd edition, Pubs: University Science Books (2008).
3. Levine I.N., Quantum Chemistry, 5th edition, Pubs: Prentice Hall (2006).
4. Kreyszig E., Advanced Engineering Mathematics, Pubs: John Wiley, NY (2001).
5. Ayres F.Jr., Matrics, Pubs. McGraw Hill, New Delhi (1974).
6. Pilar F.L., Elementary Quantum Chemistry, Pubs:McGraw Hill (1968).
7. March N.H., Self-Consistent Fields in Atoms, Pubs:Pergamon Press (1975).
8. Chandra A.K., Introductory Quantum Chemistry, Pubs: Tata-McGraw Hill(1988).
9. Pople J.A. and Beveridge D.L., Approximate Molecular-Orbital Theory, Pubs: McGraw Hill, NY (1970).
10. Lowe J.P., Quantum Chemistry, Pubs: Academic Press (1993).
11. Senior Practical Physical Chemistry: B.D. Khosla, V.C. Garg and A. Khosla
12. Experimental Physical Chemistry: V. Athawale and P. Mathur.

Chem.421 Bioinorganic Chemistry 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- to provide deep insights into the chemistry of biological systems.
- to explain the role of metals in chemical reactions involved in these systems.

LEARNING OUTCOMES:

The student will be able to

- to understand the processes associated with heme and non-heme proteins, iron-sulphur proteins, and their role in biological systems.
- to have an insight into the role of metals in the functioning of some enzymes and in nitrogen fixation.

THEORY (45 Hours)

UNIT- I: (11 Hours)

Elementary Cell Biology: Introduction to biomolecules: proteins, enzymes, nucleic acids, porphyrin and corrins. Role of metals in bio-systems: a general survey of the role of main group elements and transition elements in biological systems ionophores, cation transport: Na/K ion pump. Heme and non-heme proteins, Haemoglobin and myoglobin as oxygen carriers, Bohr effect. Coordination chemistry of Fe(II) in haemoglobin and oxyhaemoglobin. Relaxed and tense (R & T) configurations of haemoglobin, electronic formulations and mode of bonding of dioxygen in haemoglobin (modeling), Cytochromes and other natural oxygen carriers such as hemerythrins and hemocyanins. (iv) Iron sulphur proteins and electron transfer agents in biological systems: Systems, synthetic models of 4-fe ferredoxins. (v) Iron supply and transport in biological systems: Ferritin, transferrin and siderophores.

UNIT-II: (12 Hours)

Bio-inorganic chemistry of cobalt, vitamin B12, cobalamins, cobamides and their model compounds. Redox chemistry of B12, mechanisms of reactions catalysed B12 dependent enzymes and model compounds of B12.Role of Metals in Medicine: Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs, selenium and tellurium drugs, cis-platin and analogues, alternatives to cis-platin, adverse effects of anticancer drugs, toxicity due to non-essential metals.

UNIT-III **(11Hours)**

Metalloenzymes and photosynthesis Metalloenzymes: Carbonic anhydrase and carboxy peptidase, amino peptidase, Alkaline phosphate. Superoxide dismutase; inhibition of metalloenzymes. Photosynthesis: Chloropphyll in photosynthesis, current hpothesis for the photo oxidation of chlorophyl, synthetic leaf, 'Z' diagram for electron transport in PS-I and PS-II photosystem. Model studies of WOC and Photosystems.

UNIT-IV **(11 Hours)**

Nitrogen fixation: Classification of nitrogen fixing bacteria. Nitrogenase enzymes: EXAFS (Extended X-ray absorption fine structure spectroscopy) for characterization of the cofactor of nitrogenase and its synthetic analogues-double cubane cluster. Vanadium containing nitrogenases, mechanism of nitrogen fixation by nitrogenases and role of ATP in nitrogen fixation. nitrite reductase and nitrate reductase.

PRACTICAL (30 Hours)

1. **Analysis of mixtures by gravimetric and volumetric methods from the mixture solutions:**
   Copper- Nickel
   Copper -Magnesium
   Copper-Zinc
   Iron-Magnesium
   Silver-Zinc
   Copper-Nickel-Zinc
   Fe(II)-Fe(III)
2. **Green methods of Preparation of the following:**
   Bis(acetylacetonato)copper(II)
   Tris(acetylacetonato)iron(III)
   Tris(acetylacetonato)manganese(III)

SUGGUESTED READINGS:

1. Purcell K.F. and Kotz J.C., Inorganic Chemistry, Pubs: W.B. Saunders & Co., London (1977).
2. Jolly W.L., Modern Inorganic Chemistry, Pubs: W.B. Saunders & Co., London (1984).
3. Cotton F.A. and Wilkinson G, Advanced Inorganic Chemistry, 5 th Edition, Pubs:Willey Eastern (1989).
4. Hughes M.N., Inorganic Chemistry of Biological Processes, Pubs: Willey (1972).
5. Dennis, Brown G., Chemistry of Vitamin B-12 and Related Inorganic Model, Systems, Progress in Inorganic Chemistry (Vol.18)

Chem.422 **Pericyclic and Asymmetric Synthesis** **3+1**

LEARNING OBJECTIVES:

Objectives of this course are:

- to make students familiar about the concepts and applications of pericyclic reactions and asymmetric organic synthesis.
- to give information about the basic principle of enantioselective reactions and enantiomeric excess determination.

LEARNING OUTCOMES:

The student will be able to

- To apply the information about the synthetic applications of asymmetric organic synthesis
- To understand the mechanisms of various pericyclic reactions.

THEORY (45 Hours)

UNIT-I: Pericyclic Reactions-I (11 Hours)

Classification of pericyclic reactions, Molecular orbital and their symmetry properties, molecular orbitals of ethylene, 1,3-butadiene;1,3,5-hexatriene; allyl system, Woodward-Hoffmann's conservation of orbital symmetry rule; Analysis of pericyclic reactions: FMO approach, correlation diagrams method and Perturbation of molecular orbital approach. Cycloaddition reactions: Supra and antra facial additions, 4n and 4n+2 systems, 2+2 additions of ketenes. Diels-Alder reactions, 1,3-Dipolar cycloaddition and cheletropic reactions, ene reaction, retro-Diels-Alder reaction, regioselectivity, periselectivity, torque selectivity, site selectivity and effect of substituents in Diels-Alder reactions. Other Cycloaddition Reactions- [4+6] Cycloadditions, Allene Cycloadditions

UNIT-II Pericyclic Reactions-II (11 Hours)

Electrocyclic reactions – controtatory and disrotatory motions, 4n, 4n+2, allyl systems secondary effects. Electrocyclic rearrangement of cyclobutenes and 1,3 cyclohexadienes. Sigmatropic Rearrangements: H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations, detailed treatment of Claisen and Cope rearrangements, fluxional tautomerism, aza-cope rearrangements, introductions to Ene reactions. Formation of Vitamin D from 7-dehydrocholesterol, synthesis of citral using pericyclic reaction, conversion of Endiandric acid E to Endiandric acid A.

UNIT-III Asymmetric synthesis (12 Hours)

Asymmetric synthesis and its need. Basis, principles and strategiesof asymmetric synthesis, Sources of chiral compounds and methods (I-IV generations) of asymmetric synthesis, Enantiomeric excess, Analytical methods for enantiomeric excess determination, Asymmetric synthesis using chiral starting materials: addition to carbonyl compounds (face blocking/ diastereofacial bias, chiral sulfoxides, organometallics, chiral amplification), α-substitution using chiral enolatesand chiral auxiliaries (SAMP, RAMP, SULTAM, EVANS, MASAMUNE).

UNIT-IV Asymmetric synthesis-II (11 Hours)

Enantioselective and diastereoslective aldol reactions, Asymmetric addition to C-C double bond: Asymmetric hydrogenation, Enantioselective epoxidation, Enantioselective hydroxylation, Asymmetric Diels-Alder reaction (use of chiral dienes and dienophiles), Asymmetric hydroboration of alkenes, Asymmetric enzymatic transformations, oxidation, reduction and hydrolysis.

PRACTICAL (30 Hours)

1. **Qualitative Analysis:** Separation, purification, and identification of binary mixture of organic compounds, TLC, column chromatography and IR spectroscopy.
2. **Organic Synthesis:** Sandmeyer reaction: p-chlorotoluene from p-toluidine. Acetoacetic ester condensation: Synthesis of ethyl-n-butylacetoacetate by A.E.E
   Condensation. Preparation of iodoform from acetone (Haloform reaction).
   Preparation of polystyrene, anthranilic acid, fluorosceine-eosin, and methyl orange

SUGGUESTED READINGS:

1. Fleming, I., Pericyclic Reactions, Pubs: Oxford Science Publications (2015).
2. Sankararaman, S. Pericyclic reactions a textbook: reactions, applications and theory, Pubs: Wiley India, New Delhi (2016).
3. Gill, G.B.; Willis, M.R. Pericyclic Reactions, Pubs: London, Chapman & Hall. (1974).
4. Morrison J. D. (eds) Asymmetric Synthesis, Vol. 1 to 5, Pubs: Academic Press.(1992).
5. Aitken R.A. and Kilenyi S.N., Asymmetric Synthesis, Pubs: Academic Press. (1994).
6. Proctor Garry, Asymmetric Synthesis, Pubs: Academic Press (1996)

Chem.423 Surfaces and Macromolecules 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- To teach the fundamental concepts of surface chemistry and their applications.
- To develop requisite intellectual and laboratory skills.

LEARNING OUTCOMES:

The student will be able to

- understand the processes associated with surface chemistry.
- have an insight into the processes involving macromolecules

THEORY (45 Hours)

UNIT-I (11 Hours)

Surface tension and surface free energy (theory and measurement methods), Capillarity Contact angle (theory and measurement methods), wetting, Surface forces, Surface films on liquid substrates (surface potential, monomolecular films, Langmuir Blodgett layers), Electrical aspects of surface chemistry (electrical double layer, zeta potential,)Solid liquid interface, stability of dispersions, Adsorption, adsorption isotherms Langmuir and BET adsorption (derivation), Gibbs adsorption equation and its derivation from thermodynamic considerations. Characterization of colloidal particles including Brownian movement, Electrokinetic phenomena, Stabilization of colloidal systems and theories of stability; zeta potential, Coagulation, Flocculation of colloids by electrolytes and its mechanism.

UNIT-II (11 Hours)

Precipitation of sols by electrolytes, Hardy Schulz rules, other methods of precipitation. Detergency, surfactants, self-assembly, micelles and vesicles Emulsions, foams, and aerosols Thermodynamics of micellization, Phase separation and Mass action models, Solubilization, Mechanism of formation of microemulsion and their stability, Fish cut and triangular Phase maps (Two component, three component, pseudo-terinary), Applications of colloid and surface science in petroleum recovery, coating and painting, food, pharmaceutical and cosmetic industry Introduction

UNIT-III **(12 Hours)**

Macromolecular concept. Molar mass averages, distribution of molecular mass. Kinetics of Polymerizaton Kinetics of step growth polymerization, size distribution in linear polymers. Kinetics of free radical addition polymerization, distribution of molar masses, effect of temperature. Ionic polymerization, kinetics of cationic and anionic polymerization. Statistics of Linear Polymer Chains Polymer chain flexibility and internal rotation, random flight analysis of end-to end distance for freely jointed chain in one dimension and three dimensions. Effect of bond angle and restricted rotation on chain dimensions. Unperturbed chains. Long-range interactions and effect of solvent. Distribution of chain segments relative to centre of mass.

UNIT-IV **(11 Hours)**

Thermodynamics of Macromolecular Solutions Flory-Huggins theory. Flory-Krigbaum theory of dilute solutions, partial molar quantities. Osmotic pressure. Characterization of Macromolecules Flow properties, generalized flow equation. Frictional co-efficient and flow properties. Determination of molecular size and mass from diffusion, sedimentation velocity, sedimentation equilibrium and viscosity. Light scattering and small angle X-ray scattering.

PRACTICAL (30 Hours)

1. **Surface Tension Measurements:**
   i. Study the variation of surface tension with different concentration of detergent solutions. Determine CMC.
   ii. Study the effect of the addition of solutes on the surface tension of water at room temperature and explain the observations in terms of molecular interactions:
      a. sugar
      b. ethanol
      c. sodium chloride
   iii. Surface tension of pure solvents, analysis of mixtures of two miscible solvents, verification of Gibb's Thomson Rule of surface tension.
2. **Partition – Coefficient**: Determination of partition – coefficient for I2 and benzoic acid between two immiscible solvents.
3. **Adsorption Measurements:** Verification of Freundlich adsorption isotherm for I2, and acetic acid on charcoal.
4. **Colloidal Solution:** Preparation of sol solution of arsenic sulphide and estimation of flocculation value for NaCl, KCl, $BaCl_2$, $AlCl_3$.

SUGGUESTED READINGS:

1. Young R.J. and Lovell P.A., Introduction to Polymers, Pubs: Chapman and Hall, London, 2nd ed., New Delhi (2004).
2. Billmeyer F.W. Jr., Text book of polymers science, Pubs: Wiley-Interscience, 3rd edn.,(1984).
3. Myers D., Surfactant Science and Technology, Pubs: VCH Publishers (1988).
4. Flory P.J., Principles of polymer chemistry, Pubs: Cornell Univ. Press, (Indian Print 2006).
5. Tager A, Physical Chemistry of polymer, Pubs: Mir Publishers, Moscow (1971).
6. Hunter 3. R.J., Foundations of Colloid Science, Vols. I & II, Pubs: Oxford Science Publications (1989).
7. Rosen M.J., Surfactants and Interfacial Phenomena, Pubs: John Wiley & Sons (1989).

HIGHER & APPLIED AREA LEVEL COURSES:

Chem.414 Advanced Organometallics (3+1)

LEARNING OBJECTIVES:

Objectives of this course are:

- to provide knowledge about the bonding and fluxionality in organometallic compounds of transition elements.
- to explain homogeneous transition metal catalysis
- to give information about metal-metal bonding in metal clusters.

LEARNING OUTCOMES:

The student will be able to

- get information about different aspects the metal-carbon multiple bonded organometallic compounds and their different applications
- apply knowledge of homogeneous transition metal catalysis to explain hydrogenation of organic compounds.
- Explain important homogeneous catalytic reactions and their utility in organic synthesis.

THEORY (45 Hours)

UNIT-I (12 Hours)

Organometallic Compounds of transition elements: Types of ligands and their classifications in organometallic compounds, 16 and 18 electron rule and its limitations. Hapto-nomenclature, synthesis, structure and bonding aspects of following organometallic compounds with carbon- π donor ligands: (a) Two electron donor (olefin and acetylenic complexes of transition metals): (b) Three electron donor (π-allyl complexes of transition metals): (c) Four electron donor (butadiene and cyclobutadiene complexes of transition metals): (d) Five electron donor cyclopentadienyl complexes of transition metals – metallocenes with special emphasis to ferrocenes): (e) Six electron donor [Benzene (arene) complex]. Fluxional Organometallic compounds (classification)

UNIT-II (12 Hours)

Homogeneous Transition metal catalysis: General considerations, Reason for selecting transition metals in catalysis (bonding ability, ligand effects, variability of oxidation state and coordination number), basic concept of catalysis (molecular activation by coordination and addition), proximity interaction (insertion/inter-ligand igration and elimination, rearrangement). Phase transfer catalysis. Homogeneous hydrogenation of unsaturated compounds (alkenes, alkynes, aldehydes and ketones). Asymmetric hydrogenation (Olefins).

UNIT-III (5 Hours)

Some important homogeneous catalytic reactions: Ziegler Natta polymerization of ethylene and propylene, oligomerisation of alkenes by aluminium alkyl, hydroformylation of unsaturated compounds using cobalt and rhodium complexes, carbonylation of alkenes and alkynes using nickel carbonyl and palladium complexes.

UNIT-IV (8 Hours)

Metal-metal bonding in carbonyl and halide clusters Polyhedral model of metal clusters, effect of electronic configuration and coordination number, Structures of metal carbonyl clusters of three atoms $M_3(CO)_{12}$ (M=Fe, Ru & Os), Four metal atoms (tetrahedra) [$M_4(CO)_{12}$ {M= Co, Rh &Ir}] and octahedron of type $M_6(CO)_{16}$ [M= Co & Rh], and halide derivatives of Rhenium (III) triangles, metal carbonyls involving bridged-terminal exchange and scrambling of CO group.

UNIT-V **(8 Hours)**

Transition Metal-Carbon multiple bonded compounds: Metal carbenes and carbines (preparation, reactions, structure, and bonding considerations). Biological and industrial applications and environmental aspects of organometallic compounds.

PRACTICAL (30 HOURS)

1. Preparation of following compounds:
   (i) Tetrapyridine copper (II) persulphate
   (ii) Dinitritotetrapyridine nickel (II)
   (iii) Mercury (tetraisothiocyanato)cobaltate(II).
   (iv) Potassium tris(oxalato)aluminate(III)
   (v) Sodium hexa(nitro)cobaltate(III)
   (vi) Potassium tris(oxalato)cobaltate(III)
2. Characterization of above compounds by the following techniques:
   (i) Elemental analysis
   (ii) Molar conductance values
   (iii) Thermal analysis

SUGGUESTED READINGS:

1. Principles of organometallic compounds – Powell
2. Organometallic chemistry (an Introduction) – Perkin and Pollar
3. Advanced Inorganic Chemistry – Cotton and Wilkinson
4. Organometallic Chemistry-R.C. Mehrotra
5. Organometallic compounds of Transition Metal-Crabtree
6. Chemistry of the Elements – Greenwood and Earnshaw
7. Homogeneous transition metal catalysis – Christopher Masters
8. Homogeneous Catalysis – Parshall
9. Principles and Application of Homogeneous Catalysis – Nakamura and Tsutsui
10. Progress in Inorganic Chemistry Vol. 15 – Lipard. (Transition metal clusters – R.B. King)
11. Text Book of Qualitative Inorganic Analysis – A.I. Vogel
12. Synthetic Coordination Chemistry: Principles and Practice- J.A. Davies, C.M. Hockensmith, V.Y. Kukushkin and Y.N. Kukushkin.

Chem.415 **Solutions, Colligative Properties, and Chemistry of Nano-materials 3+1**

LEARNING OBJECTIVES:

Objectives of this course are:

- to explain various adsorption processes at solid – gas interface and solid-liquid interfaces.
- to give information about the solution properties and interfacial behaviour of surfactants and their practical applications

- to familiarize the students with various theories and laws of electrochemistry

LEARNING OUTCOMES:

The student will be able to

- apply the phenomenon of adsorption to derive various expressions and equations.
- solve problems by using suitable expressions and equations involving adsorption
- understand the applications of nano chemistry in fabricating some useful nanomaterials.

THEORY (45 Hours)

UNIT –I **(11 Hours)**

Dilute solutions: Lowering of vapour pressure, Raoult's and Henry's Law and their applications, Excess thermodynamic functions, thermodynamic derivation using chemical potential to derive relations between the four colligative properties (relative lowering in vapour pressure, elevation in boiling point, depression in freezing point, osmotic pressure) and amount of solute. Applications in calculating molar masses of normal, dissociated, and associated solutes in solution.

UNIT –II **(12 Hours)**

Solution and Interfacial Behaviour of Surfactants: Definition and classification of surfactants. Solution properties of surfactants: micelle formation, critical micelle concentration (CMC), dependence of CMC on chain length of the surfactant, micelle shape and size. Thermodynamics of micelle formation, hydrophobic effect (a qualitative view only). Aggregation at high surfactant concentration (a qualitative aspect) to micelles. Surface tension and detergent. Practical application of surfactants.

UNIT –III **(11 Hours)**

Electrochemistry:Quantitative treatment of Debye - Hückel and Debye-Hückel-Onsagar (D-H-O) theory of conductance of electrolyte solution their limitations and modifications. Pair-wise association of ions (Bjerrum and Fuoss treatment). Determination of association constant (Ka) from Debye – Huckel Limiting Law. Extended Debye – Huckel Law. Qualitative treatment of ion – solvent interactions (ion solvation).

UNIT –IV **(11 Hours)**

Chemistry of nano – materials: Definition and historical perspective. Effect of nanoscience and nanotechnology in various fields. Synthesis of nanoparticles by chemical routs and their characterization techniques. Properties of nanostructured material: optical, magnetic and chemical properties. An overview of applied chemistry of nanometerials.

PRACTICAL (30 Hours)

1. **Adsorption Measurements:** Verification of Freundlich adsorption isotherm for I2, and acetic acid on charcoal.
2. **Colloidal Solution:** Preparation of sol solution of arsenic sulphide and estimation of flocculation value for NaCl, KCl, $BaCl_2$, $AlCl_3$.
3. **Construction of Phase Diagram:** Phase diagram for liquids, (benzene and methanol) and phase diagram for solids, (benzoic acid and cinnamic acid, benzoic acid and naphthalene and acetamide and salicylic acid).
4. **Determination of Molar Mass:** (i) Cryoscopic and Rasts's methods.
5. **Potentiometric Titration:** Titration of HCl with NaOH, determination of dissociation constant of acetic acid and phosphoric acid. Oxidation – reduction titration.

6. **Polarimetry Measurements:** Determination of specific and molecular rotation, percentage of tow optically active substances, kinetics of acid catalysed inversion of cane sugar and comparison of strengths of two acids.

SUGGUESTED READINGS:

1. Physical Chemistry of Surfaces by A.W. Admson
2. Adsorption from Solutions byJ. J. Kipling
3. Micelles (Theoretical and Applied Aspects) by Y. Moroi
4. Foundation of Colloid Science (Vol. I and II) by R.J. Hunter
5. Physical Chemistry by P.W. Atkins
6. Frontiers in Applied Chemistry by A.K. Biswas

Chem.424 Advanced Spectroscopy 3+1*

LEARNING OBJECTIVES:

Objectives of this course are:

- to provide the basic knowledge about the principles and instrumentation of spectroscopic techniques like ultra violet-visible spectroscopy, infrared spectroscopy, nuclear magnetic resonance (NMR) spectroscopy and mass spectrometry
- to apprise the students about the applications of spectroscopic techniques for the structure elucidation of organic compounds.

LEARNING OUTCOMES:

The student will be able to

- Understand the basic principle of IR spectroscopy and its applications.
- Apply the basic concepts of Ultraviolet and Visible Spectroscopy and its applications.
- Apply the concept of mass spectrometry for the determination of structure of organic compounds based on fragmentation.
- Understand the basic principle of NMR spectroscopy and to apply its role for the structure elucidation.

THEORY (45 Hours)

UNIT-I (11 Hours)

Ultra Violet and Visible Spectroscopy: Electronic transitions (185-800 nm), Beer- Lambert Law, Effect of solvent on electronic transitions, Ultra Violet bands of carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Steric effect in biphenyls, Fieser- Woodward rules for conjugated dienes and carbonyl compounds, ultra violet spectra of aromatic and heterocyclic compounds. Applications of UV- visible spectroscopy in organic chemistry.

UNIT -II (11 Hours)

Infrared Spectroscopy: Principle, Instrumentation and sample handling, Characteristic vibrational frequencies of common organic compounds, Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance. Introduction to Raman spectroscopy. Applications of IR and Raman spectroscopy in organic chemistry.

UNIT –III (12 Hours)

Nuclear Magnetic Resonance (NMR) Spectroscopy: General introduction, chemical shift, spin-spin interaction, shielding mechanism, chemical shift values and correlation of protons present in different groups in organic compounds. chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei, virtual coupling. Stereochemistry, hindered rotation, Karplus- relationship of coupling constant with dihedral angle. First and second order spectra, Simplification of complex spectra-nuclear magnetic double resonance, spin tickling, INDOR, contact shift reagents, solvent effects. Fourier transform technique, nuclear Overhauser effect (NOE). Introduction to resonance of other nuclei –^{13}C NMR, 2-D and 3-D NMR, Applications of NMR in organic chemistry.

UNIT -IV **(11 Hours)**

Mass Spectrometry: Introduction, ion production—EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, and ion abundance. Mass spectral fragmentation of organic compounds with common functional groups, Molecular ion peak, Meta-stable peak, McLafferty rearrangement. Nitrogen Rule. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination. Introduction to negative ion Mass spectrometry, TOF-MALDI.

***Tutorial (15 Hours)**

The students will:

- Interpret and analyse spectra of the molecules using rules of various spectroscopic techniques
- Solve problems by choosing suitable spectroscopic methods and interpreting corresponding data
- Solve problems based upon IR, UV, NMR and mass spectroscopy.

SUGGUESTED READINGS:

1. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
2. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley.
3. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley.
4. Application of Spectroscopy of Organic Compounds, J.R. Dyer, Prentice Hall.
5. Spectroscopic Methods in Organic Chemistry by D.H. Williams,I. Fleming, Tata McGraw-Hill.
6. Organic spectroscopy by Jagmohan
7. Organic spectroscopy by W. Kemp.
8. Spectroscopy by Pavia

RESEARCH/PROJECT/SEMINAR:

Chem.391 **Seminar** **0+1**

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Identify and compare technical and practical issues related to the area of course specialization.

- Outline annotated bibliography of research demonstrating scholarly skills.
- Prepare a well-organized report employing elements of technical writing and critical thinking.
- Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

LEARNING OUTCOMES:

At the end of this course, students will be able to:

- Establish motivation for any topic of interest and develop a thought process for technical presentation.
- Organize a detailed literature survey and build a document with respect to technical publications.
- Analysis and comprehension of proof-of-concept and related data.
- Effective presentation and improve soft skills.
- Make use of new and recent technology for creating technical reports
- Will be able to present themselves in front of an audience. It will help them to develop skills like speaking ability, gain and express knowledge in different fields and presentation capability. They will also learn to defend themselves in front of a panel of Seminar Committee.

Chem.491 Pre-Research 0+4

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Identifying the Research Problem.
- Performing a Literature Review & Writing a Theoretical/Conceptual/experimental Framework.
- Researching the methods/experiments/Design or Approach to the Problem.

LEARNING OUTCOMES:

At the end of Research Proposal, students will be able to:

- Outline the literature on as Specific research problem.
- Construct objectives and motivations of research problem to be carried out.
- Explain the nuts and bolts of the theoretical concepts of the problem (experimental or theoretical) to be carried out.
- Making research proposal for further research.

Student will prepare a research proposal based on literature review and extensive student-mentor interactions involving discussions, meetings and presentations. Each student will submit a research/dissertation proposal of the research work planned for the research dissertation with origin of the research problem, literature review, hypothesis, objectives and methodology to carry out the planned research work, expected outcomes and bibliography. Research projects can be taken up in collaboration with industry from within the discipline or across the discipline

Chem.492 **Research** **0+8**

LEARNING OBJECTIVES:

The prime aim of this course is to:

- Collecting and Analyzing the Data and/or Designing and Validating the methods/experiments/Design
- Drawing Conclusions and Giving Recommendations
- Prepare dissertation/thesis/report on the proposed research work

LEARNING OUTCOMES:

At the end of Dissertation students will be able to:

- Demonstrate an in-depth knowledge of scientific research pertaining to the area of study
- Demonstrate experimental/theoretical research capabilities based on rigorous hands-on training
- Critically analyze, interpret and present the data in light of existing scientific knowledge to arrive at specific conclusions
- Develop higher order thinking skills required for pursuing higher studies (Ph.D.)/research-oriented career options in respective fields.

Students will carry out their research work under the supervision of a faculty member. Students will interact with the supervisors through meetings and presentations on a regular basis. After completion of the research work, students will complete the dissertation under the guidance of the supervisor. The dissertation will include literature review, hypothesis, objectives, methodology, results, discussion, and bibliography.

Chem.493 **Academic Project** **0+4**

LEARNING OBJECTIVES:

The primary aim of this course is to:

- review the Research in the subject area.
- Analyse data and other research findings.
- Report research findings in written form.

LEARNING OUTCOMES:

After completion of course, students will have hand on experience of

1. Literature survey on advanced research topics in Chemistry and its allied discipline
2. Planning and designing the experiment and theoretical modelling of the research Problem
3. Analysis and evaluation of the experimental data/ theoretical & computational modelling Deduction and systematic presentation of the results
4. Compilation of the results / information to produce written document
5. Defending the results of the project in an open viva–voice through power point presentation

All the Chemistry honours students will do a supervised Chemistry Project as an important culmination of training in Chemistry learning and research. The project will aim to introduce student to the basics and methodology of research in chemistry, which is done via theory, computation, and experiments either all together or separately by one of these approaches. It is intended to give research exposure to students.

MINOR COURSES:

Minor I

RM.311 Research Methodology 3+0

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:
- Concept of research and research ethics
- The concepts of statistical tools in research.

LEARNING OUTCOMES:

This course will enable the students to:
- Understanding of meaning and role of research.
- Understanding of patents and copy rights and provides the understanding of ethical research.
- Acquires the knowledge to define problems, formulate appropriate and relevant research questions, formulate hypotheses, test hypotheses using quantitative and qualitative data
- Understanding of appropriate methodology and tools for data collection.
- Acquires the knowledge of appropriate use of statistical and other analytical tools and techniques.

THEORY (45 Hours)

UNIT-I Introduction (9 Hours)

Meaning of research, purpose of research, research methods scientific methods, experimental methods, theoretical research, observational methods, survey, questionnaires methods, role of theory and characteristics of research. Criteria of good research. Philosophy of Science. Logical reasoning (inductive logic, deductive logic and syllogistic logic).

UNIT-II Ethics in Research (9 Hours)

Need for research design. Types of research: fundamental or pure research, applied research, action research, experimental research. History of development of science and the influence of philosophy. Sponsored Research. Ethical Conduct in Science.

UNIT-III Intellectual Property Rights (9 Hours)

Patents and copyrights, General Introduction, Design Patents & copyrights, Patent drafting, patent claims and specifications, trademarks, trade integrated circuit. Patent Life and Geographical Boundaries, Utilization of Intellectual Patents, Patent Search, Patent Acts & Rules, Legal Decision making process, Ownership of Patents, Author & ownership of Copyright, Licensing of Copyrights, Infringement of Copyrights and patents, Remedies & Actions for Infringement of

Copyrights IPR as Protection Strategy. Patent cooperation treaty (PCT), Indian & US Patent Acts & Latest Amendments.

UNIT-IV Method of Data Collection (9 Hours)

Collection of data, observation method, collection of data through questionnaires, schedules, difference between questionnaires and schedules. Data Types Nominal, Ordinal and Ratio scale; scaling techniques. Classification, analysis and presentation of data. Statistical treatment of collected data. Arithmetic mean, geometric mean and standard deviation.

UNIT-V Testing of Hypothesis (9 Hours)

Meaning, Characteristics and concepts relating to testing of Hypothesis (Parameter and statistic, Standard error, Level of significance, type-I and Type-II errors, Critical region, one tail and two tail tests); Procedure of testing Hypothesis. Sampling schemes like, simple random sampling without replacement, simple random sampling with replacement and stratified random sampling.

SUGGESTED READINGS:

1. C.R. Kothari, "Research Methodology", New Age Publishers, 2004
2. R. Kumar, "Research Methodology",3rd edition, 2011.
3. A.M. Goon, M.K. Gupta and D. Gupta, "Fundamentals of Statistics", Vol. I, 8th Edn. The World Press, Kolkata, 2002.
4. S. C. Gupta and V.K. Kapoor, "Fundamentals of Mathematical Statistics", 4thEdition (Reprint), Sultan Chand &Sons, 2008.

Minor II:

Comp.311 Programming Using Python 2+1

Learning Objectives:

The primary objective of this course is:

- Introduces programming concepts using Python to Computer Science students.
- Focuses on the development of Python programming to solve problems of different domains.
- Introduces the concept of object- oriented programming

LEARNING OUTCOMES:

This course will enable the students:

- Understand the basics of programming language
- Develop, document, and debug modular Python programs.
- Apply suitable programming constructs and built-in data structures to solve a problem.
- Use and apply various data objects in Python.
- Use classes and objects in application programs and handle files.

THEORY (30 Hours)

UNIT I: (4 Hours)

Introduction to Programming
Problem solving strategies; Structure of a Python program; Syntax and semantics; Executing simple programs in Python.

UNIT II: (10 Hours)

CreatingPythonPrograms
Identifiersandkeywords;Literals,numbers,andstrings;Operators;Expressions;Input/output statements; Defining functions; Control structures (conditional statements, loopcontrolstatements, break, continueand pass, exitfunction), default arguments.

UNIT III: (10 Hours)

Built-inDataStructures
Mutable and immutable objects; Strings, built-in functions for string, string traversal, stringoperators and operations; Lists creation, traversal, slicing and splitting operations, passing listtoafunction; Tuples, sets, dictionaries, andtheiroperations.

UNIT IV: (6 Hours)

ObjectOrientedProgramming
Introductiontoclasses,objects,andmethods;Standardlibraries.
FileandExceptionHandling
Filehandlingthroughlibraries;Errorsand exceptionhandling.

PRACTICAL (15 Hours)

ListofPractical:

1. WAPtofindtherootsofaquadratic equation
2. WAPtoacceptanumber'n'and
    a. Check if 'n' is prime
    b. Generate all prime numbers till 'n'
    c. Generate first 'n' prime numbers This program may be done using functions
3. WAPtocreateapyramidofthecharacter'*'andareversepyramid

```
    *
   ***
  *****
 *******
*********
*********
 *******
  ******
   ***
    *
```

9. WAPthatacceptsacharacterandperformsthefollowing:
    a. print whether the character is a letter or numeric digit or a special character
    b. if the character is a letter, print whether the letter is uppercase or lowercase
    c. if the character is a numeric digit, prints its name in text (e.g., if input is 9, output is NINE)
    d. WAP to perform the following operations on a string

e. Find the frequency of a character in a string.
f. Replace a character by another character in a string.
g. Remove the first occurrence of a character from a string.
h. Remove all occurrences of a character from a string.

10. WAPtoswapthefirstncharactersoftwostrings.
11. Write a function thataccepts two strings and returnsthe indicesof all the occurrencesof the second string in the first string as a list. If the second string is not present in thefirststringthenitshouldreturn-1.
12. WAP to create a list of the cubes of only the even integers appearing in the input list(mayhaveelementsofothertypesalso)usingthefollowing:
    a. 'for' loop
    b. list comprehension
13. WAPtoreadafileand
    a. Print the total number of characters, words and lines in the file.
    b. b. Calculate the frequency of each character in the file. Use a variable of dictionary type to maintain the count.
    c. c. Print the words in reverse order.
    d. d. Copy even lines of the file to a file named 'File1' and odd lines to another file named 'File2'.
14. WAPtodefineaclassPointwithcoordinatesxandyasattributes.Createrelevant methods and print the objects. Also define a method distance to calculate thedistancebetweenanytwopointobjects.
15. Writeafunctionthatprintsa dictionary where the keys are numbers between 1 and 5andthevaluesarecubes ofthekeys.
16. Consideratuplet1=(1,2,5,7,9,2,4,6,8,10).WAPtoperformfollowingoperations:
    a. Printhalfthevaluesofthetupleinonelineandtheotherhalfinthenextline.
    b. Printanothertuplewhosevaluesareevennumbersinthegiventuple.
    c. Concatenateatuplet2=(11,13,15)witht1.
    d. Returnmaximumandminimumvaluefromthistuple
17. WAPtoacceptanamefromauser.Raiseandhandleappropriateexception(s) ifthetextenteredbytheusercontainsdigitsand/orspecialcharacters.

SUGGESTED READINGS:

1. Taneja,S.,Kumar,N.PythonProgramming- AmodularApproach,1stedition,PearsonEducationIndia, 2018.
2. Balaguruswamy E. Introduction to Computing and Problem-Solving using Python, 2ndedition,McGrawHill Education, 2018.
3. Brown,MartinC.Python:TheCompleteReference,2ndedition,McGrawHillEducation, 2018.
4. Guttag,J.V.IntroductiontocomputationandprogrammingusingPython,2ndedition,MITPress, 2016.

Minor III:

Micro.321 Microbial Genetics 2+1

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- Understanding of the fundamentals of genetic processes in prokaryotes and eukaryotes.
- Understanding of fundamental genetic processes for all
- organisms, especially through the use of in vivo and in vitro genetic tools.

LEARNING OUTCOMES:

This course will enable the students to:
- Identify and distinguish genetic regulatory mechanisms at different levels
- Plan basic experiments in Microbial genetics
- Describe and summarize experimental work in a correct way.

THEORY (30 Hours)

UNIT-I **(6Hours)**

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. Bacterial genome Eukaryotic genome; Viral genome; Difference between prokaryotic and eukaryotic genome; Mechanisms and role of prokaryotic genome- an overview

UNIT-II **(6Hours)**

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. Plasmids, Mitochondrial DNA, Chloroplast DNA – structure and function.

UNIT-III **(8Hours)**

Gene structure and expression, principles of operon, gene expression in prokaryote and eukaryotes, intron and exons, post transcriptional modifications. Regulation of gene expression, negative expression (lac operon and trp operon), positive regulation (cAMP).

UNIT-IV **(10Hours)**

Principles of mutation, spontaneous and induced mutation, different types of mutations, selection principles of mutants. Mutagens and their mode of action, transposable elements and insertion sequences. DNA damage, DNA repair mechanisms in bacteria. Genetic recombination in bacteria, mechanisms of recombination, transformation, conjugation, transduction. Recombinant DNA technology

PRACTICAL (30 Hours)

1. Isolation of genomic DNA from pure cultures of bacteria and fungi.
2. Isolation of bacterial plasmids and Plasmid curring.
3. Qualitative and quantitative assay of DNA by spectrometry and gel-electrophoresis.
4. Inducing mutation by chemicals, physical and biological agents.
5. Transformation and selection of transformants.
6. Amplification of gene of interest by PCR – cloning and expression.

SUGGESTED READINGS:

1. Brown TA. 2001. Gene Cloning and DNA Analysis: An Introduction. Fourth Edition. Blackwell Science Inc., Oxford, UK.
2. Levin B. 2002. Gene VIII. Oxford Univ. Press, New York. p.990.

3. Maloy SR, Cronan JE, Freifelder D. 2008. Microbial Genetics - second edition. Narosa Publising house, New Delhi. p. 525.
4. Omoto CK and Lurquin PF. 2004. Genes and DNA: a beginner's guide to genetics and its applications. Colambia University Press, USA.
5. Sambrook J, Fritsch EF, Maniatis T. 2000. Molecular Cloning: A laboratory Manuel. Third Edition. Cold Spring Harbor Press, New York.Websites
6. Gardner JE, Simmons MJ and Snustad DP. 1991. Principles of Genetics. John Wiley& Sons.
7. Lewin B.1999. Gene. Vols. VI-IX. John Wiley & Sons

Biochem.321 General Biochemistry 3+0

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:
- Importance of Biochemistry in agricultural research.
- Involvement of Biochemical processes in our day-to-day life.
- Introduction to different biomolecules and their composition.

LEARNING OUTCOMES:

This course will enable the students to:
- Understand the importance of discipline of Biochemistry.
- Understand the role of different biomolecules in living systems.
- Understand the structure and composition of different biomolecules.
- Know about the basic metabolic processes in plant system.
- Introduction to molecular biology.

THEORY (45 Hours)

UNIT-I Introduction (9 Hours)

Introduction to the scope and importance of biochemistry in agriculture research and in our daily life.

UNIT-II Biomolecules and cell organelles(9 Hours)

Basic biomolecules and their role in living system. structure and function of different cell organelles in living system.

UNIT-III Structure and functions of biomolecules (9 Hours)

Structure and functions of carbohydrate, proteins, amino acids, lipids, and nucleic acids. structures and biological functions of vitamins.

UNIT-IVPhotosynthesis, respiration and nitrogen fixation (9 Hours)

Photosynthesis: basic mechanism of carbon assimilation, C3 and C4 cycles, photorespiration, Kranz anatomy. Respiration: Aerobic and anaerobic respiration, glycolysis, Krebs cycle, Electron transport system, oxidative phosphorylation**.** Basic steps involved in nitrogen fixation Habers process.

UNIT-V Introduction to molecular biology (9 Hours)

Introduction to DNA and RNA, basic steps in DNA replication, transcription, and translation

SUGGESTED READINGS:

1. Katoch R. 2017. "Fundamentals of Plant Biochemistry and Biotechnology". 1st edition, Kalyani Publishers, India.
2. Katoch R. 2017. "Molecular Biology". 1st edition, Kalyani Publishers, India.
3. Katoch R. 2018. "Macromolecules, Enzymology and Metabolism". 1st edition, Kalyani Publishers, India.
4. Katoch R. 2019. "Agricultural Biochemistry". 1st edition, Kalyani Publishers, India.
5. Katoch R.(2019). Principals and techniques in Biochemistry & Molecular Biology: 1st edition. Published by Department of Chemistry and Biochemistry, CSKHPKV, Palampur.

Bot.324/Zoo.324 Introduction to Biotechnology 2+1

LEARNING OBJECTIVES:

- Acquaint students to the principles, practices and application of animal biotechnology, plant tissue culture, genetic transformation and molecular breeding.

LEARNING OUTCOMES:

- On completion of this course, students should gain fundamental knowledge in animal and plant biotechnology and their applications

THEORY (30 Hours)

UNIT – I: (10 Hours)

History and Introduction to Biotechnology; Traditional and Modern Biotechnology, Branches of Biotechnology- Plant, Animal, Marine, Agriculture, Healthcare, Industrial, Pharmaceutical and Environmental Biotechnology. Biotechnology Institutions in India (Public and Private Sector) Biotech success stories, Biotech policy initiatives; Applications of Biotechnology in Agriculture (GM Food, GM Papaya, GM Tomato, Fungal and Insect Resistant Plants BT Crops, BT Cotton and BT Brinjal) and other fields; Pros and Cons Biotechnological applications in Crop and Livestock Improvements (Modifications in Plant Quality Golden Rice, Molecular Pharming, Plant Based Vaccines; Ethics in Biotechnology and IPR.

UNIT – II: (10 Hours)

Biological molecules: DNA and RNA as Genetic Material; Nucleic acid : Structural aspects – Components of DNA and RNA, Nucleosides & Nucleotides (introduction, structure & bonding), Double helical structure of DNA (Watson-Crick model), various forms of DNA; Genes are DNA – DNA is the genetic material, DNA is a double helix, DNA replication is semi-conservative, Transcription and RNA Processing in Eukaryotic Cells, Expression of genetic information : from Transcription to Translation - Genetic code, Decoding the codons : the role of transfer RNAs.

UNIT – III: (10 Hours)

Totipotency; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production.Enzymes useful in molecular cloning: Restriction endonuclease, DNA ligases

PRACTICAL (30 Hours)

1. Introduction to Instruments used in Biotechnology Laboratory
2. Preparation of Stock Solutions, buffers and pH determination
3. Sterilization techniques
4. Media Preparation and Aseptic Transfer Technique
5. Isolation and purification of DNA (genomic)
6. Agarose Gel Electrophoresis of the genomic DNA
7. Detection of DNA by gel electrophoresis
8. Estimation of DNA by UV spectroscopy

SUGGESTED READINGS:

1. Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman.
2. Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth.
3. Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. Enfield, NH: Science.
4. An Introduction to Practical Biochemistry (2017) 3rd ed., Plummer, D.T., McGraw Hill Education, ISBN: 978-0070994874.
5. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.

Bot.325/Zoo.325 Introduction to Bioinformatics 2+1

LEARNING OBJECTIVES:

- To acquaint students with the important concepts related to bioinformatics
- To understand the role of Bioinformatics in science and daily life activities
- To provide introductory exposure to various Bioinformatics databases and tools

LEARNING OUTCOMES:

At the end of this course, the student will be able to-

- Describe contents and properties of some important bioinformatics databases and tools.
- Apply and retrieve various data from Biological databases and perform basic DNA and protein sequence analysis
- Perform text- and sequence-based searches,analyze and discuss the results in light of molecular biological knowledge

THEORY (30 Hours)

UNIT – I: (10 Hours)

Introduction to Bioinformatics; History; Contentions and applications; Scope of bioinformatics; Basic introduction to Computers, Programming languages, fundamentals of the UNIX/Linux operating system-various open resources essential for bioinformatics; HPC & HTC; Role of internet and WWW in Bioinformatics; Neural networks and artificial intelligence. Basic biomolecular concepts: central dogma; Protein and amino acid, DNA & RNA Sequence, structure and function; Biological Data generation methods and problem posed by it - mass spectrometry and Edman degradation, Sanger's sequencing and Maxam–Gilbert sequencing; Introduction to NGS platforms.

UNIT – II: (10 Hours)

Concepts of database; Database management systems (DBMS); Introduction to query language; Index; Forms and Reports. Introduction to Bioinformatics data and databases:- Types of Biological data: Genomic DNA, Complementary DNA (cDNA), Recombinant DNA (rDNA), Expressed sequence tags (ESTs), Genomic survey sequences (GSSs), SNPs. Primary Databases:- GenBank, EMBL, DDBJ, Composite Databases:-NRDB, UniProt, Literature Databases:- Open access and open sources, PubMed, PLoS, Biomed CentralCentral. Sequence Databases :- Nucleotide sequence Databases (GenBank, EMBL, DDBJ); Protein sequences Databases (Swiss-ProtProt, TrEMBL, UniProt, UniProt Knowledgebase – UniProtKB, UniProt Archive –UniParc, UniProt Reference Clusters –UniRef, UniProt Metagenomic and Environmental Sequences – UniMES); Sequence motifs Databases:-Prosite, ProDom, Pfam, InterPro. Sequence file formats:- fasta, fastq, sam/bam, vcf, gff; GenBank, PIR, aln/ClustalW2, GCG/MSF. Structure and derived databases:- The primary structure databases (Protein Data Bank –PDB, Cambridge Structural Database –CSD, Molecular Modeling Database -MMDB).

UNIT – III: (10 Hours)

The secondary structure databases (Structural Classification of Proteins –SCOP, Class Architecture Topology Homology –CATH, Families of Structurally Similar Proteins –FSSP, Catalytic Site Atlas –CSA. Molecular functions/Enzymatic catalysis databases (KEGG ENZYME database, BRENDA).
Genome Databases:- Viral genome database (ICTVdb, VirGen), Bacterial Genomes database (Genomes OnLine Database –GOLD, Microbial Genome Database-MBGD), Organism specific Genome database (OMIM / OMIA, SGD, WormBase, PlasmoDB, FlyBase, TAIR), and Genome Browsers (Ensembl, VEGA genome browser, NCBI-NCBI map viewer, KEGG, MIPS, UCSC Genome Browser)Bioinformatics Database search engines:-Text-based search engines (Entrez, SRS, DBGET /LinkDB). Sequence similarity based search engines (BLAST and FASTA). Motif-based search engines (ScanProsite and eMOTIF). Structure similarity based search engines (VAST and DALI). Proteomics tools at the ExPASy server; Data Submission.

PRACTICAL (30 Hours)

1. Understanding and use of web resources: NCBI
2. Retrieval of information from nucleotide and protein databases.
3. Basic commands of Windows, Unix and Linux operating systems
4. Similarity searches using tools like BLAST and interpretation of results
5. Use of different protein structure prediction tools
6. Sequence alignment

SUGGESTED READINGS:

1. Mount D. (2004) Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press, New York.

2. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
3. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
4. Baxevanis, A.D. and Francis Ouellellette, B.F. (2009) Bioinformatics- a Practical Guide to the Analysis of Genes and Proteins. Wiley India Pvt Ltd.
5. Jean-Michel, Cand Notredame, C. (2006) "Bioinformatics for Dummies"; John Wiley& Sons, Second Edition.
6. Kayvan Najarian, Siamak Najarian, Shahriar Gharibzadeh, (2017) "Systems Biology and Bioinformatics: A Computational Approach"; CRC Press; 1 Edition, ISBN-13: 978-1138118034.

ACADEMIC WRITING:

AW.321 Academic Writing 1+1

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- Various academic and research writing techniques

LEARNING OUTCOMES:

This course will enable the students to:

- Understanding of the concept of academic and research writing.
- Understanding and acquire knowledge of research paper writing.
- Understanding and acquire knowledge of thesis writing.
- Acquires knowledge and understanding of various digital tools in academic writing.

THEORY (15 Hours)

UNIT I- Introduction (3 Hours)

Importance of report writing in academics and research. Various kinds of academic and research activities. Necessity of report writing for achievement of academic and research goals. Various kinds of reports/presentations. Characteristics of academic and research reports/presentations. Conclusions.

UNIT II- Research paper writing (3 Hours)

Types of research papers, Structure of research papers, Research paper formats, Abstract writing, Methodology, Results and discussions, Different formats for referencing, Ways of communicating a research paper.

UNIT III- Thesis writing (3 Hours)

Structure of a thesis, Scope of the work, Literature review, Experimental/Computational details, Preliminary studies, Results and Discussions, Figures and Tables preparation, Conclusions and future works, Bibliography, Appendices.

UNIT IV- Tools and Techniques (3 Hours)

Various word processors, e.g., MS Word, Libra-office, Latex etc. Making effective presentations using Power Point and Beamer, Uses of plagiarism detection tools.

UNIT V- Miscellaneous Reports (3 Hours)

Writing research proposals, Writings project proposals, Lecture notes, Progress reports, Utilization reports, Scientific reports etc.

SUGGESTED READINGS:

1. A. Whitaker, "A Step-by-Step Guide to Writing Academic Papers", 2009.
2. J. Lambert and C. Frye, "Microsoft Office 2016", Microsoft Press, Washington 98052-6399
3. C. P. R. Kumar, "On Writing a Thesis", IETE Journal of Education, 2000.
4. J. Warbrick, M. Goossens, S. Rahtz, A. Clark "Essential LATEX ++", 1994.

ABILITY ENHANCEMENT COURSES:
AEC I:

Eng.111 General English Language 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To introduce the basic tools of calculus, also known as 'science of variation'.
- To provide a way of viewing and analysing the real-world problems.

LEARNING OUTCOMES:

- Comprehensive knowledge and coherent understanding of the English Language.
- Practical, professional, and procedural knowledge required for carrying out professionalor highly skilled work/tasks based on English language.
- Create, perform, or think in different and diverse ways about the same objectsorscenarios
- Adopt innovative, imaginative, lateral thinking, interpersonal skills and emotionalintelligence.
- Enhanced comprehension skills for better analysis and interpretation of a body of work
- Inculcate a healthy attitude to be a lifelong learner.

THEORY (30 Hours)

UNIT I Functional Grammar(10 Hours)

Parts of speech: The Article, The Preposition. Agreement of the verb with the Subject. Analysis, Transformation, Synthesis and Direct-Indirect Speech. Same word used as different parts of speech. Word Building/Word Formation: Compound words, Primary Derivative, Secondary Derivatives (Prefixes, Suffixes), Common Idioms and Verb Phrases. Proverbs.

UNIT II Essential Language Skills (10 Hours)

Summary/Precis Writing. Professional writing. Vocabulary – Antonym, Synonym, Words confused and misused, Homophones, Homonyms.Preparation of CV. Job Application. Formal and Informal letters. Report/Proposal Writing. Essay Writing. Interviews. Figures of speech (Simile, Metaphor, Personification, Oxymoron, Epigram, Pun, Climax, Euphemism, Irony, Rhetoric, Alliteration).

UNIT III Reading and Comprehension (10 Hours)

Effective reading. Reading Techniques. Reading Comprehension. Study of Prose and Short Stories from Brighter English, book of short stories, plays, poems, and essays by C.E. Eckersley. The Bachelor of Arts by R.K. Narayan: Introduction to the work, Discussion of important aspects, Themes, Summary, reading of the text, Vocabulary, Discussing key questions.(10 L)

PRACTICAL (15 Hours)

1. Listening Comprehension: Listening to short talks, lectures, speeches (Scientific, commercial, and general in nature).
2. Oral Communication: Phonetics, Stress, and intonation
3. Mock interviews: Testing initiative, team spirit, leadership, intellectual ability.
4. Group Discussions
5. Conversation Practice
6. Writing practice (paragraphs, essays, stories etc.)
7. Figures of speech and their usage in Writing/Speaking.
8. Use of non-verbal media in communication.

SUGGESTED READINGS:

1. Business English, Pearson.
2. Jones, Daniel. 1970. An Outline of English Phonetics, Arnold, London.
3. Sharma, S.D. 1984. A Textbook of Spoken and Written English, Vikas, Delhi.
4. Eckersley, C.E. 1984. Brighter English, Orient Longmans, New Delhi.
5. High School English Grammar, Wren and Martin.

AEC II:

Eng.121 English Communication 2+1

LEARNING OBJECTIVES:

- Develop and enhance the linguistic and communicative competence.
- Honing the skills of reading, writing, listening, and speaking.
- Explore various forms of personal and professional communication.
- Enhance effective communication skills in a modern, globalised context.

LEARNING OUTCOMES:

- Listen carefully, read texts and research papers analytically and present complexinformation in a clear and concise manner to different groups/audiences
- Express thoughts and ideas effectively in writing and orally and communicate withothers using appropriate media
- Construct logical arguments using correct technical language related to a field oflearning, work/vocation, or an area of professional practice

- Convey ideas, thoughts, and arguments using language that is respectful and sensitive to gender and other minority groups.
- Demonstrate the ability to identify with or understand the perspective, experiences, or points of view of another individual or group, and to identify and understand other people's emotions.

THEORY (30Hours)

UNIT I **Introduction to Communication(5 Hours)**

Need for Effective Communication. The Process of Communication: Levels of communication; Flow of communication; Use of language in communication; Communication networks; Significance of technical communication. Non-verbal Communication and Body Language: Forms of non-verbal communication; Interpreting body language cues; Kinesics; Proxemics; Chronemics; Effective use of body language. Barriers to Communication: Types of barriers; Miscommunication; Noise; Overcoming measures.

UNIT II **Reading and Listening Skills(5 Hours)**

Reading Skills: Previewing techniques; Skimming; Scanning; Understanding the gist of an argument; Identifying the topic sentence; Inferring lexical and contextual meaning; recognizing coherence and sequencing of sentences; Improving comprehension skills. Listening Skills: Listening as an active skill; Types of Listeners; Listening for general content; Listening to fill up information; Intensive Listening; Listening for specific information; Developing effective listening skills; Barriers to effective listening skills.

UNIT III Writing and Speaking Skills **(5 Hours)**

Sentence formation; Use of appropriate diction; Paragraph and Essay Writing; Coherence and Cohesion**.** Technical Writing: Differences between technical and literary style, Elements of style; Common Errors. Letter Writing: Formal, informal, and demi-official letters; business letters. Job Application: Cover letter, Differences between bio-data, CV and Resume.Report Writing: Basics of Report Writing; Structure of a report; Types of reports. Interview Skills: Types of Interviews; Ensuring success in job interviews; Appropriate use of non-verbal communication. Group Discussion: Differences between group discussion and debate; Ensuring success in group discussions. Presentation Skills:Oral presentation and public speaking skills; business presentations.

PRACTICAL (15 Hours)

1. Developing Communication skills based on CEFR **(**Common European Framework of Reference for Languages)levels
2. Oral presentation and public speaking skills.
3. Group Discussion.
4. Mock Interviews.
5. Technology-based Communication: Netiquettes: effective e-mail messages; power-point presentation; enhancing editing skills using computer software.
6. Preparing a CV and job application.
7. Paragraph and Essay Writing.
8. Reading Comprehension.
9. Improving listening skills.

SUGGESTED READINGS:

1. Business English, Pearson, 2008
2. Writing Skills, Dixit Handbook.
3. Bovee, Courtland, L., John V. Thill and Barbara E. Schatzman. Business Communication Today: Seventh Edition. Delhi: Pearson Education, 2004.
4. Lesikar, Raymond V and Marie E. Flatley. Basic Business Communication: Skills for Empowering the Internet Generation: Ninth Edition. New Delhi: Tata McGraw-Hill Publishing Company Ltd., 2002.
5. Pease, Allan and Barbara Pease. The Definitive Book of Body Language. New Delhi: Manjul Publishing House, 2005.

AEC III:

Any Language Course available from the UGC approved platform (Swayam, etc.).

SKILL ENHANCEMENT COURSES:

SEC I:

Comp.121 Computer Applications 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To equip them with basic computing skills that will enhance their employability in general.
- To enable the student to analyse and present information in a meaningful manner.

LEARNING OUTCOMES:

This course will enable the students to:

- to use word-processor to generate documents with appropriate formatting, layout, review and referencing.
- to manage data in worksheets and workbooks and analyze it using spreadsheet functions and inbuilt formulas.
- to make meaningful representations of data in the form of charts and presentations.

THEORY (30 Hours)

UNIT I (6 Hours)

Basics of Computer and Communication Technology, Definition, characteristics, Advantages and Limitations, Computer Organisation, input output and processing units.

UNIT II (8 Hours)

Word Processing: formatting of text, implementation of styles, table of contents, mail merge,

UNIT III **(8 Hours)**

Spreadsheets: data types, inbuilt and user-defined formulas, arranging data, charts, Presentation: Slides, placeholders, formatting, inbuilt designs.

UNIT IV **(4 Hours)**

Database Management Systems: Introduction to Databases, Relational databases, basic SQL queries.

UNIT V **(4 Hours)**

Networking: Basics of Networks, LAN, MAN, WAN, topologies, Internet and email.

PRACTICAL (15 Hours)

1. Formatting of text in Word Processor
2. Implementation of styles and Table of contents
3. Uses of Mail Merge
4. Analyzing Data using Spreadsheets
5. Sorting of Data, using formulas.
6. Creating Charts
7. Creation of Presentations

SUGGESTED READINGS:

1. P.K. Sinha "Computer Fundaments" BPB Publications
2. R. S. Salaria "Computer Fundamentals" Khanna Publishing House
3. Reema Thareja "Fundamentals Of Computers" Oxford University Press

SEC II:

Stat.121 **Elements of Statistics** **2+1**

LEARNING OBJECTIVES:

The primary objective of this course is:

- To introduce the basic tools of statistics.
- To provide a way of viewing and analysing the real-world problems.

LEARNING OUTCOMES:

This course will enable the students to:

- Explain the definition, scope, and limitations of statistics and to compute frequency distributions and their graphical representations.
- Calculate measures of central tendency, dispersion, skewness, and kurtosis.
- Explain the definition and concept of probability and to find out correlation and fit regression equations
- Describe elements of sampling, sampling distribution, and tests of significance

- Analyze one-way and two-way classified data using analysis of variance.

THEORY (30 Hours)

UNIT I **(6 Hours)**

Definition, scope and limitations of statistics; presentation and summarization of statistical data; frequency distribution and its graphical representation; measures of central tendency, dispersion, skewness and kurtosis.

UNIT II **(6 Hours)**

Definition and concept of probability; additive and multiplication law of probability (without proof).

UNIT III **(6 Hours)**

Correlation: Types of correlation and identification through scatter diagram, computation of correlation coefficient. Linear Regression: Fitting of regression equations; Y on X and X on Y; properties of correlation and regression coefficients.

UNIT IV **(6 Hours)**

Elements of sampling: Simple random sampling, sampling distribution, standard error; tests of significance, large sample test - SND test for means, single sample and two samples; small sample tests for mean: Student's t-test, Fisher’s t-test and Paired t-test: F test.

UNIT V **(6 Hours)**

Analysis of variance for one-way and two-way classified data.

PRACTICAL (30 Hours)

1. Construction and graphical representation of frequency distribution.
2. Calculations of measures of central tendency, dispersion, skewness and kurtosis.
3. Correlation and regression analysis.
4. One sample and two sample standard normal deviation tests for mean.
5. Student's t-test, Fisher's t-test and paired t-test; F-test.
6. Analysis of variance – one way and two way classified data.

SUGGESTED READINGS:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003). An Outline of Statistical theory, Vol. I, 4th Ed., World Press, Kolkata.
2. Hogg, R.V. and Tanis, E.A. (2009). A Brief Course in Mathematical Statistics. Pearson Education.
3. Johnson, R.A. and Bhattacharya, G.K. (2001). Statistics-Principles and Methods, 4thEd., John Wiley and Sons.
4. Mood, M.A.,Graybill,F.A.and Boes,C.D.(2007). Introduction to the theory of Statistics, 3rd Ed., (Reprint).Tata McGraw-Hill Pub. Co. Ltd.

GIS.121 Geographic Information System 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To make understand students about basic of Geographic Information System and its applications.

LEARNING OUTCOMES:

- Exposure to Basic Principles of Geographic Information System
- Bringing real world to digital platform
- Understanding and using principles of GIS technology
- Applications

THEORY (30 L)

UNIT 1: (10 Hours)

Introduction to GIS; Representing a real world in digital space; Data types and data models; Advanced data models in GIS and Data Generation/Collection/Surveys

UNIT 2: (10 Hours)

GIS data quality, Global Positioning system, Basics of Remote Sensing, Database and Database Management System– Introduction

UNIT 3: (10 Hours)

Database query and Spatial analysis, Basic and Advanced Spatial analysis of data, Introduction to open source GIS software: ILWIS and Quantum GIS (QGIS)

PRACTICAL (15P)

1. Hands on working with maps, data integration, collection, digitization and extraction
2. Hands on data generation and analysis using various sources
3. Processing satellite imageries and preparation of thematic maps

SUGGESTED READINGS:

1. GIS Fundamentals: A First Text on Geographic Information Systems, Paul Bolstad, XanEdu Publishing Inc; 5th edition;
2. Introduction to Geographic Information Systems, Kang-tsung Chang, McGraw-Hill Education
3. Principles of Geographical Information Systems by Peter A. Burrough
4. Sharda Singh Ranbir Singh Rana, Vaibhav Kalia, Kunal Sood and Arun Kaushal , Centre for Geo-informatics Research & Training, COBS , CSKHPKV, Palampur, Practical Lab Manuals: 'Introduction to GIS and Hand on Exercises (using ILWIS)'.
5. QGIS documentation (https://qgis.org/en/docs/index.html), ILWIS documentation (https://www.itc.nl/ilwis/users-guide/)
6. Practical Lab Manuals: 'Introduction to GIS and Hand on Exercises (using ILWIS)'

Biochem.121 Biochemical constituents of food grains, fruits, and vegetables 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To acquaint the students about the biochemical composition of food they consume.
- To provide the knowledge on the importance of nutrients.
- Basic knowledge about food composition and analysis of different constituents.

LEARNING OUTCOMES:

This course will enable the students to understand:

- The importance of nutritional constituents in our body.
- Biochemical composition of common food stuffs.
- Disadvantages of anti-nutrients in our body.
- Basic techniques for the assessment of nutritional constituents.

THEORY (30 Hours)

UNIT – I: Fundamentals of nutrition (15 Hours)

Fundamentals of human nutrition; concept of balanced diet, nutrients and antinutrients
.

UNIT – II: Basic composition of major food materials (15 Hours)

Nutritional status and biochemical composition of major food materials *viz*., cereals, pulses oilseeds, fruits and vegetables.

UNIT – III: (15 Hours)

Importance and biological functions of nutritional and anti-nutritional factors
Importance and biological functions of vitamins and minerals; anti-nutritional factors in food stuffs; factors affecting the nutritive value of food grains, fruits and vegetables

PRACTICAL (30 Hours)

Preparation of solutions; qualitative tests for proteins, amino acids, carbohydrates, and lipids; estimation of dietary fibre; estimation of oil, iodine value and saponification value.

SUGGESTED READINGS:

1. Katoch R. 2019. "Agricultural Biochemistry". 1st edition, Kalyani Publishers, India.
2. Katoch R. 2011. "Analytical Techniques in Biochemistry and Molecular Biology". 1st edition, Springer, New York, USA.
3. Katoch R. 2018. "Macromolecules, Enzymology and Metabolism". 1st edition, Kalyani Publishers, India.
4. Katoch R. (2019). Principals and techniques in Biochemistry: 1st edition. Published by Department of Chemistry and Biochemistry, CSKHPKV, Palampur.

SEC III:

Chem.224 Chemistry of Cosmetics and Perfumes 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- familiarization of the students with essential oils and their application in Industry.
- to provide basic knowledge about various cosmetic products.

LEARNING OUTCOMES:

The student will be able to

- to understand the methods of preparation of various cosmetic products.
- to apply knowledge gained through the course to different artificial flavours and their uses.

THEORY (30 Hours)

UNIT I: (10 Hours)

A general study including preparation and uses of the following:hair dye, hair spray, shampoo, sun tan lotions, face powder, lipsticks, talcum powder

UNIT-II: (10 Hours)

Study of methods of preparation and uses of the followingnail enamel, creams (cold, vanishing and shaving creams), antiperspirants.

UNIT-III: (10 Hours)

Artificial flavours and their role in industry. Essential oils and their importance in cosmetic products with reference to Eugenol, Geraniol, sandal wood oil, eucalyptus oil, rose oil, 2-Phenyl ethylalcohol, Jasmone, Civetone, Muscone.

PRACTICAL (30 Hours)

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of nail enamels.
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of nail polish and nail polish remover.

SUGGESTED READINGS:

1. Industrial Chemistry by E. Stocchi, vol.I, Ellis Horwood Ltd.UK.
2. Industrial Chemistry by B.K. Sharma and H. Kaur, Goel Publishing House, Meerut.(1996)
3. Engineering Chemistry by P.C. Jain and M. Jain, Dhanpat Rai and Sons, Delhi.
4. Modern Approach to Fuel Chemistry and Chemistry of Cosmetics and Perfumes.

Comp.221 Computer Programming 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:
- To provide exposure to basic problem-solving techniques with computers
- To develop logical thinking abilities and to propose novel solutions for real world problems through programming language constructs.

LEARNING OUTCOMES:

This course will enable the students:
- to interpret the basic representation of the data and sequential programming
- to choose appropriate programming paradigms, interrupt and handle data and propose solutions through programming.
- to implement exemplary applications on real-world problems.

THEORY (30 Hours)

UNIT I (6 Hours)

Introduction to Problem Solving through programs. Variables and Data Types, Arithmetic expressions.

UNIT II (8 Hours)

Relational Operations, Logical expressions; Introduction to Conditional Branching, Conditional Branching and Iterative Loops

UNIT III (8 Hours)

Arranging things: Arrays, 2-D arrays, Character Arrays and Strings

UNIT IV (4 Hours)

Functions and Parameter Passing by Value, Passing Arrays to Functions, Call by Reference, Recursion.

UNIT V (4 Hours)

Structures and Pointers, Self-Referential Structures and Introduction to Lists

PRACTICAL (30Hours)

1. Simple Programs
2. Decision making
3. Programs of Loops
4. Array processing
5. Functions and subprograms

SUGGESTED READINGS:

1. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill
3. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India

4. Herbert Schildt C: The Complete Reference, McGraw Hill Education

Comp.222 Databases and SQL 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:
- To equip them with basic data skills that will enhance their employability in general.
- To enable the student to create databases and extract meaningful data from databases

LEARNING OUTCOMES:

This course will enable the students to:
- to convert the ER-model to relational tables, populate relational database and formulate SQL queries on data.
- to use database technology for data resource management.
- to organize, maintain and retrieve - efficiently, and effectively, information from a DBMS

THEORY (30 Hours)

UNIT I (8 Hours)

Introduction to Data and Database Management System, Relational Databases, Tables, Data types, primary key.

UNIT II (10 Hours)

Structured Query Language (SQL), Create Table, SELECT Query with WHERE, SORT and GROUP BY, UPDATE and INSERT commands. SQL JOINS

UNIT III (4 Hours)

Relational Algebra. Entity-Relationship Model, Normalisation of databases.

UNIT IV (4 Hours)

Application Development. Case Studies. Storage and File Structure, Indexing and Hashing. Query Processing

UNIT V (4 Hours)

Query Optimization. Transactions (Serializability and Recoverability)

PRACTICAL (30Hours)

1. Creation of Simple Database using MS Access
2. Queries using SQL
3. Creation of Relations in Database
4. Simple Joins with SQL

SUGGESTED READINGS:

1. Abraham Silberschatz, Henry F. Korth, and S. Sudarshan "Database System Concepts" McGraw-Hill Education.

2. Raghu Ramakrishnan and Johannes Gehrke, “Database Management Systems” McGraw Hill,

Micro.221 Techniques in Microbiology 1+2

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- Various techniques used for the study of microorganisms.
- The instrumentation methods required for conducting microbiological experiments.

LEARNING OUTCOMES:

This course will enable the students to:

- Appreciate the scientific foundation of general microbiology and relate the key learning to the job of a microbiologist professional.
- Utilise methods and tools for sustainable development of nation through microbiological interventions.
- Increase the probability of use of different microbial cultures for the benefits society.

THEORY (15 Hours)

UNIT-I (4 Hours)

History and scope of microbiology. Microorganisms and their natural habitats. Emergence and future of Special Fields of Microbiology.

UNIT-II (5 Hours)

Microscopy; Bright field, Dark field, Phase contrast, Confocal, Fluorescence, TEM,SEM – Working Principles and applications; Properties of light; Simple staining, differential and special staining.

UNIT-III (6 Hours)

Bacterial Growth, nutrition, and Culture media; Environmental factors affecting bacterial growth: physical chemical, temperature, pH, osmotic pressure, light (UV) and bacteriostatic agents.

PRACTICAL (60Hours)

1. Microbiology laboratory rules, tools equipment’s and other requirements in microbiology laboratory.
2. Microscopy: Working with microscope.
3. Preparation of Culture media; Isolation and enumeration of microorganisms; Methods of obtaining Pure culture of microorganisms and their maintenance.
4. Staining methods viz. Simple, Negative, Gram, Spore, Capsule, Flagella, Lactophenol cotton blue etc.
5. Control of Microorganism: Physical agents/Mechanical agents/Chemical Agents.
6. Biochemical/Molecular characterization of Microorganisms
7. Microbiological application experiments viz. Testing microbiological quality of Milk; Antibiotic Sensitivity test etc.

SUGGESTED READINGS:

1. Brock, T.D. 2008. Biology of microorganisms (Ed.) Madigan MT, Martinko J M, Dunlap P V, Clark D.P., 12th ed. Pearson, New Jersey.
2. Pelczar, M.J. Jr., Chan, E.C.S. and Kreig, N.R. 1997. Microbiology, Concepts and Application, 5th edition, Tata McGraw Hill, New York.
3. Prescott, L.M., Harley and Klein. 2002. Microbiology 5th Edition, Tata McGraw Hill, New York.
4. Bhatia, M.S. 2009. Principles of Microbiology. Swastik Publishers., DeIhi.
5. K.R. Aneja Laboratory Manual of Microbiology and Biotechnology 2nd Edition. Meditech New Delhi.

IAPC (Internship/Apprenticeship/Project/Community Engagement/Vocational):

IAPC I:

IAPC111/Bio.111 Vermi-composting 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To train students for harvesting and management of Vermi-composting.
- To develop the skills to grow vermi-culture and adopt vermi-composting as entrepreneurship.

LEARNING OUTCOMES:

- Cultivate skills to understand vermi-culture and vermicomposting.
- Learning how to do composting in a limited space.
- Development of Technical skills on harvesting and management of vermicompost.
- Understand the scope of vermi-composting as entrepreneurship.

THEORY (15 Hours)

UNIT 1: (5 Hours)

Introduction to vermicomposting and vermiculture, definition, classification, history, economic importance, its value in maintenance of soil structure. Its role in bio transformation of the residues generated by human activity and production of organic fertilizers. Choosing the right worm. Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Biology of *Pheretima posthuma*. a) Taxonomy, Anatomy, physiology and reproduction. b) life cycle *of Pheretima posthuma*, its fecundity, annual reproducer potential

UNIT 2: (5 Hours)

Limit factors (gases, diet, humidity, temperature, pH , light, and climatic factors). Physio-chemical parameters of vermicompost. Different Methods of Vermicomposting: Small- and large-scale Bed method, Pit method, Small Scale Earthworm farming for home gardens. Conventional commercial composting. Pest and diseases of earthworms. Nutritional Composition of Vermicompost for plants, comparison with other fertilizers.

UNIT 3: (5 Hours)

Earthworm Farming (Vermiculture), vermicompost harvest and processing. Packaging, transport and storage of Vermicompost. Vermicomposting Products and their benefits :Vermiwash, vermicompost-tea and vermicast

PRACTICAL (30 Hours)

1. Scientific classification of Earthworm
2. Study of external morphology of Earthworm.
3. Study of habit and habitat of Earthworm
4. Study of Digestive system of earthworm
5. Study of Reproduction of earthworm
6. Choosing the right worm
7. Hands on vermicomposting by Pit method and Bed method
8. Hands on Vermicompost harvesting
9. Preparation of vermiwash.
10. Vermicompost production, harvesting and packaging.
11. Frequent problems of vermicomposting and how to prevent and fix them.
12. Study of cocoon and vermicast.
13. Study of Pests and diseases of Earthworms

SUGGESTED READINGS:

1. Bhatt J.V. & S.R. Khambata (1959) "Role of Earthworms in Agriculture" Indian Council of Agricultural Research, New Delhi
2. Edwards, C.A. and J.R. Lofty (1977) "Biology of Earthworms" Chapman and Hall Ltd., London.
3. Lee, K.E. (1985) "Earthworms: Their ecology and Relationship with Soils and Land Use" Academic Press, Sydney.
4. Kevin, A and K.E.Lee (1989) " Earthworm for Gardeners and Fisherman" (CSIRO, Australia, Division of Soils)
5. Satchel, J.E. (1983) "Earthworm Ecology" Chapman Hall, London. 8. Wallwork, J.A. (1983) "Earthworm Biology" Edward Arnold (Publishers) Ltd. London.

IAPC112/Zoo.112 Freshwater Aquaculture 1+1

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- To give first-hand training on traditional and technology-based Aquaculture.
- To understand the importance of different types of ponds required for aquaculture.

- To understand the requirement of advanced technology for sustainable development of aquaculture in India.
- To gain experience in the management of optimum water quality in the fish production systems.
- To enhance the quality of fish and increase the production.

LEARNING OUTCOMES:

By the end of the course, the students will be able to:
- Identify the useful aquaculture systems for sustainable aquaculture development.
- Recognize the suitable and economically important aquacultural species.
- Understand the importance of aquaculture in nutrition security, poverty elevation and employment generation.

THEORY (15 Hours)

UNIT I: **(5 Hours)**
Present global and national scenario; Overview of national and international agricultural systems. Freshwater resources of India: river, reservoir, wetlands, lakes, ponds etc; water resources of Himachal Pradesh.

UNIT II: **(5 Hours)**
Nursery, Rearing and grow-out ponds management: control of aquatic weed, control of weed & predatory fish, control of aquatic insects, application of lime, fertilizer etc. Advance freshwater aquaculture system; Organic farming; integrated farming: fish cum agriculture & Fish cum animal husbandry; recirculating aquaculture system (RAS); aquaponics, biofloc technology, responsible aquaculture; rotational aquaculture; bioremediation; role of biotechnology; traceability; Sewage-fed fish culture.

UNIT III: **(5 Hours)**
Water and soil quality management in aquaculture: temperature, dissolved oxygen, hardness, alkalinity, free carbon dioxide, ammonia, transparency, turbidity etc; Seed certification; Eco labelling.

PRACTICAL (30 Hours)

Practices on pre-stocking and post stocking management; Analysis of water and soil samples; Collection, storage and analysis of livestock wastes and crop residues; Study of biogas slurry on water quality, keeping and maintenance of aquarium.

SUGGESTED READINGS:

1. ICAR, Indian Council of Agricultural Research. 2013. Handbook of Fisheries and Aquaculture. Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, New Delhi, India.

2. Rath, R.K., 2011. Fresh water Aquaculture, Scientific publications.
3. E-course ICAR, Indian Council of Agricultural Research.

IAPC II:

IAPC121/Micro.121 Biofertilizer Production 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To familiarize the targeted population with large scale production of different agriculturally important microorganisms which are being used as biofertilizers for maintaining the soil and plant health for sustaining crop productivity and their importance in organic farming.
- To gain employment in biofertilizer industries and set up their own production units at the grass-root level.

LEARNING OUTCOMES:

This course will enable the students to understand:

- The role of biofertilizers in sustainable growth and development of agriculture and role of microorganisms in enhancing soil quality and environmental protection.
- To set up their own facilities for mass production of biofertilizers to improve their social status and helps in managing the menace of chemical fertilizers.
- To set up their own facilities for mass production of biofertilizers to improve their social status and helps in managing the menace of chemical fertilizers.

THEORY (15 Hours)

UNIT 1 Biofertilizers (3 Hours)

Agriculturally important beneficial microorganisms used as biofertilizers for various crop plants, advantages of biofertilizers over chemical fertilizers.

UNIT 2 Symbiotic and Non- Symbiotic N_2 fixers (4 Hours)

***Rhizobium* - Isolation, characteristics, types, inoculum production and field**

application, legume/pulses plants

Frankia - Isolation, characteristics, Alder, Casuarina plants, non-leguminous crop symbiosis.

Cyanobacteria, *Azolla* - Isolation, characterization, mass multiplication, Role in rice cultivation, Crop response, field application.

Free living *Azospirillum*, *Azotobacter* - isolation, characteristics, mass inoculums, production and field application.

UNIT 3 Phosphate Solubilizers (4 Hours)

Microorganisms involved in phosphorus solubilisation: bacteria and fungi - Isolation, characterization, mass inoculum production, field application

UNIT 4 Mycorrhizal Biofertilizers (4 Hours)

Importance of mycorrhizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM, field applications of Ectomycorrhizae and VAM.

PRACTICAL (30 Hours)

1. To study the principle and applications of important instruments used in the microbiology laboratory.
2. Preparation of culture media and sterilization for bacterial cultivation.
2. Sterilization of glassware using Hot Air Oven and assessment for sterility.
3. Isolation of pure cultures of bacteria by streaking method.
4. Preservation of bacterial cultures by various techniques.
5. Estimation of CFU count by spread plate method/pour plate method.
6. Isolation of *Rhizobium* from leguminous plants.
7. Isolation of free living nitrogen fixing bacteria (*Azotobacter*) from soil.
8. Isolation of P-solubilizers from rhizospheric soil.
9. Staining of mycorrhizal fungi colonized roots.
10. Preparation of liquid and carrier based formulations of biofertilizers and their field application.

SUGGESTED READINGS:

1. Mahendra K. Rai. Hand Book of Microbial Biofertilizers. The Haworth Press, Inc. New York. 2005.
2. Shah Fahad, Shah Saud, Fazli Wahid, Muhammad Adnan. Biofertilizers for Sustainable Soil Management. CRC Press. 2023.
3. Coyne MS. Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning. 2001. Print
4. Reddy, S.M. et. al. Bioinoculants for Sustainable Agriculture and Forestry. Scientific Publishers. 2002.
5. Subba Rao NS. Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi, 1999.
6. K. R. Aneja. Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology. New Age International Private Limited. 2022.

IAPC122/ Agron.361 Organic Farming 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To create awareness among the students about organic farming and its importance in sustainable agriculture.
- To provide a skill set of Organic farming to students to help them become self-reliant.

LEARNING OUTCOMES:

This course will enable the students to understand:

- practice organic farming along with application of indigenous knowledge.

- establish entrepreneurial ventures and generate employment (Organic Grower).
- evaluate the organic produce as per FSSAI standards (Government rules).

THEORY (15 Hours)

Organic farming, principles and its scope in India; Initiatives taken by Government (central/state), NGOs and other organizations for promotion of organic agriculture; Organic ecosystem and their concepts; Organic nutrient resources and its fortification; Restrictions to nutrient use in organic farming; Choice of crops and varieties in organic farming; Fundamentals of insect-pest, disease and weed management under organic mode of production; Operational structure of NPOP; Certification process and standards of organic farming; Processing, levelling, economic considerations and viability, marketing and export potential of organic products.

PRACTICAL (30 Hours)

1. Visit of organic farms to study the various components and their utilization
2. Preparation of enriched compost, vermicompost, bio-fertilizers/bio-inoculants and their quality analysis.
3. Indigenous Technology Knowledge (ITK) for nutrient, insect-pest, disease and weed management.
4. Cost of organic production system
5. Post-harvest management
6. Quality aspect, grading, packaging, and handling.

SUGGESTED READINGS:

1. Dhama, A.K. (2014). Organic Farming for Sustainable Agriculture (2nd edition), Agrobios (India), Jodhpur.
2. Sharma, Arun K. (2013). A Handbook of Organic Farming, Agrobios (India), Jodhpur
3. Palaniappan, S.P. and Anandurai, K. (1999). Organic Farming – Theory and Practice. Scientific Pub. Jodhpur
4. Thapa, U and Tripathy, P. (2006). Organic Farming in India, Problems and prospects, Agritech, Publising Academy, Udaipur.
5. Jaivik Kheti Sahayak Pustika- National Centre for Organic and Natural Farming, Department of Agriculture & Farmers Welfare, GoI.
6. National Program for Organic Production-APEDA, Ministry of Commerce & Industry, GoI.

IAPC122 /EECM 368 Community Organization 2+0

LEARNING OBJECTIVES:

The primary objective of this course is:

- Develop through understanding about the relevance of community organization as a method.
- To introduce students to the theory and practice community organizing in India.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Will have the basic knowledge of methods and models of community organization.
- Students will have the understanding about the scope of

THEORY (30 Hours)

Basic Conceptual Framework of Community - concept of community in Social Work; Common terminologies- Community organization, community work, community development; Community Organization skills of Community Organizer; Role of Community Organizer- Approaches , Strategies of Community Organization will have the basic and people's Participation; Interventions of NGO's and Government in community organization; Social Action -Concept , objectives and scope ; Tactics and methods of social action in Community Organization.

SUGGESTED READINGS:

1. Community Organization and Development: An Indian Perspective. By Patil A.R
2. Social Work and Community Development, 2011 by Krishna Kant Singh and Ram Shankar Singh.
3. Social Work: An Integrated Approach, 2003 by S. Bhattacharya
4. Community Organization in Social Work, 2016 by Sheeba Joseph

IAPC III:

IAPC211/Zoo.214 Finfish Breeding and Hatchery Management 1+1

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- To give first-hand training on various aspects of brood stock maintenance of carps.
- To understand the breeding techniques for carps.
- To understand the larviculture techniques for carps.
- To gather knowledge in the management of optimum water quality for fish seed.
- To gather knowledge on the nutritional requirements of the cultivable species.

LEARNING OUTCOMES:

By the end of the course, the students will be able to:

- Produce seeds of carps and air breathing fishes.
- Start the Fish hatchery business.
- Start fish-food production.
- Initiate entrepreneurship in fish seeds production

THEORY (15 Hours)

UNIT I: (5 Hours)

Freshwater fish seed resources and natural breeding of finfishes, Riverine fish seed collection Sexual maturity, breeding season and development of gonads.

UNIT II: (5 Hours)

Methods of breeding carps in bundhs; Induced breeding of warm water finfishes and environmental factors affecting spawning; Synthetic hormones for induced breeding of fishes; Induced breeding of Indian major carps & exotic carps (silver carp and grass carp); Different types of fish hatcheries.

UNIT III: (5 Hours)

Packing and transportation of fish seed and use of anaesthetics and disinfectants in fish breeding and transport; Breeding of common carp, mahseers, trouts etc; Cryopreservation of fish gametes.

PRACTICAL (30 Hours)

Study of maturity stages in fish; Collection and preservation of fish pituitary gland; Calculation of fecundity; Different fish hatchery systems; study of fish eggs and embryonic developmental stage; Identification of eggs, spawn, fry and fingerlings of different species; Preparation and management of fish nursery; Fish seed and brood stock transportation.

SUGGESTED READINGS:

1. ICAR, Indian Council of Agricultural Research. 2013. Handbook of Fisheries and Aquaculture. Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, New Delhi, India.
2. PC Thomas, Finfish breeding and hatchery management, Blackwell Publishing, New Delhi, India.
3. Pillay, T. V. R. 2005. Aquaculture. Principles and Practices. Blackwell Publishing, New Delhi, India.

IAPC212/HHA 117 Personality Development and Communication Skills 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To develop inter personal and effective communication skills.
- To develop problem solving skills and understand its influence on behaviour and attitudes of individuals.

LEARNING OUTCOMES:

This course will enable the students to:

- After studying this course, students will be able to understand the importance of oral and written communication in day-to-day working of the organisation.

- After studying this course, students will be able to develop inter personal skills androblem-solving skills.
- After studying this course, students will be able to understand the role of body language in effective communication.

THEORY (15 Hours) PRACTICALS (30 Hours)

(a) Personality Enrichment Grooming, Personal hygiene, Social and Business and Dining Etiquettes, Body language, Art of good Conversation, Art of Intelligent Listening (b) Etiquettes & Manners Social & Business Dinning Etiquettes, Social &Travel Etiquettes (c) Personality Development Strategies Communication Skills, Presentation Skills, Public Speaking, Extempore Speaking, importance and art of 'Small Talk' before serious business (d) Interpersonal Skills Dealing with seniors, colleagues, juniors, customers, suppliers, contract workers, owners etc at work place (e) Group Discussion Team Behaviors, how to effectively conduct yourself during GD, do's and don'ts, clarity of thoughts and its expression (f) Telephone conversation Thumb rules, voice modulation, tone, do's & don'ts, manners and accent (g) Presentation Presentation skills, seminars skills role – plays (h) Electronic Communication Techniques: E mail, Fax.

SUGGESTED READINGS:

1. Kushal Jin – Business Communication, VK India.
2. Krishnamacharyulu, C. S. G, Ramakrishnan Lalitha – Personality Development, Interpersonal Skills and Career Management, Himalaya Publishing.
3. Corvette Budjac – Conflict Management: A Practical Guide to Developing
4. Negotiation Strategies, Pearson Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015).
5. Mitra, B. K., Personality Development and Soft Skills, Oxford University Press.
6. Kumar Sanjay and Pushplata, Communication Skills, Oxford University Press.
7. Mandal S. K., Effective Communication and Public Speaking, Jaico Publishing.

IAPC213/HHA 237 Event Management 0+2

LEARNING OBJECTIVES:

The primary objective of this course is:

- introduce the tools to conceptualize, plan and promote and manage events of varying scales and purposes.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Analyse the role of events in image building
- Explain all the steps of planning and organizing the events
- Discuss ways of strategic marketing and media planning for events

THEORY (30 Hours)

Roleofeventsforpromotionoftourism, TypesofEvents-Cultural,festivals,religious,businessetc. Needofeventmanagement,keyfactorsforbesteventmanagement, Casestudyofsomeculturalevents(GangaMahotsava,SurajkundFairandTaj Mahotsava and G20 meet)Concept ofMice. Introduction of meetings, incentives, conference/ conventions, and exhibitions.Conferenceandthecomponentsoftheconferencemarket. Thenatureofconferencemarketsanddemandforconferencefacilities. RoleoftravelAgencyinthemanagementofconferences. Theimpactofconventionsonlocalandnationalcommunities Introduction of meetings, incentives, conference/ conventions, and exhibitions.conferenceandthecomponentsoftheconferencemarket. Thenatureofconferencemarketsanddemandforconferencefacilities. RoleoftravelAgencyinthemanagementofconferences. Theimpactofconventionsonlocalandnationalcommunities. Management of conference at site tradeshowsandexhibitions, principalpurpose, Types ofshows, Benefits, Majorparticipants, Organization andmembership, Evaluation ofattendees. Convention/exhibitionfacilities;Benefitsofconventionsfacilities, Interrelatedvenues,Projectplanninganddevelopment

SUGGESTED READINGS:

1. Event Planning: Management & Marketing For Successful Events: Become an event planning pro & create a successful event series, by Alex Genadinik
2. Art of Event Management: A complete guide to plan and execute the event Kindle Edition by Dr. Vineet Gera
3. Event is Life : Mini Event Management Kindle Edition by Piyush Matta
4. A Book of Event Management, by Bhavana Chaudhari and Dr. Hoshi bhiwandiwalla

IAPC214/ Hort.111 Fundamentals of Horticulture 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To acquaint students with the basic, principles, concepts and importance of Horticulture
- To train students in lawn designing, species selection for lawns, parks, home gardens and terrace gardens.
- To provide information about the employment and business opportunities and other avenues in the horticulture sector

LEARNING OUTCOMES:

This course will enable the students to understand:

- design gardens and learn the art of landscape design.
- describe and implement methods of preparing soil, cultivation and propagation for growing hedges, climbers, vegetables, and fruit yielding plants
- create and maintain nurseries, green houses and implement innovative practices in maintenance, harvesting and storage of horticultural produce.
- apply the skills for enhancing the job opportunities (Horticulturist) as well as self-employment.

THEORY (15 Hours)

Horticulture-Its definition and branches, importance and scope; horticultural and botanical classification; climate and soil for horticultural crops; Plant propagation-methods and propagating structures; principles of orchard establishment; Principles and methods of training and pruning, juvenility and flower bud differentiation; unfruitfulness; pollination, pollinizers and pollinators; fertilization and parthenocarpy; kitchen gardening; garden types and parts; lawn making; medicinal and aromatic plants; species and condiments; use of plant bio-regulators in horticulture. Irrigation & fertilizers application-method and quantity.

PRACTICAL (30 Hours)

1. Identification of garden tools.
2. Identification of horticultural crops.
3. Preparation of seed bed/nursery bed.
4. Practice of sexual and asexual methods of propagation.
5. Layout and planting of orchard plants.
6. Training and pruning of fruit trees.
7. Transplanting and care of vegetable seedlings.
8. Making of herbaceous and shrubbery borders.
9. Preparation of potting mixture, potting and repotting.
10. Fertilizer application in different crops.
11. Visits to commercial nurseries/orchard.

SUGGESTED READINGS:

1. Edmondson, J.L., Cunningham, H., Densley Tingley, D.O. et al. (2020). The hidden potential of urban horticulture. Nat Food 1, 155–159.
2. Musser E., Andres. (2005). Fundamentals of Horticulture. New Delhi, Delhi: McGraw Hill Book Co. 2.
3. Sandhu, M.K. (1989). Plant Propagation. Madras, Bangalore: Wile Eastern Ltd.
4. Bird, C. (Ed.). (2014). The fundamentals of horticulture: Theory and practice. Cambridge University Press.
5. The Practical Gardener (1994). Reader's Digest Special Volume.

VALUE ADDED COURSES (VAC):

VAC I:

Env.111 Introduction to Environmental Sciences 2+0

LEARNING OBJECTIVES:

The primary objective of this course is:

- To provide the understanding of natural processes and resources.
- To provide the understanding of critical thinking of environmental issues and environmental challenges.

LEARNING OUTCOMES:

By the end of the course, the students will be able to:

- Understanding the natural processes and resources that sustain life and govern economy.

- Develop critical thinking for scientific, social, economic, and legal strategies for environmental issues
- Study the consequences of human activities on sustainable development and economy
- Understand the current environmental challenges and active participation in solving current problems

THEORY (30 Hours)

UNIT I Fundamental of Environmental Sciences (6 Hours)

Definition, Principles and Scope of Environmental Science, Components of environment: Atmosphere, Hydrosphere, Lithosphere and Biosphere, Agro-climatic Zone of India, concept of sustainable development, Environmental education, Environmental ethics, Brief history environmentalism

UNIT II Ecosystems (7 Hours)

Definition and concept of Ecosystem, Structure of ecosystem (biotic and abiotic components); Functions of ecosystem: Physical (energy flow models), Biological (Food chains, food web, ecological succession) and biogeochemical cycles (nutrient cycling), ecological pyramids and homeostasis, Ecosystem services (Provisioning, Regulating, Cultural and Supporting); Ecosystem preservation and conservation strategies: Basic of ecosystem restoration. Basic of ecosystem classification, types of ecosystem: desert, forest, rangeland wetlands, lotic, lentic, estuarine (mangrove), oceanic. Biomes: Concept, classification and distribution. Characteristics of different biomes, community ecology

UNIT III Environmental Pollution and Control (6 Hours)

Environmental Pollution (Air, water, soil, noise, thermal, marine and Radioactive pollution): cause, effects and control, Ambient air quality standards and Indian standards for drinking water, Primary and secondary air pollutants, Photochemical smog, waste water treatment, Nuclear hazards and human health risks, Solid waste- types and sources. Solid waste characteristics, solid waste processing and recovery, hazardous waste, E-waste: classification, methods of handling and disposal, Biomedical waste generation and management, Pollution case studies: Ganga Action Plan, air pollution and public health issues, Bhopal gas tragedy

UNIT IV Natural Resources (6 Hours)

Introduction:

Land resources: minerals, soil, agricultural crops, natural forest products, medicinal plants and forest-based industries and livelihoods, land degradation, man-induced land-slides, soil erosion and desertification. Forest resources: use and over-exploitation, deforestation, case studies, timber extraction, mining, dams and their effects on forests and tribal people. Water resources: use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams- benefits and problems. Mineral resources: use and exploitation, environmental effects of extracting and using mineral resources, case studies. Energy resources: Increasing energy needs, renewable/non-renewable, use of alternate energy sources, case studies.

UNIT V Natural Hazards and disaster management (5 hours)

Definition, cause, classification and impacts of: Hydrological, atmospheric, and geological hazards; Earthquake, volcanoes, Floods, Landslides, Drought, Tornadoes, Cyclones and Hurricanes, tsunamis, coastal erosion, Risk and vulnerability assessment, disaster management in India

SUGGESTED READINGS:

1. Singh, J.S., Singh, S.P. and Gupta, S.R. (2017). Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi
2. Odum, E.P., Odum, H.T., and Andrews, J. (1971). Fundamentals of Ecology. Saunders, Philadelphia, USA.
3. Carson, R. (2002). Silent Spring. Houghton Mifflin Harcourt, USA.

VAC II:

Soc.121 Human Values and Ethics 2+0

LEARNING OBJECTIVES:

The primary objective of this course is:

- To help students distinguish between values and skills, and understand the need, basic guidelines, content and process of value education.
- To help students initiate a process of dialog within themselves to know what they ‘really want to be’ in their life and profession
- To help students understand the meaning of happiness and prosperity for a human being.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Understand the significance of values, distinguish between values and skills, understand the need, basic guidelines, content and process of value education,
- Explore the meaning of happiness and prosperity and do a correct appraisal of the current scenario in the society
- Distinguish between the Self and the Body, understand the meaning of Harmony in the Self the Co-existence of Self and Body.
- Understand the value of harmonious relationship based on trust, respect and other naturally acceptable feelings in human-human relationships and explore their role in ensuring a harmonious society

THEORY (30 Hours)

UNIT – I (20 Hours)

Values and Ethics-An Introduction. Goal and Mission of Life. Vision of Life. Principles and Philosophy. Self Exploration. Self Awareness. Self Satisfaction. Decision Making. Motivation. Sensitivity. Success. Selfless Service. Case Study of Ethical Lives.

UNIT – II (10 Hours)

Positive Spirit. Body, Mind and Soul. Attachment and Detachment. Spirituality Quotient.

SUGGESTED READINGS:

1. A Textbook on Human Values and Ethics m by Debabrata Basu and Samarpan Chakraborty
2. Human Values and Professional Ethics, 2003 by Jayshree Suresh, B S Raghavan.
3. Human Values And Ethics - As per ICAR syllabus, 2022 by Bhanwar lal Dhaka, Kirti, Pankaj Kumar ojha.

VAC III:

VAC 211/Zoo.215 Ornamental Fish Production and Management 1+1

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:
- To give first-hand training on Aquarium preparation and decoration.
- To gain hands-on training on breeding and culture of various Ornamental fishes.
- To gain experience in the management of optimum water quality in the fish aquarium.
- To gather knowledge on the nutritional requirements of the cultivable species.

LEARNING OUTCOMES:

By the end of the course, the students will be able to:
- Prepare and decorate ornamental fish aquarium.
- Identify the suitable and economically important Ornamental fish species.
- Initiate entrepreneurship on Aquarium making and Ornamental fish production

THEORY (15 Hours)

UNIT I: (8 Hours)

World trade of ornamental fish and export potential. Different varieties of exotic and indigenous fishes. Principles of a balanced aquarium. Fabrication, setting up and maintenance of freshwater and marine aquarium. Water quality management. Water filtration system – biological, mechanical and chemical. Types of filters, Lighting and aeration. Aquarium accessories and decoratives. Aquarium fish feeds and their preparation. Dry, wet and live feeds.

UNIT II: (7 Hours)

Breeding and rearing of ornamental fish: guppy, molly, platy, swordtail, gold fish, angel fish etc.; Broodstock management; Conditioning, packing, transport and quarantine methods. Diseases of ornamental fishes.

PRACTICAL (30 Hours)

Identification of common ornamental fishes and plants; Fabrication of all glass aquarium; Setting-up and maintenance; Aquarium accessories and equipments; Conditioning and packing of ornamental fishes. Identification of ornamental fish diseases and prophylactic measures, Fish seed and brood stock transportation.

SUGGESTED READINGS:

1. ICAR, Indian Council of Agricultural Research. 2013. Handbook of Fisheries and Aquaculture. Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, New Delhi, India. 143
2. Pillay, T. V. R. 2005. Aquaculture. Principles and Practices. Blackwell Publishing, New Delhi, India.
3. Swain, S. K., Sarangi, N. and Ayyapan, S. 2010. Ornamental Fish Farming. DIPAS, Indian Council of Agricultural Research, New Delhi, India.

VAC212/HHA 355 Food Safety and Quality 2+0

LEARNING OBJECTIVES:

The primary objective of this course is:

- The present course is designed to address the issues of food safety and quality. It's a multidisciplinary subject which can be taken by students of varied background.
- To improve students' understanding of basic food industry.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Students will be aware about different legislations regarding the food safety.
- Understand the food borne diseases and adulterants.

THEORY (30 Hours)

UNIT – I (15 hours)

Basic introduction to food safety, food hazards & risks, contaminants and food hygiene; micro-organisms in food : general characteristics of micro-organisms based on their occurrence and structure, factors affecting their growth in food (intrinsic and extrinsic), common food borne micro-organisms: bacteria (spores/capsules), fungi, viruses, parasites; Food spoilage & food preservation : types & causes of spoilage, sources of contamination, spoilage of different products (milk and milk products, cereals and cereal, products, meat, eggs, fruits and vegetables, canned products), basic principles of food preservation, methods of preservation (high temperature, low temperature, drying, preservatives & irradiation); Beneficial role of micro-organisms : fermentation & role of lactic and bacteria, fermentation in foods (dairy foods, vegetable, Indian foods, bakery products and alcoholic beverages), miscellaneous (vinegar & anti-biotics; Food borne diseases : types (infections and intoxications), common diseases caused by food borne pathogens, preventive measures; Food additives : introduction, types (preservatives, anti-oxidants, sweeteners, food colours and flavours, stabilizers and emulsifiers); Food contaminants & adulterants : introduction to food standards, types of food contaminants (pesticide residues, bacterial toxins, mycotoxins, seafood toxins, metallic contaminants, residues from packaging material), common adulterants in food, method of their detection (basic principle).

UNIT – II **(15 hours)**

Food laws and regulations : national - PFA essential commodities act (FPO, MPO etc.), international - codex alimentarius, ISO, regulatory agencies - WTO, consumer protection act; Quality assurance : introduction to concept of TQM, GMP and risk assessment, relevance of microbiological standards for food safety, HACCP (basic principle and implementation); Hygiene and sanitation in food sector : general principles of food hygiene, GHP for commodities, equipment, work area and personnel, cleaning and disinfect ion (methods and agents commonly used in the hospitality industry), safety aspects of processing water (uses & standards), waste water & waste disposal; Recent concerns : emerging pathogens, genetically modified foods, food labeling, newer trends in food packaging and technology, BSE (bovine serum encephthalopathy).

SUGGESTED READINGS:

1. Encyclopedia of Food Safety by Yasmine Motarjemi
2. Encyclopedia of Food Microbiology by Carl A. Batt; Pradip Patel; Richard K. Robinson

VAC IV:

VAC213/Zoo.216 **Fish Products and By-products Technology** **1+1**

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- To give first-hand training on fish production and by-products.
- To gather knowledge on the how to prepare products.
- To enhance the quality of fish product.

LEARNING OUTCOMES:

- By the end of the course, the students will be able to:
- Start the Fish processing industry.
- Initiate entrepreneurship on processing

THEORY (15 Hours)

UNIT I: **(5 Hours)**

Principle of fish preservation and processing; Processing of fish by traditional methods salting, sun drying, smoking, marinading and fermentation; Theory of salting, methods of salting –wet salting and dry salting.

UNIT II: **(5 Hours)**

Fish and prawn pickles, fish sauce and Fish paste, traditional Indian fermented products; Principles and methods of preparation of various fish paste products like fish sausage, fish ham, surimi, fish cake, kamaboko etc. Preparation of salted fish, dried fish and smoked fish by different methods; Preparation of fish manure, fishmeal, fish body oil, fish liver oil; Preparation of prawn & fish pickles. Preparation of fermented fish sauces

UNIT III: (5 Hours)

Canning as a method of preservation; Unit operations in canning; Thermal process for canned foods; Changes in canned foods and spoilage; Canning of commercially important fish.

Fish Packaging method; Use of Metal Containers in packaging; Plastics for Packaging; Manufacture of plastic packages; Heat Sealing; Additives in plastics; Paper and Board; Glass containers and Closures.

PRACTICAL (30 Hours)

Preparation of salted fish, dried fish and smoked fish by different methods; Preparation of fish manure, fishmeal, fish body oil, fish liver oil; Preparation of prawn & fish pickles. Preparation of fermented fish sauces.

Canning Machineries and Equipments, Retorts and its operation; Examination of can double seam; Study of relationship between head space and resultant vacuum; study of different fish packaging methods

SUGGESTED READINGS:

1. Brody. J. Fishery By-products Technology. AVI Publishing Company.
2. Velayutham, P. and Indira Jasmine, G. 1996.Manual on Fishery By-Products, Tamilnadu Veterinary and Animal Sciences University, Chennai.
3. Gopakumar, K. 1997.Tropical Fishery Products. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

VAC214 Drone Technology 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- Introduction of the students to the basics of Drone and Ariel fights systems.
- Introduction to Multirotor Unmanned Aerial System (UAS), Unmanned Aerial Vehicle (UAV), power system, flight controller, attitude sensing
- UAV positioning and navigation based on Global Navigation Satellite System (GNSS)
- UAS wireless communication systems
- UAS safety & risk assessment

LEARNING OUTCOMES:

This course will enable the students to understand:

- Use a drone for your application or challenge.
- Understanding about the available airborne technology.
- Overview of legislation and regulations concerning drones.
- Flight preparations and create- and execute a safe mission setup.
- Define a mission planning with the available open source and commercial tools.
- Discuss the potential of image product delivery for different purposes.
- Examine drone data and derive information from it.

THEORY (30 Hours)

UNIT I Fundamentals of Drones and Autonomous Systems (5 Hours)

History and Introduction, Types of Drones and classifications, Critical Technologies and equirements, Aviation, Theory of flight, Stake holders and Laws, DGCA Rules of Drones 2021, Drone flying requirements, Type certifications, Operations of Drones

UNIT II Remote Sensing, UAV's and Applications (5 Hours)

Fundamentals of Flight, Aerodynamics, Air traffic procedures, Mission and Flight planning, Field operation and Reece techniques, Introduction to Sensors and Cameras, Weather and Meteorology, UAVs as tool, Introduction of Applications in Agriculture and allied sectors

UNIT III Planning, Acquisition to visualization (5 Hours)

Types of Imagery Products, Manual Flight Profiles, Sample Image Lists Introduction Selection of the drone, Mission Planning, Dos and Donts of flight, Prechecks and Flight operation compliance, Agriculture drones, Surveillance drones, Digital imaging, Crop damage identification, Crop irrigation, Crop Observation

PRACTICAL (30 Hours)

1. Introduction drones equipment and other components
2. Check list and Pre flight operation Checks and Drone equipment maintenance
3. Risk Assesment & Analysis – Failure, Drone stray controls and other emergencies
4. Nozzle selection and Spray patterns
5. Payload installation and utilization
6. Refills
7. Load calculations
8. Hands on flying with instructor
9. Mission planning and operations

SUGGESTED READINGS:

1. K. R. Krishna, "Agricultural Drones A Peaceful Pursuit", Apple Academic Press Inc. Canada, 2018.
2. K S Subramanian, S Pazhanivelan, R Santhi and G Srinivasan, "Drones in Digital Agriculture", Om Publications 2783, Bhagat Singh gali no. 6, Pahar ganj, New Delhi, 2022.

VAC215 Digital Empowerment 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- Understand the digital world and need for digital empowerment
- Create awareness about Digital India.
- Explore, communicate and collaborate in cyberspace.
- Imparting awareness on cyber safety and security.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Use ICT and digital services in daily life.
- Communicate and collaborate in cyberspace using social platforms, teaching/learning tools.
- Understand the significance of security and privacy in the digital world.
- Recognise ethical issues in the cyber world.

THEORY AND PRACTICAL(45 Hours)

UNIT I Digital inclusion and Digital Empowerment (12 Hours)

1. Needs and challenges
2. Vision of Digital India: DigiLocker, E-Hospitals, e-Pathshala, BHIM, e-Kranti (Electronic Delivery of Services), e-Health Campaigns
3. Public utility portals of Govt. of India such as RTI, Health, Finance, Income Tax filing, Education

UNIT II Communication and Collaboration in the Cyberspace (12 Hours)

1. Electronic Communication: electronic mail, blogs, social media
2. Collaborative Digital platforms
3. Tools/platforms for online learning
4. Collaboration using file sharing, messaging, video conferencing

UNIT III Towards Safe and Secure Cyberspace (12 Hours)

1. Online security and privacy
2. Threats in the digital world: Data breach and Cyber Attacks
3. Blockchain Technology
4. Security Initiatives by the Govt of India

UNIT IV Ethical Issues in Digital World (9 Hours)

1. Netiquettes
2. Ethics in digital communication
3. Ethics in Cyberspace

SUGGESTED READINGS:

1. Cyber Security: A practitioner's guide, 2017 by David Sutton.
2. Digital Empowerment: A Cornerstone for eGovernance, 2018, by K. S. Vijaya Sekhar, G. P. Sahu and Prabhu Gollamudi.
3. Digital Empowerment: A Concerstone for E-Governance by Sekhar, BSP.

Other Activities

NCC **0+12(NC)**

[(0+4) for First Year, (0+4) for Second Year and, (0+4) for Third Year]

Introduction to: Defence services, system of NCC training, Leadership and NCC song, Foot drill, sizing, getting on parade, dismissing and falling out, saluting, marching, weapon training. Introduction and characteristics of weapons, judging distance, five discipline and five control orders, field signals, description of ground; conventional signs, general principles, First aid, Hygiene, and sanitation; Camouflage and concealment, NCC annual training camp.

Forming up in three ranks, open and close order march, dressing; Arms drill, shoulder arm, order arm, present arm, Guard of honour; Ceremonial; Weapon training-rife bayonet, light machine gun, sten machine carbine, introduction and characteristics stripping, assembling and cleaning, loading, uploading and firing; Field craft, visual training, targets, battle craft; Section formation, section battle drill; scouts and patrols, ambush, field engineering; Map reading, grid systems, use of service protractor, prismatic compass and its use, Self-defence, precautions and training, attach and counter attacks, marching and searching, Civil defence, NCC annual training camp. Note: One annual training camp is compulsory for award of degree.

NSS **0+12(NC)**

[(0+4) for First Year, (0+4) for Second Year and, (0+4) for Third Year]

Orientation of NSS volunteers regarding National Service Scheme; formation of group/houses; Adoption of villages; Strategic Frame work: Communication for HIV/AIDS; Environment concerns and strategies in new millennium; Drug abuse, social policing in conflict situation; Role of youth: Disaster management through NSS; Understanding gender; Combating female foeticide; Deadly human diseases; Appointment of office bearers; visit to adopted villages and interaction with villagers to identify the needs and problems of the community; involving the community in the solutions of their problems; Campus beautification drive; Celebration of important days; Van mahotsava.

Study of philosophy of NSS; Fundamental rights; Socio-economic structure of Indian society; Population problems; Brief of five year plan; Eradication of social evils; Awareness programmes related to HIV/AIDS; Chronic diseases, Cancer, TB etc.; Consumer acts and rights; Disaster management; Motivation of donation of blood and eyes etc.; Campus beautification; Environment enrichment and conservation; Celebration of important days; Van mahotsava; Health, Family welfare and nutrition.

Note: One NSS special camp is compulsory for award of degree.

NSS Special Camping Programme

Activities in the adopted villages:

i) Environment enrichment and conservation:
Water Conservation
Health, family welfare and nutrition programme
Water conservation
Health, family welfare and nutrition programme
Literacy programme (adult education)
Creating awareness for improvement of the status of women
Assistance and guidance in poultry farming animal husbandry, care of animal health
Self-employment programme.

Annexure III

COLLEGE OF BASIC SCIENCES

CSKHPKV, Palampur (H.P.)

Four Years Undergraduate Programme

(Under National Education Policy 2020)

Course Catalogue

2024-25 onwards

B.Sc.(Hons.) Physical Sciences /

B.Sc.(Hons. with Research) Physical Sciences

Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya
COLLEGE OF BASIC SCIENCES
Palampur Distt Kangra Himachal Pradesh 176 062 India

Contents

FOUR YEARS UNDER GRADUATE PROGRAMME (FYUGP)

The Undergraduate Curriculum Framework- 2022 (UGCF) is meant to bring about systemic change in the higher education system in the University and align itself with the National Education Policy 2020. In accordance with the NEP 2020, the UGC has formulated a new student-centric "Curriculum and Credit Framework for Undergraduate Programmes (CCFUP)" incorporating a flexible choice-based credit system, multidisciplinary approach, and multiple entry and exit options. This will facilitate students to pursue their career path by choosing the subject/field of their interest. This new curriculum framework will have the features such as:

1. Flexibility to move from one discipline of study to another;
2. Opportunity for learners to choose the courses of their interest in all disciplines;
3. Facilitating multiple entry and exit options with UG certificate/ UG diploma/ or degree depending upon the number of credits secured;
4. Flexibility for learners to move from one institution to another to enable them to have multi and/or interdisciplinary learning;
5. Flexibility to switch to alternative modes of learning (offline, ODL, and Online learning, and hybrid modes of learning).

The Regulations for Academic Bank of Credit (ABC) and guidelines for Multiple Entry and Exit are already framed by UGC for adoption by Higher Education Institutes (HEIs) to facilitate the implementation of the proposed CCFUP.

Academic Credit: An academic credit is a unit by which the course work ismeasured. It determines the number of hours of instructions required per week.One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours ofpractical work/field work per week.

Types of Courses:

Courses in a programme will be of the following types:

i) **Core Course:**Compulsory course to be studied by thestudent as a core requirement. These courses will consist of major and minor stream cores.

a) **Discipline Specific Course (DSC):** DSCs shall be the major course of that particular discipline which are to be compulsory studied and will be appropriately graded and arranged across the semesters of study. The DSCs specified in the framework would be identified by the concerned department as major courses to be taught in a programme.

b) **Discipline Specific Elective Course (DSE):**A pool of courses of a particular discipline which are offered as specific/ specialized/ advanced/ supportive to the discipline/ subject of study. Student is required to choose one course from available pool.

c) **Minor:** Agroup of interdisciplinary courseswhich are offered in addition to DSC and DSE courses, related to the applied area of the discipline/ subject of the study.

d) **Higher Level Discipline Specific Courses (HLDSC):** The courses, which should compulsorily be studied by a candidate as a core requirement for Hons. / Hons. with research in one of the main discipline/ subject of study.

e) **Higher Level and Applied AreaMinor (HAA Minor):** The coursesbroader and applied understanding of the one of the main discipline / main field of study.

ii) Ability Enhancement course (AEC), Skill Enhancement Course (SEC) & Value Addition Course (VAC): The supplementary courses offered as follows:

a) **AEC:** Language and communication development courses mandatory for all disciplines.
b) **SEC:**Skill-based courses in different disciplines aimed at providing hands-on training and skills to the students.
c) **VAC:**Courses aimed towards personality building; embedding ethical, cultural, and constitutional values to the students.

iii) **Internship/Apprenticeship/Project/Community engagement (IAPC):** Job-orientedcourses aimed at the Vocational training and community exposure to the students.

iv) **Academic Project**/**Research:** Students undergoing 4-Year Bachelor's degree (Hons. / Hons. with Research) shall execute an academic project or undertake research aimed at developing thinking skills required for pursuing higher studies.

Table 1: Structure for Multidisciplinary Four Year Under Graduate Programme (FYUGP) Under Multiple Entry and Multiple Exist (ME-ME)

Sem.	Discipline Specific Course (DSC)/ Higher Level Discipline Specific Course (HLDSC)/ Higher & Applied Area Minor (HAA Minor)	Ability Enhancement Course (AEC)/ Discipline Specific Elective (DSE)	Skill Enhancement Course (SEC) Minor	IAPC (Internship/Apprenticeship/Projects/ Community Engagement/Vocational Courses)	Value Added Courses (VAC)	Other Activities (NC)	Total Credit Hours
I	DSC I – A (4) DSC I – B (4) DSC I – C (4)	AEC I (3)	SEC I (3)	IAPC I (2) (from Pool of Courses)	VAC I (2) (from Pool of Courses)	NCC/NSS (2 NC)	22 +2 NC
II	DSC II –A (4) DSC II– B (4) DSC II– C (4)	AEC II (3)	SEC II (3) (from Pool of Courses)	IAPC II (2) (from Pool of Courses)	VAC II (2) (from Pool of Courses)	NCC/NSS (2 NC)	22 + 2 NC
	Students exiting the programme after securing 44 credits + 4 NC will be awarded UG Certificate after 1st Year						**44 + 4 NC**
III	DSC III – A (4) DSC III – B (4) DSC III – C (4)	DSE I A/B/C (4)		IAPC III (2) (from Pool of Courses)	VAC III (2) (from Pool of Courses) VAC IV (2) (from Pool of Courses)	NCC/NSS (2 NC)	22 +2 NC
IV	DSC IV – A (4) DSC IV – B (4) DSC IV – C (4)	AEC III (3) DSE II A/B/C (4)	SEC III (3) (from Pool of Courses)			NCC/NSS (2 NC)	22 +2 NC
	Students exiting the programme after securing 88 credits + 8 NC will be awarded UG Diploma after 2nd Year.						***88 + 8 NC***
V	DSC V – A (4) DSC V – B (4) DSC V – C (4)	-	Minor I [RM] (3) Minor II (3)	AW I (2)		NCC/NSS (2 NC)	20 +2 NC
VI	DSC VI – A (4) DSC VI – B (4) DSC VI – C (4)	DSE III A/B/C (4)	Minor III (3) (from Pool of Courses)	Seminar I A/B/C (1)	-	NCC/NSS (2 NC)	20 +2 NC
	Students exiting the programme after securing 128 credits + 12 NC will be awarded UG Degree in Physical Sciences/Life Sciences.						**128 + 12 NC**
	Students will opt any one Major discipline out of A/B/C for HLDSCs and HAA Minor from Subjects Closely related to chosen Major discipline						
VII	HLDSC- I (4) HLDSC- II (4) HLDSC -III (4) HAAMinor- I (4) HAA Minor- II (4)	-	-	R- I (4)	-	-	20
VIII	HLDSC- IV (4) HLDSC- V (4) HLDSC -VI (4) HAAMinor- III (4)	-	-	R-II (8) or Academic Project (4)	-	-	20
	Students will be awarded UG Degree (Honors) or (Honors with Research) in the relevant Discipline/Subject upon securing 168 credits + 12 NC.						**168 + 12 NC**

Table 2: Types of Courses for Four Year Under Graduate Programme (FYUGP)

Sr. No	Type of Courses	Credits		
		Theory (No. of Courses x Credits)	**Practical/Tutorial** (No. of Courses x Credits)	**Total**
I	**Discipline Specific Course [DSC]** (4 Credits) (18 Courses)	18 x 3 = 54	18 x 1 =18	72
II	**Discipline Specific Elective [DSE]** (4 Credits) (3 Courses)	3 x 3 = 9	3 x 1 = 3	12
III	**Minor Courses** (3 Credits) (3 Courses)	3 x 2 = 6	3 x 1 = 3	9
IV	**Higher Level Discipline Specific Course[HLDSC]** (4 Credits) (6 or 5 Courses)	6 x 3 = 18 or 5 x 3 = 15	6 x 1 = 6 or 5 x 1 = 5	24 or 20
V	**Academic Project***(4 Credits)or **Research Dissertation**[$](12 Credits)	-	1 x 4= 4 or 1 x 12 = 12	4 or 12
VI	**Higher Level & Applied Area Minor [HAA Minor]** (4 Credits) (3 or 2Courses)	3 x 3 = 9 or 2 x 3 = 6	3 x 1 = 3 or 2 x 1 = 2	12 or 8
VII	**Ability Enhancement Courses [AEC]** (3 Credits) (3 Courses)	3 x 2 = 6	3 x 1 = 3	9
VIII	**Skill Enhancement Courses [SEC]** (3 Credits) (3 Courses)	3 x 2 = 6	3 x 1 = 3	9
IX	**Internship/Apprenticeship/Projects/Community Engagement [IAPC]** (2 Credit) (3 Courses)	3 x 1 = 3	3 x 1 = 3	6
X	**Academic Writing [AW]** (2 Credit) (1 paper)	2 x 1 = 2	-	2
XI	**Seminar**(1 Credits) (1 paper)		1 x 1 = 1	1
XII	**Value Added Courses [VAC]** (2 Credits) (4 Courses)	4 x 1 = 4	4 x 1= 4	8
XIII	**Other Activities [NCC/NSS]** (2 Non-Credit)	-	6 x 2 = 12(NC)	12(NC)
	Total Credits	**117 or 111**	**51 or 57 + 12 (NC)**	**168 + 12(NC)**

[*]**Student opting for UG degree (Hons.) shall passsixcourses of HLDSC, threecourses of HAAMinor and Academic Project of 4 Credits.**

[$]**Student opting for UG degree (Hons. with Research) shall passfivecourses of HLDSC, twocourses of HAAMinor and Research Dissertation of 12 Credits.**

 # A maximum of 40% of the credits in each category can be earned from UGC approved online platforms (SWAYAM etc.).

Table 3: Details of Courses to be offered to Four Year Under Graduate Programme(FYUGP) Physical Sciences (*Semester-wise*)

Year	Semester	Discipline/Subject/ Type of Course	Type of Course Code	Course No.	Course Title	Course Cr. Hrs.
First	I	Physics	DSC-I-A	Phys.111	Mechanics	3+1
		Mathematics	DSC-I-B	Math.111	Differential Calculus	3+1*
		Chemistry	DSC-I-C	Chem.111	Atomic Structure & Chemical Bonding	3+1
		English	AEC-I	Eng.111	General English Language	2+1
		Computer	SEC- I	Comp.111	Computer Applications	2+1
		Internship/Apprenticeship/Projects/Community Engagement/ Vocational Courses)	IAPC -I	*Any one of the following:*		
				IPAC111 /Bio.111	Vermi-composting	1+1
				IPAC112 /Zoo.112	Freshwater Aquaculture	1+1
		Environmental Science	VAC-I	Env.111	Introduction to Environmental Studies	2+0
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
	Total Credit Hours in Semester-I					***22+2(NC)***
	II	Physics	DSC-II-A	Phys.121	Electricity, Magnetism and EMT	3+1
		Mathematics	DSC-II-B	Math.121	Differential Equations	3+1*
		Chemistry	DSC-II-C	Chem.121	Basic concepts and Aliphatic Hydrocarbons	3+1
		English	AEC-II	Eng.121	English Communication	2+1
		Statistics/GIS/ Biochemistry	SEC- II	*Any one of the following:*		
				Stat.121	Elements of Statistics	2+1
				GIS.121	Geographic Information System	2+1
				Biochem.121	Biochemical Constituents of food grains, fruits, and Vegetables	2+1
		Internship/Apprenticeship/Projects/Community engagement/ Vocational Courses)	IAPC -II	*Any one of the following:*		
				IAPC121 /Micro.121	Biofertilizer Production	1+1
				IAPC122 /Agron.361	Organic Farming	1+1
				IAPC123 /EECM 121	Community Organization	1+1
		Sociology	VAC-II	Soc.121	Human values and Ethics	2+0

		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
Total Credit Hours in Semester-II						***22 +2(NC)***
Second	I	Physics	DSC-III-A	Phys.211	Statistical and Thermal Physics	3+1
		Mathematics	DSC-III-B	Math.211	Real analysis	3+1*
		Chemistry	DSC-III-C	Chem.211	States of Matter and Chemical Kinetics	3+1
		Physics/Mathematics/ Chemistry	DSE-I-A/B/C	*Any one of the following:*		
				Phys.212	Atomic and Molecular Physics	3+1*
				Phys.213	Quantum Physics	3+1*
				Math.212	Elements of Number Theory	3+1*
				Math.213	Combinatorics	3+1*
				Chem.212	Basic Concepts and Photochemistry	3+1
				Chem.213	Spectroscopy	3+1
		Internship/Apprenticeship/Projects/Community engagement/Vocational Courses)	IAPC -III	*Any one of the following:*		
				IAPC211 /Zoo.214	Finfish Breeding and Hatchery Management	1+1
				IAPC212/ HHA 117	Personality Development and Communication Skills	1+1
				IAPC213/ HHA 237	Event Management	0+2
				IAPC214/ Hort.111	Fundamentals of Horticulture	1+1
		Zoology/Value Added course	VAC-III	*Any one of the following:*		
				VAC211/ Zoo.215	Ornamental Fish Production and Management	1+1
				VAC212/ HHA 355	Food Safety and Quality	2+0
		Zoology/Value Added course	VAC-IV	*Any one of the following:*		
				VAC213/ Zoo.216	Fish Products and By-Products Technology	1+1
				VAC214/	Drone Technology	1+1
				VAC215/	Digital Empowerment	0+2
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
	Total Credit Hours in Semester-III					***22 +2(NC)***
	II	Physics	DSC-IV-A	Phys.221	Waves and Optics	3+1
		Mathematics	DSC-IV-B	Math.221	Algebra	3+1*
		Chemistry	DSC-IV-C	Chem.221	Chemistry of s- and p- Block Elements	3+1
		Physics/Mathematics/ Chemistry	DSE-II-A/B/C	*Any one of the following:*		
				Phys.222	Electronics-I	3+1

				Phys.223	Mathematical and Computational Physics	3+1*
				Math.222	Introduction to Graph Theory	3+1*
				Math.223	Elements of Discrete Mathematics	3+1*
				Chem.222	Analytical Chemistry	
				Chem.223	Organometallics, Heterocyclic and Polynuclear Hydrocarbons	3+1
		Ability Enhancement Course	AEC-III	AEC221/	Any Language Course available from the UGC approved platform (Swayam, etc.).	2+1/3 +0
		Chemistry/Computer/ Microbiology	SEC- III	*Any one of the following:*		
				Chem.224	Chemistry of Cosmetics and Perfumes	2+1
				Comp.221	Computer Programming	2+1
				Comp.222	Databases and SQL	2+1
				Micro.221	Techniques in Microbiology	2+1
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
Total Credit Hours in Semester-IV						***22 +2(NC)***
Third	I	Physics	DSC-V-A	Phys.311	Condensed Matter Physics-I	3+1
		Mathematics	DSC-V-B	Math.311	Elementary linear Algebra	3+1*
		Chemistry	DSC-V-C	Chem.311	Chemistry of Functional Groups	3+1
		Research Methodology	Minor I	RM 311	Research Methodology	3+0
		Computer	Minor II	Comp.311	Programming using Python	2+1
		Academic Writing	AW	AW 311	Academic Writing	2+0
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
	Total Credit Hours in Semester-V					***20 + 2 (NC)***
	II	Physics	DSC-VI-A	Phys.321	Nuclear and Particle Physics-I	3+1*
		Mathematics	DSC-VI-B	Math.321	Numerical Analysis	3+1*
		Chemistry	DSC-VI-C	Chem.321	Chemical Thermodynamics and Electrochemistry	3+1
		Physics/Mathematics/ Chemistry	DSE-III-A/B/C	*Any one of the following:*		
				Phys.322	Electronics- II	3+1
				Phys.323	Astronomy and Astrophysics	3+1
				Math.322	Linear Programming	3+1*
				Math.323	Complex Analysis	3+1*
				Chem.322	Chemistry of Polymers	3+1
				Chem.323	Molecules of Life	3+1
		Statistics/ Environmental Science/Biochemistry	Minor III	*Any one of the following:*		
				Stat.321	Probability and Probability Distribution	2+1
				Env.321	Environmental Science and	2+1

					Disaster Management	
				Biochem.321	General Biochemistry	2+1
		Physics/Mathematics/ Chemistry	Seminar I – A/B/C	Phys.391/ Math.391/ Chem.391	Seminar	1+0
		Other Activities		NCC/NSS	NCC/NSS	0+2 (NC)
Total Credit Hours in Semester-VI						***20 + 2 (NC)***
Fourth	I	Physics/Mathematics/ Chemistry	HLDSE-I	*Any one from the discipline of choice, of the following:*		
				Phys.411	Classical Mechanics	3+1*
				Math.411	Advanced Real Analysis	3+1*
				Chem.411	Group Theory and X-ray Crystallography	3+1
			HLDSE-II	*Any one from the discipline of choice, of the following:*		
				Phys.412	Quantum Mechanics	3+1*
				Math.412	Advanced Algebra	3+1*
				Chem.412	Chemistry of Natural Products	3+1
			HLDSE-III	*Any one from the discipline of choice, of the following:*		
				Phys.413	Statistical Physics	3+1*
				Math.413	Ordinary Differential Equations	3+1*
				Chem.413	Statistical Thermodynamics and Quantum Chemistry	
		Physics/ Mathematics/ Chemistry	HAAMinor-I and HAAMinor-II	*Any two from the discipline of choice [for Honors only], of the following:* *or* *Any one from the discipline of choice [for Honors with Research], of the following:*		
				Phys.414	Physics LAB Course	0+4
				Phys.415	Material Physics	3+1*
				Phys.416	Plasma Physics	3+1*
				Phys.417	Laser and Spectroscopy	3+1*
				Math.414	Operational Research	3+1*
				Math.415	Fuzzy Set Theory	3+1*
				Math.416	Fluid Dynamics	3+1*
				Math.417	Mathematical Python	3+1*
				Chem.414	Advanced Organometallics	3+1
				Chem.415	Solutions, Colligative Properties, and Chemistry of Nano-materials	3+1
		Physics/ Mathematics/ Chemistry	R-I	Phys.491/ Math.491/ Chem.491	Pre-Research	0+4
	Total Credit Hours in Semester-VII = 20					
	II	Physics/	HLDSE-IV	*Any one from the discipline of choice, of the following:*		

		Mathematics/ Chemistry		Phys.421	Condensed Matter Physics-II	3+1
				Math.421	Field Theory	3+1*
				Chem.421	Bioinorganic Chemistry	3+1
			HLDSE-V	*Any one from the discipline of choice, of the following:*		
				Phys.422	Electrodynamics	3+1*
				Math.422	Partial Differential Equations	3+1*
				Chem.422	Pericyclic and Asymmetric Synthesis	3+1
			HLDSE-VI	*Any one from the discipline of choice, of the following:*		
				Phys.423	Nuclear and Particle Physics-II	3+1*
				Math.423	Linear Algebra and Matrix Analysis	3+1*
				Chem.423	Surfaces and Macromolecules	3+1
		Physics/ Mathematics/ Chemistry	HAAMinor-III	*Any one from the discipline of choice, of the following:*		
				Phys.424	Nano Physics	3+1*
				Phys.425	Optoelectronics	3+1*
				Phys.426	Communicative and Digital Electronics	3+1*
				Math.424	Integral Equations and Calculus of Variations	3+1*
				Chem.424	Advanced Spectroscopy	3+1*
		Physics/ Mathematics/ Chemistry	R-II	Phys.492/ Math.492/ Chem.492	Research	0+8
		Physics/ Mathematics/ Chemistry	Project	Phys.493/ Math.493/ Chem.493	Academic project	0+4
Total Credit Hours in Semester-VIII= 20						
TOTAL CREDIT HOURS TO BE STUDIED						***168+12(NC)***

PHYSICS
(DISCIPLINE – A)

DISCIPLINE SPECIFIC COURSES:

Phys.111 Mechanics 3+1

LEARNING OBJECTIVES:

The primary objective of this course is to:

- review the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts.
- learn the collisions in the centre of mass frame, rotational motion and central forces.
- be able to apply the concepts learnt to several real world problems.
- In the laboratory part of the course, the students will learn to use various instruments, estimate the error forevery experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.

LEARNING OUTCOMES:

Upon completion of this course, students will be able to,

- Learn the Galilean invariance of Newton's laws of motion.
- Understand translational and rotational dynamics of a system of particles.
- Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.
- Understand Einstein's postulates of special relativity.
- Apply Lorentz transformations to describe simultaneity, time dilation and length contraction
- Use various instruments for measurements and perform experiments related to rotational dynamics, elastic properties, fluid dynamics, acceleration due to gravity, collisions, etc.
- Use propagation of errors to estimate uncertainty in the outcome of an experiment and perform the statistical analysis of the random errors in the observations.

THEORY(45 Hours)

UNIT 1 (14 Hours)

Fundamentals of Dynamics: Inertial and Non-inertial frames, Newton's Laws of Motion, and their invariance under Galilean transformations. Momentum of variable mass system: motion of rocket. Dynamics of a system of particles. Principle of conservation of momentum. Impulse. Determination of Centre of Mass of discrete and continuous objects having cylindrical and spherical symmetry. Differential analysis of a static vertically hanging massive rope
Work and Energy:Work and Kinetic Energy Theorem. Conservative forces and examples (Gravitational and electrostatic), non-conservative forces and examples (velocity dependent forces e.g. frictional force, magnetic force), Potential Energy. Energy diagram. Stable, unstable, and neutral equilibrium. Force as gradient of the potential energy. Work done by non-conservative forces.
Collisions:Elastic and inelastic collisions between two spherical bodies. Kinematics of $2 \rightarrow 2$ scattering in centre of mass and laboratory frames.

UNIT2 **(12 Hours)**

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Determination of moment of inertia of symmetric rigid bodies (rectangular, cylindrical and spherical) using parallel and perpendicular axes theorems. Kinetic energy of rotation. Motion involving both translation and rotation.
Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Centrifugal force. Coriolis force and its applications.

UNIT3 **(7 Hours)**

Central Force Motion: Central forces, Law of conservation of angular momentum for
central forces, Two-bodyproblem, and its reduction to equivalent one-body problem and its solution. Concept of effective potential energy and stability of orbits for central potentials of the form krn for n = 2 and -1 using energy diagram, discussion on trajectories for n=-2. Solution of the Kepler Problem, Kepler's Laws for planetary motion, orbit for artificial satellites

UNIT4 **(12 Hours)**

Relativity: Postulates of Special Theory of Relativity, Lorentz Transformations, simultaneity, length contraction, time dilation, proper length and proper time, life time of a relativistic particle (for example muon decay time and decay length). Space-like, time-like and light-like separated events, relativistic transformation of velocity and acceleration, variation of mass with velocity, mass-energy equivalence, transformation of energy and momentum.

PRACTICAL(30 Hours)

Introductory Concepts and related activities (Mandatory)
• Use of Basic Instruments
Determination of least count and use of instruments like meter scale, vernier callipers, screw gauge and travelling microscope for measuring lengths.
• Errors
(a) Types of errors in measurements (instrumental limitations, systematic errors, and random errors), accuracy and precision of observations, significant figures.
(b) Introduction to error estimation, propagation of errors and reporting of results along with uncertainties with correct number of significant figures.
(c) Statistical analysis of random errors, need for making multiple observations, standard error in the mean as estimate of the error.
• Graph Plotting
Pictorial visualization of relation between two physical quantities, points to be kept in mind while plotting a graph manually.
• Data Analysis
Principle of least square fitting (LSF) and its application in plotting linear relations, estimation of LSF values of slope, intercept and uncertainties in slope and intercept.
Mandatory Activities
• Determine the least count of meter scale, vernier callipers, screw gauge and travelling microscope, use these instruments to measure the length of various objects multiple time, find the mean and report the result along with the uncertainty up to appropriate number of significant digits.
• Take multiple observations of the quantities like length, radius etc. for some spherical, cylindrical and cubic objects, find mean of these observations and use them to determine the surface area and volume of these objects. Estimate the uncertainties in the outcome using law of propagation of errors. Report the result to appropriate number of significant figures.

• Given a data (*x, y*) corresponding to quantities *x* and *y* related by a relation $y = f(x)$ that can be linearised, plot the data points (manually) with appropriate choice of scale, perform least square fitting to determine the slope and intercept of the LSF line and use them to determine some unknown quantity in the relation. Determine the uncertainties in slope and intercept and use these to estimate the uncertainty in the value of unknown quantity.

Every student must perform at least 6 experiments from the following list.

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle
6. To determine the Elastic Constants of a Wire by Searle's method
7. To determine g by Bar Pendulum
8. To determine g by Kater's Pendulum
9. To determine g and velocity for a freely falling body using Digital Timing Technique
10. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of g

SUGGUESTED READINGS:

1. An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.
2. Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education
3. Classical Mechanics by Peter Dourmashkin, 2013, John Wiley and Sons.
4. Introduction to Classical Mechanics With Problems and Solutions, David Morin, 2008, Cambridge University Press.
5. Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.
6. Introduction to Special Relativity, Robert Resnick, 2007, Wiley.
7. Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
8. Newtonian Mechanics, A.P. French, 2017, Viva Books.
9. Advanced Practical Physics for students, B. L. Flint and H. T. Worshnop, 1971, Asia Publishing House.
10. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
11. A Text Book of Practical Physics, Vol I, Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
12. An introduction to Error Analysis: The study of uncertainties in Physical Measurements, J. R. Taylor, 1997, University Science Books

Phys.121 Electricity, Magnetism and EMT 3+1

LEARNING OBJECTIVES:

The primary objective of this course is to:

- Review the concepts of electromagnetism learnt at school from a more advanced perspective and goes on to build new concepts.
- The course covers static and dynamic electric and magnetic fields due to continuous charge and current distributions respectively.

LEARNING OUTCOMES:

After completing this course, student will be able to,

- Apply Coulomb's law to line, surface, and volume distribution of charges.
- Apply Gauss's law of electrostatics to distribution of charges
- Solve boundary value problems using method of images
- Understand the concept of electric polarization and bound charges in dielectric materials
- Understand and calculate the vector potential and magnetic field of arbitrary current distribution
- Understand the concept of bound currents and magnetic susceptibility in magnetic materials
- Understand the impact of time-varying magnetic and electric fields in order to comprehend the formulation of Maxwell's equations.

THEORY (45 Hours)

UNIT 1 **(15 Hours)**

Electric Field and Electric Potential: Electric Field and Electric Potential for continuous charge distributions: Electric field due to a line charge, surface charge and volume charge, Divergence of electric field using the Dirac Delta function, Curl of electric field, Electric field vector as negative gradient of scalar potential, Ambiguities of electric potential, Differential and integral forms of Gauss's Law, Application of Gauss's law to various charge distributions having spherical, cylindrical and planar symmetries.
Boundary Value Problems in Electrostatics: Formulation of Laplace's and Poisson equations, First and second uniqueness theorems, Solutions of Laplace and Poisson equations in onedimension using spherical and cylindrical coordinate systems and solutions in three-dimensional using Cartesian coordinates applying separable variable technique, Electrostatic boundary conditions for conductors and capacitors.

UNIT 2 **(11 Hours)**

Electrostatic energy of system of charges: Electrostatic energy of a charged sphere.Conductors in an electrostatic Field. Surface charge and force on aconductor.Capacitance of a system of charged conductors.Parallel-plate capacitor.Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.
Electric Field in Matter: Polarization in matter, Bound charges and their physical interpretation, Field inside a dielectric, Displacement vector **D**, Gauss' law in the presence of dielectrics, Boundary conditions for **D**, Linear dielectrics, electric susceptibility and dielectric constant, Idea of complex dielectric constant due to varying electric field, Boundary value problems with linear dielectrics

UNIT 3 **(19 Hours)**

Magnetic Field: Divergence and curl of magnetic field B, Magnetic field due to arbitrary current distribution using Biot-Savart law, Integral and differential forms of Ampere's law, Vector potential and its ambiguities, Coulomb gauge and possibility of making vector potential divergence less, Vector potential due to line, surface and volume currents using Poisson equations for components of vector potential.
Magnetic Properties of Matter: Magnetization vector, Bound currents, Magnetic intensity, Differential and integral form of Ampere's Law in the presence of magnetized materials, Magnetic susceptibility and permeability of diamagnetic, paramagnetic and ferromagnetic materials.
Electrodynamics: Faraday's law, Lenz's law, Inductance and electromotive force, Ohm's law ($\vec{J}=\sigma E$), Energy stored in a magnetic field, Continuity equation, Displacement current and

displacement current density, Basic introduction to Maxwell's equations in electromagnetism.

PRACTICAL(30 Hours)

Every student must perform at least 6 experiments from the following list.

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses
2. Ballistic Galvanometer:
    a. Measurement of charge and current sensitivity
    b. Measurement of CDR
    c. Determine a high resistance by Leakage Method
3. To compare capacitances using De'Sauty's bridge
4. Measurement of field strength B & its variation in a Solenoid (Determine dB/dx)
5. To study the Characteristics of a Series RC Circuit
6. To study a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factorQ
8. To determine a Low Resistance by Carey Foster's Bridge
9. To verify the Thevenin and Norton theorem
10. To verify the Superposition, and Maximum Power Transfer Theorem

SUGGUESTED READINGS:

1. Introduction to Electrodynamics, D. J. Griffiths, 3rd Edn., 1998, Benjamin Cummings
2. Electricity, Magnetism & Electromagnetic Theory, S.Mahajan and Choudhury,2012, Tata McGraw .
3. Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2nd Edn.1981, McGraw-Hill.
4. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
5. Electricity and Magnetism, Tom Weideman, University of California Davis. [url: https://zhu.physics.ucdavis.edu/Physics9C_2021/Physics%209C_EM%20by%20Tom%20Weideman.pdf]
6. Feynman Lectures Vol. 2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
7. Electricity and Magnetism, J. H. Fewkes and J. Yarwood, Vol. I, 1991, Oxford Univ. Press.
8. Problems and Solutions in Electromagnetics (2015), AjoyGhatak, K Thyagarajan and Ravi Varshney.
9. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
10. A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal
11. Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
12. Practical Physics, G. L. Squires, 2015, 4th Edition, Cambridge University Press

Phys.211 Statistical and Thermal Physics 3+1

LEARNING OBJECTIVES:

The primary objective of this course is to:

- Make the student understand the applications of fundamental laws of thermodynamics to various systems and processes.

- Enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behaviour of atoms and molecule through a brief knowledge of statistical mechanics.
- It also includes a basic idea about thekinetic theory of gases, transport phenomena involved in ideal gases, phase transitions andbehaviour of real gases.
- The students will be able to apply these concepts to several problems on heat.
- The lab course deals with providing the knowledge of the concepts ofthermodynamics along with Planck's law and Stefan Boltzmann laws related to black body radiation studied in the theory paper with the help of experiments and give thestudents a hands-on experience on the construction and use of specific measurementinstruments and experimental apparatuses used in the Thermal Physics lab, including necessary precautions.

LEARNING OUTCOMES:

At the end of this course, students will be able to

- Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics.
- Understand the concept of reversibility, irreversibility and entropy.
- Understand various thermodynamic potentials and their physical significance with respect to different thermodynamic systems and processes.
- Deduce Maxwell's thermodynamical relations and use them for solving various problems in Thermodynamics.
- Understand the concept and behaviour of ideal and real gases.
- Apply the basic concept of kinetic theory of gases in deriving Maxwell-Boltzmanndistribution law and its applications.
- Understand mean free path and molecular collisions in viscosity, thermal conductivity, diffusion and Brownian motion.
- Learn about the black body radiations, Stefan- Boltzmann's law, Rayleigh-Jean's law and Planck's law and their significances.
- Gain the basic knowledge about quantum statistics: the Bose-Einstein statistics and the Fermi-Dirac statistics.
- While doing the practical, the students will have an opportunity to understand and hence use the specific apparatus required to study various concepts of thermodynamics. Hence, the student will be able to comprehend the errors they can encounter while performing the experiment and how to estimate them.

THEORY (45 Hours)

UNIT 1 **(6 Hours)**

Zeroth and First Law of Thermodynamics: Fundamental idea of thermodynamic equilibrium and Zeroth Law of Thermodynamics, concept of work and heat, First law of Thermodynamics and its differential form, internal energy, applications of First law: General relation between $C_P$and Cv, work done during various processes (all four) and related problems, Compressibility and Expansion Co-efficient for various processes.

UNIT 2 **(12 Hours)**

Second law of Thermodynamics: Reversible and Irreversible processes, Carnot engine and Carnot's cycle, Refrigerator, efficiency of Carnot engine and refrigerator, Second Law of Thermodynamics: Kelvin-Planck and Clausius statements and their equivalence, Carnot's theorem, Applications of Second Law of Thermodynamics in the light of Phase Change, Thermodynamic Scale of Temperature, and its equivalence to Perfect Gas Scale.

Concept of Entropy, Entropy changes in Reversible and Irreversible processes with examples, Clausius Theorem, Second Law of Thermodynamics in terms of Entropy. Temperature-Entropy diagrams for Carnot's cycle and related problems, Entropy of perfect and real gases, conceptual problems related to Entropy during a Phase Change, Nernst Heat Theorem: Unattainability of Absolute Zero and Third Law of Thermodynamics.

UNIT 3 **(12 Hours)**

Thermodynamic Potentials and Maxwell's Relations: Basic concept of Thermodynamic Potentials, Internal Energy, Enthalpy, Helmholtz FreeEnergy, Gibb's Free Energy, Magnetic work, and basic idea about cooling due to adiabaticdemagnetization, Phase Transitions: First order and Second order Phase Transitions withexamples, ClausiusClapeyron Equation, Ehrenfest Equations, Derivation of Maxwell'sThermodynamic Relations and their applications in ClausiusClapeyron Equation, value of CP
– Cv, TdS equations, Energy equations, evaluation of C_P /$C_v$and Ratio of Adiabatic toIsothermal elasticity.

UNIT 4 **(6 Hours)**

Kinetic Theory of Gases and Molecular Collisions: Maxwell-Boltzmann law of distribution of velocities in an ideal gas and its experimental verification with any one method. Mean, Root Mean Square and Most Probable Speeds, Maxwell-Boltzmann equation for distribution of Energy: Average Energy and Most Probable Energy, Mean Free Path, Collision Probability, estimation of Mean Free Path, transport phenomena in ideal gases: viscosity, thermal conductivity and diffusion with continuity equation

UNIT 5 **(5 Hours)**

Statistical Mechanics: Macrostate and Microstate, phase space, Entropy and thermodynamic probability, Maxwell-Boltzmann law, qualitative description of Quantum statistics – Bose Einstein and Fermi Dirac, comparison of three statistics.

UNIT 6 **(4 Hours)**

Theory of Radiation: Blackbody radiation, Spectral distribution, Derivation of Planck's law, Deduction of Wien's law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law

PRACTICAL(30 Hours)

Every student must perform at least 6 experiments from the following list.

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee andCharlton's disc method using steam or electrical heating.
4. To determine the coefficient of thermal conductivity of Copper (Cu) by Angstrom's method.
5. To determine the Temperature Coefficient of Resistance by Platinum ResistanceThermometer (PRT) using Carey Foster's Bridge.
6. To determine the Temperature Coefficient of Resistance using Platinum Resistance Thermometer (PRT) by Callender-Griffith Bridge.
7. To study the variation of thermo-e.m.f. of a thermocouple with difference of temperature of its two junctions using a null method.
8. To calibrate a thermocouple to measure temperature in a specified range by direct method and/or by using Op Amp and to determine Neutral Temperature.
9. Measurement of Planck's constant using black body radiation.

10. To study the variation of thermo-e.m.f. across two junctions of a thermocouple with
6. temperature.
11. To determine Stefan's Constant.
12. To prove the law of probability by using one coin, two coins and 10 or more coins.

SUGGUESTED READINGS:

1. Heat and Thermodynamics: M. W. Zemansky and R. Dittman, Tata McGraw-Hill, 1981
2. Thermal Physics: S. C. Garg, R. M. Bansal and C. K. Ghosh, 2nd Edition, Tata McGraw-Hill.
3. Thermodynamics, Kinetic Theory and Statistical Thermodynamics: Sears and Salinger,Narosa, 1988Concepts in Thermal Physics: Blundell and Blundell, 2nd Edition, Oxford UniversityPress, 2009
4. Thermal Physics, A. Kumar and S. P. Taneja, R. Chand Publications, 2014
5. A Text Book of Heat and Thermodynamics for Degree Students, J. B. Rajam, S. Chand,1981
6. An Introduction to Thermal Physics: D. Schroeder, Oxford University Press (earlierpublished by Pearsons), 2021
7. Thermal Physics: C. Kittel and H. Kroemer, 2nd Edition, W. H. Freeman, 1980
8. Heat, Thermodynamics and Statistical Physics, Brij Lal, N. Subrahmanyam and P. S.Hemne, S. Chand and Company
9. Advanced Practical Physics for students: B. L. Flint and H. T. Worsnop, Asia PublishingHouse, 1971
10. A Text Book of Practical Physics: Indu Prakash and Ramakrishna, 11th Edition, KitabMahal
11. An Advanced Course in Practical Physics: D. Chattopadhyay and P. C. Rakshit, 1990,New Central Book Agency.
12. Practical Physics: G. L. Squires, Cambridge University Press, 1985
13. B.Sc. Practical Physics: Harnam Singh, P. S. Hemne, revised edition 2011, S. Chand andCo.
14. B. Sc. Practical Physics: C. L. Arora, S. Chand and Co.

Phys.221 Waves and Optics 3+1

LEARNING OBJECTIVES:

The primary objective of this course is to:

- Study the phenomena related to oscillatory systems.
- review the fundamentals of oscillatory systems for application to understanding of waves and optics.
- Review the concepts of waves, their properties.
- This course provides an in depth understanding of phenomena of light such as: interference, diffraction and Polarization with emphasis on practical applications of both.

LEARNING OUTCOMES:

At the end of this course, students will be able to

- Understand Simple harmonic oscillations and their origin
- Superposition of oscillatory quantities and their applications
- Wave equation and its significance
- How the superposition principle play crucial role in explaining many optical phenomenon such as interference, diffraction

- Appreciate the dual nature of light which is part of the electromagnetic spectrum and the dual nature of matter simultaneously.
- Delve in to the depth of understanding wave optics with its various kinds of interference, Diffraction and Polarization exhibited by light.
- Demonstrate basic concepts of diffraction: Superposition of wavelets diffracted from aperture, understand Fraunhofer and Fresnel diffraction.
- In the laboratory course, students will gain hands-on experience of using various optical instruments, measurement of resolving power and dispersive power, and making finer measurements of wavelength of light using Newton's rings experiment.
- They will alsofind wavelength of Laser sources by single and double slit experiment, wavelength and angular spread of He-Ne Laser using plane diffraction grating

THEORY (45 Hours)

UNIT 1 **(15 Hours)**

Simple harmonic motion: Simple Harmonic Motion Characteristics, graphical representation of SHM, phase relation between displacement, velocity and acceleration of a particle, executing SHM, SHM oscillator (mass attached to a spring placed on horizontal frictionless surface). energy of a simple harmonic oscillator. solution of the differential equation of SHM. Average kinetic energy, average potential energy and total energy.
Superposition of Two Collinear Harmonic oscillations: Simple harmonic motion (SHM). Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.
Damped SHM: Damped oscillations. differential equation of motion of one dimensional damped harmonic mechanical oscillator. Types of damping. damped harmonic electric oscillator. Determination of the damping constants. Logarithmic decrement. Relaxation time. The quality factor, power dissipation in a damped harmonic oscillator when damping is weak. Relation between power dissipation energy and relaxation time of damped harmonic oscillator.

UNIT 2 **(15 Hours)**

The Forced Oscillator: Transient and steady behaviour of forced oscillator. Displacement and velocity variation with driving force frequency. Variation of phase with frequency. Powersupplied to an oscillator and its variation with frequency. Q- value and band width. Q-value asan amplification factor (Phasor treatment to be followed).
Coupled Oscillators: Stiffness coupled pendulums. Normal co-ordinates and normal modes ofvibration. Inductance coupling of electrical oscillators.
Wave Motion: The type of waves. The wave equation and its solution. Characteristic impedance string. Impedance matching. Reflection and transmission of energy. Reflected andtransmitted energy coefficients. Standing waves on a string of fixed length. Energy of a vibratingstring. Wave velocity and group velocity.
Sound: Intensity and loudness of sound- Decibels- Intensity levels – musical notes- musical scale. Acoustics of buildings: Reverberation and time of reverberation-Absorption coefficient-Sabine's formula- measurementofreverberationtime-Acousticaspectsofhallsandauditoria.

UNIT 3 **(15 Hours)**

Wave Optics: Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.
Interference: Concept of interference, Coherence, Division of wavefront and division of amplitude. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes'treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes).

Newton’s Rings: measurement of wavelength and refractive index. Michelson’s Interferometer. Diffraction: Fraunhofer diffraction: Single slit; Double Slit. Multiple slits & Diffraction grating, Dispersive power of diffraction grating, Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. Polarization: Transverse nature of light waves. Unpolarized and plane polarized light,production of polarized light, Wire grid polarizer, Polaroid, Effect of intensity of light passing through Polaroid, Malus’ law, double refraction; ordinary ray and extraordinary ray, positive and negative crystals, birefringence, Nicol Prism, quarter wave plate and half wave plate,Polarization by reflection (Brewster law), polarization by scattering,. Circular and elliptical polarization, production of elliptically polarized and circularly polarized light.

PRACTICAL(30 Hours)

Every student must perform at least 6 experiments from the following list.

1. To investigate the motion of coupled oscillators.
2. To determine the Refractive Index of the Material of a given Prism using Sodium Light.
3. To determine Dispersive Power and Resolving power of the Material of a given Prismusing Mercury Light.
4. To determine the value of Cauchy Constants of a material of a prism.
5. To determine wavelength of sodium light using Fresnel Bi prism.
6. To determine wavelength of sodium light using Newton’s Rings.
7. To determine the wavelength of Laser light using Diffraction of Single Slit.
8. To determine wavelength of (1) Sodium & (2) spectrum of Mercury light using plane diffraction Grating.
9. To determine the Resolving Power of a Plane Diffraction Grating.
10. To measure the intensity using photo sensor and laser in diffraction patterns of single and double slits.
11. To find the refractive index of glass slab using travelling microscope
12. To find the refractive index of water using travelling microscope
13. To determine the magnifying power of a telescope.
14. To determine the specific rotation of sugar using Laurent’s half-shade polarimeter.
15. Plot a graph between the concentration and rotation for various strengths of sugarsolution and hence find (a) the specific rotation and (b) the concentration of the givensugar solution.

SUGGUESTED READINGS:

1. A text book of Optics, N. Subrahmanyam, B. Lal, M.N. Avadhanulu, S. Chand &Company Ltd.
2. Fundamentals of Optics, F A Jenkins and H E White, 1976, McGraw-Hill.
3. Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
4. Fundamentals of Optics: Geometrical Physical and Quantum, D. R. Khanna, H. R.Gulati R. Chand Publication.
5. Optics, Eugene Hecht, Addison-Wesley 2002.
6. The Physics of Waves and Oscillations by N.K. Bajaj (Tata McGraw-Hill, 1988)
7. Fundamentals of Waves and Oscillations By K. Uno Ingard (Cambridge University Press, 1988)
8. An Introduction to Mechanics by Daniel Kleppner, Robert J. Kolenkow (McGraw-Hill, 1973)
9. Waves: BERKELEY PHYSICS COURSE by Franks Crawford (Tata McGrawHill, 2007).

Phys.311 Condensed Matter Physics-I 3+1

LEARNING OBJECTIVES:

The primary objective of this course is to:

- understand of crystal structure, band theory of solid, lattice dynamics, magnetic and dielectric properties of matter, ferroelectric materials, and superconductivity phenomenon.
- Understanding the basics of crystalline materials will be useful for other high level courses such as condensed matter physics, material characterization and engineering.

LEARNING OUTCOMES:

On successful completion of the module, students should be able to:

- Have a basic knowledge of crystal systems and spatial symmetries; Be able to account for how crystalline materials are studied using diffraction, including concepts like the Edwald's sphere, form factor, structure factor, and scattering amplitude.
- perform structure determination of simple structures; Understand the concept of reciprocal space and be able to use it as a tool to know the significance of Brillouin zones; Know what phonons are, and be able to perform estimates of their dispersive and thermal properties
- understand the elementary lattice dynamics, phonons and its influence on the properties of materials, describe the main features of the physics of electrons in solids;
- calculate thermal and electrical properties in the free-electron model and know Bloch's theorem and energy band and distinction between metals, semiconductors and insulators; Be able to estimate the charge carrier mobility and density; Be able to account for what the Fermi surface is and how it can be measured.
- explain the dielectric ferroelectric and magnetic properties of solids and understand the basic concept in superconductivity.

THEORY (45 Hours)

UNIT 1 (10 Hours)

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis– Central and Non-Central Elements. Symmetry Elements Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg‟s Law. Laue Condition, experimental methods, Atomic and Geometrical Factor.

UNIT 2 (8 Hours)

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit‟s Law, Einstein and Debye theories of specific heat of solids. T^3law.

UNIT 3 (7 Hours)

Electrons in Solids: Electrons in metals- Drude Model, Density of states (1-D,2-D,3-D),Fermi energy and fermi velocity, electronic contribution to specific heat of metals. Elementary band theory: Kronig Penny model. Band Gap, Effective mass, mobility, Hall Effect (Metal and Semiconductor).

UNIT 4 (10 Hours)

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical

Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie"s law, Weiss"s Theory of Ferromagnetism and Ferromagnetic Domains, B-H Curve. Hysteresis, soft and hard material and Energy Loss.
Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London"s Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

UNIT-V **(10 Hours)**

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant.
Ferroelectric Properties of Materials: Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

PRACTICAL(30 Hours)

Every student must perform at least 6 experiments from the following list.

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR) technique.
6. To determine the refractive index of a dielectric using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature (up to 150oC) by four-probe method and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. To measure the resistivity of a semiconductor (Ge) with temperature by two-probe method and to determine its band gap.
12. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.
13. Measurement of change in resistance of a semiconductor with magnetic field.

SUGGUESTED READINGS:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edn., 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Edn., 2006, Prentice-Hall of India.
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Solid-state Physics, H.Ibach and H. Luth, 2009, Springer.
6. Solid State Physics, Rita John, 2014, McGraw Hill
7. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.
8. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
9. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
10. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

Phys.321 Nuclear and Particle Physics-I 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to:

- impart the understanding of the general properties of nucleus, models for the nucleus, various theories of the nuclear decay, basics of nuclear reactions and its types and the interaction of the radiation with matter to understand the construction and working of the nuclear radiation detectors.
- Brief introduction to the world of the fundamental particles.
- It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application.
- The course will focus on the developments of problem based skills.

LEARNING OUTCOMES:

On successful completion of the module, students should be able to:

- understand the basic properties of nuclei as well as knowledge of experimental determination of the same, the concept of binding energy, its various dependent parameters, N-Z curves and their significance
- To appreciate the formulations and contrasts between different nuclear models such as Liquid drop model, Fermi gas model and Shell Model and evidences in support.
- Knowledge of radioactivity and decay laws. A detailed analysis, comparison and energy kinematics of alpha, beta and gamma decays.
- Familiarization with different types of nuclear reactions, Q- values, compound and direct reactions.
- To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter and neutron interaction with matter. Through the section on accelerators students will acquire knowledge about Accelerator facilities in India along with a comparative study of a range of detectors and accelerators which are building blocks of modern day science.
- It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub- atomic particles with the different conservation laws, concept of quark model.
- The acquired knowledge can be applied in the areas of nuclear medicine, medical physics, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

THEORY (45 Hours)

UNIT 1 (10 Hours)

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density, matter density (experimental determination of each), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/Z plot, angular momentum, parity, magnetic moment, electric moments.

UNIT 2 (6 Hours)

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumptions of shell model.

UNIT 3 **(9 Hours)**

Radioactivity decay: Decay rate and equilibrium (Secular and Transient) (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. (b) β- decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion.

UNIT 4 **(5 Hours)**

Nuclear Reactions: Types of Reactions, units of related physical quantities, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

UNIT 5 **(10 Hours)**

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production), neutron interaction with matter.
Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter. Basic principle of Scintillation Detectors
and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.
Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons (Principal, construction, working, advantages and disadvantages).

UNIT 6 **(5 Hours)**

Particle physics: Particle interactions (concept of different types of forces), basic features, Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons.

***Tutorial(15 Hours) one hour per week**

SUGGUESTED READINGS:

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
3. Introductory Nuclear Physics by K S Krane, Wiley-India Publication, 2008.
4. Nuclear Physics: principles and applications by J Lilley, Wiley Publication, 2006.
5. Radiation detection and measurement, G F Knoll, John Wiley & Sons, 2010.
6. Introduction to elementary particles by D J Griffiths, Wiley, 2008.
7. Concepts of Nuclear Physics by B L Cohen, Tata McGraw Hill Publication, 1974.
8. Physics and Engineering of Radiation Detection by S N Ahmed, Academic Press Elsevier, 2007.
9. Techniques for Nuclear and Particle Physics experiments by WR Leo, Springer, 1994.
10. Modern Physics by R ASerway, C J Moses and C A Moyer, 3rd edition, Thomson Brooks Cole, 2012.
11. Modern Physics for Scientists and Engineers by S T Thornton and A Rex, 4th edition, Cengage Learning, 2013.
12. Modern Physics by R ASerway, C J Moses and C A Moyer, 3rd edition, Thomson Brooks Cole, 2012.
13. Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.
14. Schaum's Outline of Modern Physics, McGraw-Hill, 1999.

15. Schaum's Outline of College Physics, by E. Hecht, 11th edition, McGraw Hill, 2009.
16. Modern Physics by K Sivaprasath and R Murugeshan, S Chand Publication, 2010.
17. Nuclear Physics "Problem-based Approach" Including MATLAB by Hari M. Aggarwal, PHI Learning Pvt. Ltd. (2016).

DISCIPLINE SPECIFIC ELECTIVES:

Phys.212 Atomic and Molecular Physics 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to:

- Understandthe hydrogen and alkali spectra, coupling schemes, atoms in magnetic fields.
- Learn Infrared and Raman spectroscopy, and electron spectra.
- Know about line broadening mechanisms and Lasers.

LEARNING OUTCOMES:

On successful completion of the module, students should be able to:

- describe the atomic spectra of one and two valance electron atoms.
- Study the Bohr Atom model in detail and understand about atomic excitations
- explain the change in behaviour of atoms in external applied electric and magnetic field.
- explain rotational, vibrational, electronic and Raman spectra of molecules.
- Describe electron spin and nuclear magnetic resonance spectroscopy and their applications.

THEORY (45 Hours)

UNIT 1 (15 Hours)

Hydrogen and Alkai Spectra: Series in hydrogen, nuclear mass effect, elliptical orbits, Sommerfeld model, spin-orbit coupling, relativistic correction and Lamb shift (qualitative). Alkali Spectra and intensity ratios in doublets

Complex Spectra: LS-Coupling scheme, normal triplets, basic assumptions of the theory,identification of terms, selection rules, jj- coupling, Lande's interval rule, Selection rules, intensity ratios, regularities in complex spectra. Normal and anomalous Zeeman and Paschen Back effects, intensity rules.

UNIT 2 (15 Hours)

Infrared and Raman Spectra: Rigid rotator, energy levels, spectrum, intensity of rotational lines, Harmonic oscillator: energy levels, eigenfunctions, spectrum, Raman effect, Quantum theory of Raman effect, Rotational and Vibrational Raman spectrum. Anharmonic oscillator: energy levels, Infrared and Raman Spectrum, Vibrational frequency and force constants, Dissociation of molecules.

Non-rigid rotator including symmetric top: energy levels, spectrum, Vibrating-rotator energy levels, Infrared and Raman spectrum, Symmetry properties of rotational levels, influence of nuclear spin, isotope effect on rotational spectra.

Electronic Spectra: Classification of electronic states: Orbital angular momentum, Electronic energy and potential curves, resolution of total energy, Vibrational Structure of Electronic transitions.

Vibrational analysis, Rotational Structure of Electronic bands: General relations, branches of a band, band-head formation, Intensity distribution in a vibrational band system. Franck-Condon Principle and its wave mechanical formulation.

UNIT 3 **(15 Hours)**

Lasers: Temporal and spatial coherence, shape and width of spectral lines, line broadening mechanism, natural, collision and Doppler broadening. Laser Pumping and Resonators: Resonators, modes of a resonator, number of modes per unit volume, quality factor, threshold condition.
Dynamics of the Laser Processes: Rate equations for two, three and four level systems, production of a giant pulse – Q switching, mode-locking.
Types of Lasers: He-Ne gas laser, Nitrogen Laser, CO_2 laser, Ruby laser, Semiconductor lasers, dye lasers.
Applications: Holography, non-linear optics: harmonic generation, second harmonic generation, phase matching and optical mixing.
Tutorial*(15 Hours) one hour per week

SUGGUESTED READINGS:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
6. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
7. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
8. Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
9. Modern Physics, John R. Taylor, Chris D. Zafiratos, Michael A.Dubson,2009, PHI Learning
10. Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003

Phys.213 Quantum Physics 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to:
- Review the basics of quantum mechanics.
- Formulate time dependent and time independent Schrodinger equations and their solutions with different potentials,
- Solve applications of quantum mechanics for hydrogen-like and many electron atoms and atoms in electric and magnetic fields

LEARNING OUTCOMES:

On successful completion of the module, students should be able to:
- acquainted with the basic principles of Quantum Mechanics and its applications
- Have gained a clear knowledge about wave properties of particles, De Broglie waves and its implications on the uncertainty principle.
- Have grasped the idea of Wave Mechanics and gain the concept of eigen values, eigen functions and learn the basic postulates of quantum mechanics

- find solution to Schrödinger’s equation for many systems such as particle in a box, Hydrogen Atom and familiarize with different quantum numbers.

THEORY (45 Hours)

UNIT 1 **(15 Hours)**

Planck’s quantum, Planck’s constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Heisenberg uncertainty principle- impossibility trajectory; estimating minimum energy of a confined principle; Energy-time uncertainty principle. Wave-particle duality. Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles;
Momentum and Energy operators; stationary states; physical interpretation of wave function, probabilities and normalization; Probability and probability current densities in one dimension. Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles.
Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.
Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

UNIT 2 **(15 Hours)**

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.
One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier.

UNIT 3 **(15 Hours)**

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells.
Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor’s Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).
Many electron atoms: Pauli’s Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms-L-S and J-J couplings. Hund’s Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

*Tutorial(15 Hours) one hour per week

SUGGUESTED READINGS:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
6. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
7. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
8. Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
9. Modern Physics, John R. Taylor, Chris D. Zafiratos, Michael A.Dubson,2009, PHI Learning
10. Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003 McGraw Hill

Phys.222 Electronics- I 3+1

LEARNING OBJECTIVES:

The primary objective of this course is to:
- cover the fundamental and concepts of basic electronics in real-life.
- receive an introduction to the principle, performance and applications of basic electronic components
- Basics of Analog and Digital Electronics are envisioned to be introduced with emphasis on applications of diodes, transistor (BJT), operational amplifier,

LEARNING OUTCOMES:

At the end of this course, students will be able to:
- The students will gain an insight on the existence of analog and digital signals and their necessity.
- Specifically, they would know the difference between active and passive electronic components including filters.
- Students will learn about diodes and its uses in rectification (analog) and switching properties thereof (digital).
- They will gain an insight into working principle of Photodiodes, Solar Cells, LED and Zener Diode as Voltage Regulator.
- They will gain an understanding of construction and working principle of bipolar junction transistors (BJTs).Specifically, they would understand the fundamentals of amplification.

THEORY (45 Hours)

UNIT1 (15 Hours)

Analog and digital signals, Active and passive electronic components, RC integrator and differentiator (use as low pass and high pass filter): Qualitative analysis and frequency response.
DigitalCircuits: DifferencebetweenAnalogandDigitalCircuits.BinaryNumbers.DecimaltoBinary andBinaryto DecimalConversion,AND,ORandNOTGates(RealizationusingDiodes andTransistor).NANDandNORGatesasUniversalGates.XORandXNORGates. De

Morgan'sTheorems.BooleanLaws.Simplificationof LogicCircuitusingBooleanAlgebra.FundamentalProducts.MintermsandMaxterms.ConversionofaTruthTableintoanEquivalentLogicCircuitby(1)SumofProductsMethodand(2)KarnaughMap. BinaryAddition.BinarySubtractionusing2'sComplementMethod).HalfAddersandFullAddersandSubtractors,4-bitbinaryAdder-Subtractor.

UNIT2 (15 Hours)

Basics of Semiconductors, intrinsic and extrinsic Semiconductors, BarrierFormationin PNJunction Diode.QualitativeIdeaofCurrentFlowMechanisminForwardandReverseBiased Diode. Principleandstructureof Zener diode, voltage regulation, tunnel diode, LED and LCD, Solar cell, diode as circuit element, load line concept, Rectifiers: Half Wave, full wave and bridge rectifier, efficiency and ripple factor, filter circuits.
Transistors: Characteristics of a transistor in CB, CE and CC mode, idea of equivalent circuits, α and β of BJT, common emitter amplifier. Application of BJT as a switch and an amplifier in CE configuration (Graphical Analysis). Field Effect Transistor: working of JFET, voltage ampere curves, biasing JFET, ac operation of JFET, depletion and enhancement mode, MOSFET, FET amplifier.

UNIT3 (15 Hours)

Amplifiers: Small signal amplifiers: General principles of operation, classification, distortion, RC coupled amplifier, gain frequency response, input and output impedance. Multistage amplifiers, transformed coupled amplifiers, Equivalent circuits at low, medium and high frequencies, emitter follower, low frequency common source and common drain amplifier, Noise in electronic circuits. Feedback in amplifiers; negative feedback and stability.
Oscillators: Braukhausen criteria for oscillations, Tuned collector, Hartley and colpitts oscillators, phase shift oscillators, operational amplifiers, inverting and non-inverting amplifiers, operational amplifier as adder, subtractor, comparator, integrator and differentiator.

PRACTICAL(30 Hours)

1. To study the characteristics of FET
2. To find energy gap of a semiconductor.
3. To study the characteristics of Zener diode.
4. To study the voltage regulation using Zener diode
5. To study the characteristics of NPN transistor
6. To study the characteristics of PNP transistor
7. Half Adder and Full Adder using NAND gates
8. Half Subtractor and Full Subtractor using NAND gates
9. To measure the efficiency and ripple factors for: a) Half wave b) full wave and c) bridge rectifier circuits.
10. To study the gain of an amplifier at different frequencies and to find band width and gain band width product.
11. (a) To draw forward and reverse bias characteristics for a PN-junction diode and draw a load line.
    (b) Study of a diode as a clipping element.

SUGGUESTED READINGS:

1. Electronic Devices, Thomas L Floyd; Pearsons Education
2. Electronic Principles, A. Malvino, D. J. Bates, 7th Edition, Tata Mc-Graw Hill Education, 2018
3. Basic Electronics, D.C. Tayal, Himalya Publishing House.

4. Physics of Semiconductor Devices, Dilip K. Roy (1992), Universites Press, Distributed by Orient Longman Limited.
5. Solid State Electronic Devices, Ben G. Streetman, 2nd Edtion(1986), Prentice Hall Of India New Delhi-110001.
6. Principle of Electronics, VK Mehta, S Chand and Company
7. Electronic Devices and circuit theory, R. L. Boylestad and L. D. Nashelsky, Pearson Learning
8. Digital Principles and Applications, Donald P Leach, Albert Paul Malvino and Goutam Saha, Pearson Education, Tata Mc-Graw Hill.

Phys.223 Mathematical and Computational Physics 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to:

- impart knowledge about various mathematical tools employed to study physics problems.
- develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics.
- The course will also expose students to fundamental computational physics skills enabling them to solve a wide range of physics problems.
- The skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

LEARNING OUTCOMES:

Upon completion of the course, the student should be able to:

- Solve differential equation of various types arising in physics and mathematics.
- Develop techniques to solve complicated equations using the series solution method.
- Understand the importance of Fourier spaces and analyse functions accordingly.
- Solve equations of mathematical physics in various coordinate systems.
- basic numerical techniques to solve ordinary and partial differential equations appearing in some situations in physics.
- Monte-Carlo techniques and its applications in solving integral equations.
- Pseudo-Random number generation and its application in quantum mechanical problems.
- Spectral decomposition techniques and Fourier transforms

THEORY (45 Hours)

UNIT 1 **(15 Hours)**

Fourier Intergals: Fourier expansion of functionsFourier Series: Periodic functions.Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only).Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients.Complex representationof Fourier series.Expansion of functions with arbitrary period.Expansion of non-periodic functions over an interval.Even and odd functions and their Fourierexpansions.Application.Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.
Laplace integrals: Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

UNIT 2 **(15 Hours)**

Frobenius Method and Special Functions:Singular Points of Second Order Linear Differential Equations and their importance.Frobenius method and its applications to differential equations.Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations.Expansion of function in a series of Legendre Polynomials.
Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions and Orthogonality.
Partial Differential Equations:Solutions to partial differential equations, usingseparation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution forvibrational modes of a stretched string, rectangular and circular membranes
Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals. Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem.

UNIT 3 **(15 Hours)**

Regression: Algorithm for Least square fitting of a straight line, Fitting a Power function,and Exponential Function using conversion to linear relation by transforming the variables.Solution of Ordinary Differential Equations: First Order ODE's: solution of Initial Valueproblems: (1) Euler's Method and (2) Runge Kutta methods
Random Processes and Monte-Carlo Methods: Random number generation-uniform and non-uniform distributions;Monte Carlo Integration- Hit and miss, Sample mean integration, Metropolis Method;Computer "Experiments" - applications of Monte-Carlo methods toproblems in physics;Variational Monte-Carlo tecnique: Application to solving for the ground state of quantum mechanical systems in 1D and 2D
Fast Fourier Transforms and Spectral Methods:Discrete Fourier Transform,Fast Fourier Transform,SandeTukey Algorithm, Pseudospectral technique to solve the Schroedinger equation

***Tutorial(15 Hours) one hour per week**

SUGGUESTED READINGS:

1. G. Arfken: Mathematical Methods for Physicist 4th edition (Academic Press).
2. J. Mathews and R. L. Walker: Mathematical Methods of Physics (I. B. House Pvt.Ltd.).
3. C. Harper: Introduction to Mathematical Physics (Prentice Hall of India).
4. A. W. Joshi: Vectors & Tensors (Wiley Eastern Limited).
5. A. W. Joshi: Elements of Group Theory (Wiley Eastern).
6. Riley, Hobson & Bence: Mathematical Methods for Physics and Engineering (Cambridge University Press)
7. Introduction to Numerical Analysis, S. S. Sastry, 5th Edition, PHI Learning Pvt. Ltd, 2012
8. Computational Physics, Darren Walker, 1st Edition, Scientific International Pvt. Ltd, 2015
9. Applied numerical analysis, Cutis F. Gerald and P. O. Wheatley, Pearson Education, 2007
10. An Introduction to Computational Physics, T. Pang, Cambridge University Press, 2010
11. Numerical Recipes: The art of scientific computing, William H. Press, Saul A. Teukolsky and William Vetterling, Cambridge University Press, 3rd Edition, 2007
12. Computational Problems for Physics, R. H. Landau and M. J. Páez, CRC Press, 2018

Phys.322 **Electronics- II** **3+1**

LEARNING OBJECTIVES:

The primary objective of this course is to:

- acquire the basic knowledge of digital logic levels and application of knowledge to understand digital electronics circuits
- To prepare students to perform the analysis and design of various digital electronic circuits.
- teach how to design simple combinational logics using basic gates and to optimize Boolean logic using Karnaugh maps.
- introduce the basic sequential logic components: SR Latch, D Flip-Flop and their usage and make the students able to analyze sequential logic circuits.
- This course contents covers Basics of Analog and Digital Electronics are envisioned to be introduced with emphasis on applications of operational amplifier, 555 timer oscillators

LEARNING OUTCOMES:

Upon completion of the course, the student should be able to:

- Have a thorough understanding of the fundamental concepts and techniques used in digital electronics.
- understand and examine the structure of various number systems and its application in digital design.
- The ability to understand, analyze and design various combinational and sequential circuits.
- learn basic sequential logic components such as SR Latch, D Flip-Flop, JK Flip-Flop and their usage.
- identify and prevent various hazards and timing problems in a digital design.
- develop skill to build, and troubleshoot digital circuits.
- Students will learn the fundamentals of operation amplifier and their regular application including those used to sum, subtract and compare two or more signals.
- They will gain an in-depth understanding of working of Cathode Ray Oscilloscope which effectively acts as an electronic stethoscope for analysis of electronic signal in any laboratory.
- This paper will essentially connect the text book knowledge with the most common electronic components available that influence design of technology in a real world.
- The practical section is envisaged to impart much needed hands-on skill sets to the student. Therein he/she gets an experience in correctly choosing components required to build an electronic circuit, identifying the procurement source (online/offline) besides gaining valuable experience in trouble-shooting

THEORY (45 Hours)

UNIT1 **(15 Hours)**

Sequential Logic: Flip-Flop: Al-Bit memory-The RS Flip-Flop, JK- Flip-Flop, JK-master slave-Flip-Flop, T Flip-Flop, D- Flip-Flop-Shift Registers, Synchronous and Asynchronous Counter, Cascade Counters, A/D and D/A Converters.
Microprocessors: Introduction to microcomputers – input/output- interfacing devices 8085 CPU – Architecture- BUS timings- Demultiplexing the address bus generating control signals-Instruction Set – Addressing Modes- Illustrative Programmes – Writing Assembly Language Programmes, Looping, Counting and Indexing – Counters and Timing Delays- Stack and Subroutine.

UNIT2 **(15 Hours)**

Operational amplifiers: Differential amplifiers-circuit configuration-Dual Input, Balanced Output, Differential Amplifier-DC analysis-AC analysis, Inverting and Non- Inverting Inputs, CMRR-constant current bias level translator. Block diagram of typical Op-ampanalysis, Open loop configuration, Inverting and Non-Inverting Amplifiers, Op-Amp with negative feedback-voltage series feedback –effect of feedback on closed loop gain, Input Resistance, Output Resistance Bandwidth and Output Offset Voltage, Voltage Follower, Practical Op-Amp Input Offset voltage-Input Bias Current-Input Offset current, Total Output Offset Voltage, CMRR frequency response, DC and AC Amplifiers, Summing, Scaling and Averaging Amplifiers, Instrumentation Amplifiers, Integrator and Differentiator

UNIT3 (15 Hours)

Microwave Devices: Klystron amplifiers, Velocity Modulation, Basic principle of two Cavity Klystron, Reflex klystron, Traveling Wave Tubes (TWT), Transferred Electron Devices (Gunn Diode), Tunnel Diode, IMPATT Diode, TRAPATT Diode.

Microwave Communications: Advantages and Disadvantages of Microwave Transmission, Loss in free space, Propagation of microwaves, Atmospheric effects on propagation, Fresnel zone problem, Ground reflection, Fading sources, Detectors, Components, Antennas used in MW Communication Systems.

Instrumentations: Introduction to CRO:Block DiagramofCRO.Applications of CRO: (1)StudyofWaveform,(2)MeasurementofVoltage,Current,Frequency,andPhaseDifference.TimerIC :IC555PindiagramanditsapplicationasAstable&MonostableMultivibrator.

PRACTICAL (30 Hours)

1. Design Astable, Mono-stable and Bi-stable Multivibrator using IC 555
2. Study the Frequency Response of Op Amp in Inverting and Non Inverting configurations.
3. Study of zero crossing detector using Op amp IC 741
4. Addition of two dc voltages using OP Amp in inverting and non-inverting configurations.
5. Study of CRO.
6. Design of a Regulated Power Supply
7. Design of a Common Emitter Transistor Amplifier
8. Experiment on Bias Stability
9. Negative Feedback (Voltage series/shut and current series/shunt)
10. Op-Amp characteristics: Vio, Ib, Vol, CMRR, Slew Rate.
11. Realization of universal logic gates.
12. Implementation of the given Boolean function using logic gates in both SOP and POS form.
13. Perform the logic state tables of RS and JK flip-flops using NAND & NORgates.
14. Perform the logics gate tables of T and D flip-flops using NAND& NOR gates.
15. Perform the Verification of logic state tables of master slave flip flop using NAND & NOR gates.
16. Triggering mechanism of flip flop.
17. Perform the Realization of Half adder and full adder.
18. Perform the Half subtractor and full subtractor.
19. Decoders and code converters.
20. Up/Down Counters.
21. Shift Resistor.

SUGGUESTED READINGS:

1. Digital Principle and Application by, A. P. Malvino and Donald P. Leach, TMH, New
2. Delhi 1993.
3. Electronic communication system by G. Kennedy and B. Davis, TMH, New Delhi 1993.
4. Semiconductor Devices by S. M. Sze JWS,1995
5. Op-amp and Linear Integrated Circuit by Ramakanth A. Gayakwad,sss PHI, second

6. edition, 1991.
7. Microprocessor Architecture, programming and Applications with 8085/8086 by
8. Ramesh S. Gaonkar, Wiley – Eastern Let. 1987 (for unit v)
9. Microwaves by K.L. Gupta, Wiley Eastern Ltd. New Delhi, 1983.

Phys.323 Astronomy and Astrophysics 3+1

LEARNING OBJECTIVES:

The primary aim of this course is to:

- provide a pedagogical introduction to astronomy and astrophysics both on the galactic and extragalactic scale at the graduation level along with the brief introduction to astronomical techniques.
- provide hands-on experience of the astronomy lab.

LEARNING OUTCOMES:

After completing the course satisfactorily, a student will be able:

- To understand the technique in observational astronomy
- To understand the distance ladder in the context of the size of the Universe
- Sun and stellar synthesis. Interstellar medium
- Galaxies and their morphology
- Smooth and clumpy universe. The basic mathematical machinery of the background Universe.
- To understand the technique used to analyze the astronomy data
- To analyze the data from the astronomy archive
- To get familiar with the night sky
- To learn to use the astronomical software in the various electromagnetic bands.

THEORY (45 Hours)

UNIT 1 **(15 Hours)**

Astronomical Scales: Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.
Astronomical techniques: Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes).
Physical principles: Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium.

UNIT 2 **(15 Hours)**

The sun (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology).

The solar family (Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets.
Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification)
Cosmology and Astrobiology: Standard Candles (Cepheids and SNe Type1a), Cosmic distance ladder, Olber's paradox, Hubble's expansion, History of the Universe, Chemistry of life, Origin of life, Chances of life in the solar system

UNIT3 **(15 Hours)**

The milky way: Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.
Galaxies: Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms.
Active galaxies: 'Activities' of Active Galaxies, How 'Active' are the Active Galaxies? Classification of the Active Galaxies,
Large scale structure & expanding universe: Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance-Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).
Astronomy in India: Astronomy in ancient, medieval and early telescopic era of India, current Indian observatories (Hanle-Indian Astronomical Observatory, Devasthal Observatory, Vainu Bappu Observatory, Mount Abu Infrared Observatory, Gauribidanur Radio Observatory, Giant Metre-wave Radio Telescope, Udaipur Solar Observatory, LIGO -India) (qualitative discussion), Indian astronomy missions (Astrosat, Aditya)

PRACTICALS(30 Hours)

List of Experiments

1. To become familiar with the astronomical objects visible to naked eye in the night sky using the software Stellarium. Go For The Experiment...
2. To become familiar with the Constellations in the night sky using the software Stellarium. Go For The Experiment...
3. To identify the retrograde motion of Mars with respect to the Background stars. Go For The Experiment...
4. To identify some of the prominent spectral lines in the spectrum of our sun. Go For The Experiment...
5. To get familiar with the spectra of different stars. Go For The Experiment...
6. To extract coordinates of a star assuming a telescope in equatorial mount. You will also learn the concept of sidereal time. Go For The Experiment...
7. To measure astronomical distances using Cepheid variables. Go For The Experiment...
8. To measure the Proper Motion of Barnard's Star. Go For The Experiment...
9. To identify a Circumpolar Star. Go For The Experiment...
10. To determine the distance and age of cluster using Colour Magnitude Diagram. Go For The Experiment...
11. To determine Orbital Inclination of the planet Mars. Go For The Experiment...
12. To measure planetary distances Go For The Experiment...
13. To measure distance to the Moon Go For The Experiment...
14. To determine observer's location by means of the stars Go For The Experiment...

SUGGUESTED READINGS:

1. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
2. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
3. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
4. K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, New Delhi,2002.
5. BaidyanathBasu, 'An introduction to Astrophysics', Second printing, Prentice - Hall of India Private Limited, New Delhi, 2001.
6. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
7. The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
8. Theoretical Astrophysics Volume I, II, III : Astrophysical Processes Padmanabhan, T. Published by Cambridge University Press..
9. Introduction to cosmology, by Jayant V. Narlikar Published by Cambridge University Press.
10. Structure formation of the Universe, by T. Padmanabhan Published by Cambridge University Press.
11. Manual in lab Virtual Astronomy/Astrophysics Laboratory https://vaiitk.vlabs.ac.in/?page=listexp

HIGHER LEVEL DISCIPLINE SPECIFIC COURSES:

Phys.411 Classical Mechanics 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:

- revise Newtonian mechanics and introduce Lagrangian formulation of mechanics.
- emphasis the understanding of Classical Mechanics using Lagrangian and Hamiltonian Approach.
- realize the reduction of a two-body problem to a one-body problem in a central force system.
- appreciate the theory of relativity for particles having relativistic speeds.

LEARNING OUTCOMES:

After completion of course, students will able to

- Understand the limitations of Newtonian mechanics in modern branches of Physics such quantum mechanics, statistical physics, electrodynamics etc.
- Realize significance of Lagrangian and Hamiltonian formulations in macroscopic (classical) and microscopic physics.
- Use Lagrangian and Hamiltonian formulations in solving mechanics problems such as central force problem, Kinematics and Dynamics of Rigid bodies etc.
- Realize the significance of advanced formulations of mechanics such as Hamilton- Jacobi theory in handling periodic motion problems.
- Understand the role of canonical transformation in describing the motion of a system and symmetry properties.

- Use Lagrangian and Hamiltonian formulations to describe continuous systems so as to understand basic concept of Classical Field Theory.
- Apply theory of relativity to determine time dilation, length contraction and simultaneity.

THEORY (45 Hours)

UNIT I **(15 Hours)**

Variational Principles and Lagrangian Formulation of Mechanics: D'Alembert's Principle and Lagrange's equations. Constraints and generalized coordinates. Calculus of variations, Hamilton's principle and derivation of Lagrange's equation from it. Extension to non-holonomic and non-conservative systems. Symmetry properties of space and time and the corresponding theorems (with reference to cyclic coordinates). Simple applications of Lagrangian formulation for a single particle and a systems of particles. Lagrangian formulation of relativistic mechanics.
Central Force Problem: Equations of motion and first integrals. Equivalent one dimensional problem andclassification of orbits. The virial theorem. Differential equation for a orbit with a generalpower law potential. Applications: Kepler problem; scattering in c. m. and lab-coordinates.

UNIT 2 **(15 Hours)**

Kinematics and Dynamics of Rigid Bodies: Generalized coordinates of a rigid body, orthogonal transformations and the transformationmatrix. The Euler's angles and Euler's theorem on motion of rigid bodies, infinitesimalrotations, motion in a rotating frame of reference, Coriolis force on (i) air flow on thesurface of earth (ii) projectile motion (iii)atomic nuclei. Angular momentum and Kinetic energy of motion about a point. Moment of inertia tensor, the principle axis transformation. Euler's equation of motion.
Applications: Torque free motion of a rigid body. Heavy symmetric top with one pointfixed.
Hamilton-Jacobi Theory: The Hamilton-Jacobi equation for (i) Hamilton's principle function, and (ii) Characteristicsfunction. Separation of variables in Hamilton- Jacobi equation. Action angle variables.
Applications: Harmonic oscillator with Hamilton-Jacobi and action angle variable methods.
Kepler's problem with action angle variable method.

UNIT 3 **(15 Hours)**

Hamiltonian Formulation of Mechanics: Legendre's transformations and Hamilton's equations of motion. Derivation of Hamilton's equations from variational principle. The principle of least action. Canonical transformations; Poisson's and Lagrangian brackets, their invariance under a canonical
transformation, equations of motion in the Poisson's bracket notation; infinitesimalcanonical transformations, constants of motion and symmetry properties.
Applications: Hamiltonian formulation of (i) harmonic oscillator and (ii) relativisticmechanics. Examples of canonical transformations, with reference to harmonic oscillator. Example of Poisson bracket, (i) harmonic oscillator; (ii) angular momentum. Lagrangian and Hamiltonian Formulations for continuous systems and fields:Transition from discrete to continuous system, Lagrangian formulation for continuous systems stress- energy tensor and conservation theorems. Hamiltonian formulation otherstheorems

***Tutorial(15 Hours) one hour per week**

SUGGESTED READINGS:

1. H. Goldstein, Classical Mechanics 2nd ed. (Indian Student Edition, Addison-Wesley/ Narosa).

2. J. B. Marion, Classical Mechanics (Academic Press).

3. L. D. Landau and E. M. Lifshitz, Mechanics 3rd ed. (Pergamon).
4. R. G. Takwale& P. S. Puranik, Introduction to Classical Mechanics (Tata McGraw –Hill)
5. Kiran C. Gupta, Classical Mechanics of Particles and Rigid Bodies (Wiley Eastern).
6. N. C. Rana and P. S. Joag, Classical mechanics (TMH).

Phys.412 Quantum Mechanics 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:

- make students aware about the basic formulations in quantum mechanics.
- There are many different types of representations of state and operators that are very useful in studying the subject deeply.
- The course takes up the responsibility to give information about hermitian operators, their eigenvalues and eigenvectors. It teaches about various commutation and uncertainty relations.
- Students will be given knowledge about unitary transformations, dirac delta function, matrix representation of operators and their applications.
- Main focus is on angular momentum operator and their representation in spherical coordinates. Addition of angular momenta is also taught.
- Students will be given insight to solve Schrodinger wave equation in three dimensions.
- Basic idea of time independent perturbation theory is provided.

LEARNING OUTCOMES:

After completion of course, students will able to

- Learn the basic concepts of matrix algebra in quantum mechanics.
- Understand Hilbert space, concepts of basis and operators, Dirac, bra and ket notations.
- Understand the theory of orbital and spin angular momentum, tensor operators, CG

7. coefficients and Wigner Eckart theorem.

- To understand time independent and dependent perturbation theory.
- To apply time independent and dependent perturbation theory to non-degenrate and

8. degenerate systems.

- Make use of variation principle to ground state of helium atom.

THEORY (45 Hours)

UNIT 1 (15 Hours)

Matrix formulation of Quantum Mechanics:Matrix Algebra: Matrix addition and multiplication, Null unit and Constant Matrices, Trace,Determinant and Inverse of a Matrix, Hermitian and unitary Matrices, Transformation anddiagonalization of Matrices, Function of Matrices and matrices of infinite rank. Vectorrepresentation of states, transformation of Hamiltonian with unitary matrix, representation of anoperator, Hilbert space. Dirac bra and ket notation, projection operators, Schrodinger, Heisenberg and interaction pictures. Relationship between Poisson brackets and commutationrelations. Matrix theory of Harmonic oscillator.

UNIT 2 (15 Hours)

Symmetry in Quantum Mechanics:Unitary operators for space and time translations. Symmetry and degeneracy. Rotation andangular momentum; Commutation relations, eigenvalue spectrum, angular momentum matricesof J +, J-, Jz, J2. Concept of spin, Pauli spin matrices. Addition of angular momenta, Clebsch-Gordon coefficients and their properties, recurssion relations. Matrix elements for rotated state,irreducible tensor operator, Wigner-Eckart theorem. Rotation matrices

and group aspects. Spaceinversion and time reversal: parity operator and anti-linear operator. Dynamical symmetry ofharmonic oscillator.
Applications: non-relativistic Hamiltonian for an electron with spin included. C. G. coefficients of addition for j =1/2, 1/2; 1/2, 1; 1, 1.

UNIT 3 (15 Hours)

Approximation Methods for Bound State:Time independent perturbation theory for non-degenerate and degenerate systems upto secondorder perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogenatom, Zeeman effect without electron spin. Variation principle, application to ground state ofhelium atom, electron interaction energy and extension of variational principle to excited states.WKB approximation: energy levels of a potential well, quantization rules. Time-dependentperturbation theory; transition probability (Fermi Golden Rule), application to constantperturbation and harmonic perturbation. Semi-classical treatment of radiation. Einsteincoefficients; radiative transitions.

***Tutorial(15 Hours) one hour per week**

SUGGESTED READINGS:

1. H. Goldstein, Classical Mechanics 2nd ed. (Indian Student Edition, Addison-Wesley/ Narosa).

2. J. B. Marion, Classical Mechanics (Academic Press).
3. L. D. Landau and E. M. Lifshitz, Mechanics 3rd ed. (Pergamon).

Phys.413 Statistical Physics 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:

- provides an introduction to the microscopic formulation of thermal physics, generally known as statistical mechanics.
- We explore the general principles, from which emerge an understanding of the microscopic significance of entropy and temperature.
- We develop the machinery needed to form a practical tool linking microscopic models of many-particle systems with measurable quantities.
- We consider a range of applications to simple models of crystalline solids, classical gases, quantum gases and blackbody radiation.

LEARNING OUTCOMES:

After completion of course, students will able to

- Explain the fundamental principles of statistical physics.
- Have vast knowledge of thermodynamic quantities.
- Build knowledge of Gibb’s distribution and Maxwell distribution.
- Utilize Gibb’s distribution for derivation of thermodynamics relations.
- Grasp the knowledge ideal gases and non-ideal gases and related phenomena and theories.
- Build the knowledge of quantum statistical distribution laws: Bose-Einstein and Fermi-Dirac and study examples of these distributions.
- Explain and apply the Phenomenon in very high density systems

THEORY (45 Hours)

UNIT 1 **(15 Hours)**

The Fundamental Principles of Statistical Physics: Statistical Distributions, Statistical independence, Loiuville's theorem, The significance of energy, The statistical matrix,Statistical distribution in quantum statistics , entropy, the law of increase of entropy.Thermodynamic Quantities: Temperature, Macroscopic motion, Adiabatic processes,Pressure, Work and quantity of heat, The heat function, The free energy and thethermodynamic potential , Relations between the derivatives of thermodynamic quantities,The thermodynamic scale of temperature, The joule-Thomason process, Maximum work,Maximum work done by a body in an external medium, thermodynamic inequalities, Le Chatelier's principle, Nernst's theorem, The dependence of the thermodynamic quantitieson the number of particles, Equilibrium of a body in an external field, Rotating bodies,Thermodynamic relation in the relativistic region.

UNIT 2 **(15 Hours)**

The GIBBS Distribution: The Gibbs Distribution, The Maxwellian Distribution, The probability distribution for an oscillator, The free energy in the Gibbs distribution, Thermodynamic perturbation theory, Expansion in powers of h , the Gibbs distribution forrotating bodies, the Gibbs distribution for a variable number of particles, The derivation ofthe thermodynamic relations from the Gibbs distribution.

Ideal Gases: The Boltzmann distribution, The Boltzmann distribution in classicalstatistics, Molecular collisions, Ideal gases not in equilibrium, the free energy of an idealBoltzmann gas, The equation of state of an ideal gas, Ideal gases with constant specificheat, The law of equipartition, Monatomic ideal gases, The effect of the electronic angularmomentum.

Non- ideal Gases: Deviations of gases from the ideal state, Expansion in powers ofthe density, Van der Waals formula, relationship of the virial coefficient and the scatteringamplitude, Thermodynamic quantities for a classical plasma, The method of correlationfunctions, Thermodynamic quantities for a degenerate plasma. The method of correlationfunction, thermodynamic quantities of a degenerate plasma.

UNIT 3 **(15 Hours)**

Approximation Methods for Bound State: Time independent perturbation theory for non-degenerate and degenerate systems upto second order perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogenatom, Zeeman effect without electron spin. Variation principle, application to ground state ofhelium atom, electron interaction energy and extension of variational principle to excited states.WKB approximation: energy levels of a potential well, quantization rules. Time-dependentperturbation theory; transition probability (Fermi Golden Rule), application to constantperturbation and harmonic perturbation. Semi-classical treatment of radiation. Einstein
coefficients; radiative transitions.

***Tutorial(15 Hours) one hour per week**

SUGGESTED READINGS:

1. L. D. Landau and I. M. Lifshitz: Statistical Physics Third Edition (Part – I)(Pergamon).
2. R. K. Pathria, Statistical Physics (Pergamon).
3. David Chandler: Introduction to Modern Statistical Mechanics (Oxford UniversityPress).
4. R. P. Feynmann: Statistical Mechanics (Addison Wesley).
5. F. Mandl, Statistical Physics (Wiley).
6. C. Kitlle, Elementary Statistical Physics (John Willey & Sons)

Phys.421 Condensed Matter Physics-II 3+1

LEARNING OBJECTIVES:

The primary aim of this course is to:

- This course is designed to teach students the relation between the structure and properties of exhibited by the crystalline solids.
- The details of band theory and effect of periodic potential on energy dispersions of electron. Role of lattice dynamics in thermal properties of solids.
- This course also aim to introduce the students to various typesof properties of materials such as dielectrics, magnetic and superconducting properties.

LEARNING OUTCOMES:

After reading this course, the students will be able to:

- understand how the energy dispersions of the electron are affected when large number of atoms come together to form crystalline materials.
- What is the impact of periodic potential on electronic energy states in a crystal?
- What causes the magnetism in any material and how one can explain various type of magnetic behaviours exhibited different materials.
- The students will also be able to understand the dielectric and superconducting materials and underlying mechanisms to explain their properties.
- Pursue the research work in the field of material science and nanotechnology.

THEORY (45 Hours)

UNIT 1 (10 Hours)

Structure of solids: Bravais lattice, primitive vectors, primitive unit cell, conventional unit cell, Wigner-Seitz cell; Symmetry operations and classification of 2- and 3-dimensional Bravais lattices; point group and space group (information only); Common crystal structures: NaCl and CsCl structure, close-packed structure, Zinc blende and Wurtzite structure, tetrahedral and octahedral interstitial sites, Spinel structure; Intensity of scattered X-ray, Friedel's law, Anomalous scattering; Atomic and geometric structure factors; systematic absences; Reciprocal lattice and Brillouin zone; Ewald construction; Explanation of experimental methods on the basis of Ewald construction; Electron and neutron scattering by crystals (qualitative discussion); Surface crystallography; Graphene; Real space analysis — HRTEM, STM, FIM. Non crystalline solids-Monatomic amorphous materials; Radial distribution function; Structureof vitreous silica.

UNIT 2 (5 Hours)

Band theory of solids: Bloch equation; Empty lattice band; Number of states in a band; Effective mass of an electron in a band: concept of holes; Classification of metal, semiconductor and insulator; Electronic band structures in solids - Nearly free electron bands; Tight binding method - application to a simple cubic lattice; Band structures in copper, GaAs and silicon; Topology of Fermi-surface; Quantization of orbits in a magnetic field, cyclotron resonance — de Haas-van Alphen effect; Boltzmann transport equation - relaxation time approximation, Sommerfeld theory of electrical conductivity.

UNIT 3 (5 Hours)

Lattice dynamics and Specific heat, Classical theory of lattice vibration under harmonic approximation; Dispersion relations of one dimension lattices: monatomic and diatomic cases, Characteristics of different modes, long wavelength limit, Optical properties of ionic crystal in the infrared region; Inelastic scattering of neutron by phonon; Lattice heat capacity, models of Debye and Einstein, comparison with electronic heat capacity; Anharmonic effects in crystals - thermal expansion.

UNIT 4 **(5 Hours)**

Dielectric properties of solids Electronic, ionic, and orientational polarization; static dielectric constant of gases and solids; Complex dielectric constant and dielectric losses, relaxation time, Debye equations; Cases of distribution of relaxation time, Cole - Cole distribution parameter, Dielectric modulus; Ferroelectricity, displacive phase transition, Landau Theory of Phase Transition.

UNIT 5 **(8 Hours)**

Magnetic properties of solids, Origin of magnetism; Diamagnetism: quantum theory of atomic diamagnetism; Landau diamagnetism (qualitative discussion); Paramagnetism: classical and quantum theory of paramagnetism; case of rareearth and iron-group ions; quenching of orbital angular momentum; Van-Vleck paramagnetism and Pauli paramagnetism; Ferromagnetism: Curie-Weiss law, temperature dependence of saturated magnetisation, Heisenberg's exchange interaction, Ferromagnetic domains - calculation of wall thickness and energy; Ferrimagnetism and antiferromagnetism.
Magnetic resonances:Nuclear magnetic resonances, paramagnetic resonance, Bloch equation, longitudinal and transverse relaxation time; spin echo; motional narrowing in line width; absorption and dispersion; Hyperfine field; Electron-spin resonance.

UNIT 6 **(5 Hours)**

Imperfections in solids: Frenkel and Schottky defects, defects by non stoichiometry; electrical conductivity of ionic crystals; classifications of dislocations; role of dislocations in plastic deformation and crystal growth; Colour centers and photoconductivity; Luminescence and phosphors; Alloys, Hume-Rothery rules; electron compounds; Bragg - Williams theory, order-disorder phenomena, superstructure lines; Extra specific heat in alloys.

UNIT 7 **(7 Hours)**

Superconductivity: Phenomenological description of superconductivity - occurrence of superconductivity, destruction of superconductivity by magnetic field, Meissner effect; Type-I and type-II superconductors; Heat capacity, energy gap and isotope effect; Outlines of the BCS theory; Giaver tunnelling; Flux quantisation; a.c. and d.c. Josephson effect; Vortex state (qualitative discussions); High Tc superconductors (information only).

PRACTICAL (30 Hours)

1. Measurement of lattice parameters and indexing of powder photographs.
2. Interpretation of transmission laue photographs.
3. Determination of orientation of a crystal by back reflection Laue method.
4. Rotation/oscillation photographs and their interpretation.
5. To study the modulus of rigidity and internal friction in metals as a function of temperature.

7. To measure the cleavage step height of crystal by Multiple Fizeaue fringes.
8. To obtain Multiple beam Fringes of Equal Chromatic order.
6. To determine crystal step height and study birefringence.
7. To determine magnetoresistance of a Bismuth crystal as a function of magnetic field.
8. To study hysteresis in the electrical Polarization of a TGS crystal and measure the Curie Temperature.

SUGGUESTED READINGS:

1. Solid State Physics by Neil W. Ashcroft and N. David Mermin
2. Introduction to Solid State Physics by C. Kittle
3. Introduction to Solids by Azaroff
4. Crystallography Applied to Solid State Physics by A. R. Verma and O. N. Srivastava
5. Principles of Condensed Mater Physics by P. M. Chaikin and C. Lubensky
6. Solid State Physics: A. J. Dekker

Phys.422 Electrodynamics 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Maxwell's theory of electromagnetic phenomenon is a basic component of all modern courses of theoretical physics and all students of physics must have a thorough knowledge of its principles and working.
- The basic ingredient of this theory is the concept of a field and the equations which govern the space and time evolution of these fields.
- These fields are called electromagnetic fields and the equations are known as the Maxwell equations.
- Moreover, these fields show a wave behaviour and are termed as electromagnetic waves. Visible light is an example of electromagnetic wave.
- In this course, we shall learn about the working and applications of the Maxwell equations and how it is consistent with the theory of relativity.
- One of the objectives of this course is to introduce students with the formulation of four vectors. They are to be introduced by the Lorentz transformations and the invariance of various quantities in four dimensions.
- Main aim is to feed student's mind by fields and radiations from various types of dipoles and localized sources. They will be taught to calculate power radiated in each case.
- Students will be introduced by the formation and characteristics of ionosphere and how waves propagate through it.
- The objective is to introduce them about wave guides and their applications.
- They will be taught about the transmission lines and propagation of waves through them.

LEARNING OUTCOMES:

After successful completion of this course, students shall be able to:

- Evaluate the electrostatic fields and potential in free space and in a dielectric media.
- Evaluate configuration energy of an electrostatic system.
- Understand the production of magnetic field due to steady current and calculate magnetic fields using Boit Savart and Amperes law.
- Understand the Maxwell's equation of electrodynamics and its applications to propagation of electromagnetic waves.
- Understand the concept of wave guide and basic concept of plasma and confinement.

THEORY (45 Hours)

UNIT 1 (15 Hours)

Electrodynamics: Ohm's Law, Electromotive force, motional emf, Electromagnetic Induction: Faraday's Law, The induces Electric field, Inductance, energy in Magnetic Fields
Maxwell's theory and conservation laws

Electrodynamics befor Maxwell, Maxwell's equations, magnetic charge, magnetic equation in matter, boundary conditions, Charge, energy and momentum conservation: The continuity equation, Poynting's theorem, Newton's Third law in Electrodynamics, Maxwell's stress tensor, conservation of momentum, angular momentum
Electromagnetic waves
Waves in one dimension: The wave equation, Sinusoidal waves. Boundary Conditions: Reflection and Transmission, Polarization. Electromagnetic waves in Vacuum: The wave equation in E and B, Monochromatic plane waves, Energy and momentum in Electromagnetic waves. Electromagnetic waves in Matter: propagation in liner media, reflections and transmissions at: normal incidence and oblique incidence. Absorption and Dispersion: Electromagnetic waves in conductors, reflection at a conducting surface, the frequency dependence of permittivity. Guided Waves: wave guides, the waves in a rectangular wave guide, the coaxial transmission line

UNIT 2 (15 Hours)

Potentials and fields: The potential formulations, scalar and vector potentials, Gauge Transformations, Coulomb Gauge and Lorentz Gauge
Radiation from time-dependent sources of charges and currents: Inhomogeneous wave equations and their solutions; Radiation from localised sources and multipole expansion in the radiation zone.
Radiation from moving point charges
Lienard- Wiechert potentials; Fields due to a charge moving with uniform velocity; Fields due to an accelerated charge; Radiation at low velocity; Larmor's formula and its relativistic generalisation; Radiation when velocity (relativistic) and acceleration are parallel, Bremsstrahlung; Radiation when velocity and acceleration are perpendicular, Synchrotron radiation; Cherenkov radiation; Radiation reaction, Problem with Abraham-Lorentz formula, Limitations of classical theory.

UNIT 3 (15 Hours)

Relativistic formulation of electrodynamics: Introduction to special relativity: Postulates of Einstein, Geometry of relativity, Lorentz transformations. Relativistic mechanics: Proper time, proper velocity, Kinematics and dynamics. Four vector notation, Electromagnetic field tensor, covariance of Maxwell's equations.
Quantum electrodynamics: Classical electromagnetic fields and quantization problems, Modified Lagrangian, propagator, Fourier decomposition, Feynman rules for photons, Local Gauge invariance and it's consequences: SU(1), SU(2) and SU(3).

***Tutorial(15 Hours) one hour per week**

SUGGUESTED READINGS:

1. D. J. Griffiths: Introduction to electrodynamics, Prentice Hall.
2. W. Panofsky and M. Phillips: Classical electricity and magnetism, Addison Wesley.
3. J. Marion and M. Heald: Classical electromagnetic radiation, Saunders college publishing.
4. L. Landau and E. Lifshitz: Classical theory of fields, Pergamon Press.
5. J. Jackson: Classical electrodynamics, Wiley international.
6. M. Schwartz: Classical electromagnetic theory, Dover publication

Phys.423 Nuclear and Particle Physics-II 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:

- introduce students to the fundamental principles and concepts governing nuclear and particle physics
- observational aspects of nuclei, including their binding energy, size, spin and parity
- nuclear models: liquid drop and shell models
- the semi-empirical mass formula and deductions from it concerning nuclear stability
- The classification of fundamental particles and their interactions according to the Standard Model quark structure of mesons and baryons.
- To find out properties of the strong and weak interactions - scattering Theory
- The course is designed to prepare the students for their CSIR-UGC National Eligibility Test (NET) for Junior Research Fellowship and Lecturer-ship.

LEARNING OUTCOMES:

After successful completion of this course, students shall be able to:

- The students gather advanced knowledge in Nuclear physics. The different

9. nuclear interactions and the corresponding nuclear potentials and its dependence on the couplings are learned.

- The knowledge helps to choose for an Advance course in Nuclear and particle Physics.
- The students will be able to understand the structure of nuclei through nuclear models and nuclear reaction dynamics and its mechanism. Also, the students will:
- Demonstrate knowledge of fundamental aspects of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of radiation and matter.
- Discuss nuclear and radiation physics connection with other physics disciplines – solid state, elementary particle physics, radiochemistry, astronomy.
- Determine nuclear properties such as binding energy, spin and parity in the framework of the liquid drop model and the shell model of the nucleus.
- Use the liquid drop model and the law of radioactive decay to describe alpha-decay, beta-decay, fission and fusion, predict decay reactions and calculate the energy release in nuclear decays
- Explain the experimental evidence for quarks, gluons, quark confinement, asymptotic freedom, sea quarks, the running coupling constant and colour charge

THEORY (45 Hours)

UNIT 1 **(15 Hours)**

Nuclear shapes and sizes: matter and charge distribution Quantum properties: parity, spin and magnetic dipole moment Mass spectroscopy, binding energy, Fusion and fission Semi-empirical mass formula: the Liquid drop model. Nuclear size determination from electron scattering; nuclear form factor, Rutherford scattering.

Nuclear Interaction (Classification of fundamental forces, Nature of the nuclear forces, Qualitative aspects of nuclear force: Strength and range, Two-body bound state problem (deuteron), Nucleon-nucleon scattering at low energies, Saturation of nuclear forces and charge-independence and charge- symmetry, Nuclear reaction mechanisms, Compound nucleus reaction, Direct nuclear reactions and heavy ion reactions.

UNIT 2 **(15 Hours)**

Nuclear Structure:Evidence of shell structure, Single particle shell model its validity and limitations, Collective Model: rotational spectra.

Theory of α-decay and β-ray spectra, Fermi theory of β-decay and selection rules, conditions for spontaneous emission, continuous β-ray spectrum and neutrino hypothesis, Theory of γ-decays and selection rules.

Accelerators: Van de Graaff Generator, Linear Accelerator, Cyclotron, Betatron, and Light and Heavy Ion Synchro-Cyclotron. Idea of Large Hadron Collider

Detectors of Nuclear RadiationsInteraction of Energetic particles with matter. Ionization chamber. GM Counter. Cloud Chambers. Wilson Cloud Chamber. Bubble Chamber. Scintillatipn Detectors. Semiconductor Detectors (Qualitative Discussion Only). An Idea about Detectors used in Large Hadron Collider

UNIT 3 (15 Hours)

Introduction to the Elementary particles: Classification and properties of elementary particles and their interactions, quarks, leptons, Spin and parity assignments, iso-spin, strangeness, Gell-Mann-Nishijima formula, Quantum numbers and their conservation laws, Quark model, eightfold way. Elementary particles dynamics.

C, P, and T invariance and applications of symmetry arguments to particle reactions, parity non-conservation in weak interaction

Symmetry Groups-SU(2), SU(3), four forces, weak interactions, decay and conservation laws, unification scheme.

***Tutorial(15 Hours) one hour per week**

SUGGUESTED READINGS:

1. K.S. Krane: Introductory Nuclear Physics, John Wiley& Sons Ltd.
2. D. Griffiths: Introduction to Elementary particles, John Wiley & Sons, 1987.
3. B.R. Martin: Nuclear and Particle Physics, John Wiley & Sons Ltd.
4. H.A. Enge: Introduction to Nuclear Physics, Addison-Wesley (1971).
5. V.K. Mittel, R.C. Verma and S.C. Gupta: Nuclear & Particle Physics, PHD.
6. D.C. Tayal: Nuclear Physics, Himalaya Publishing House Pvt. Ltd (2008).
7. M.P. Khanna: Particle Physics, PHD.
8. Introduction to the physics of nuclei and particles by R.A. Dunlap.Singapore: Thomson Asia, 2004.
9. Nuclear physics by Irving Kaplan. Oxford & IBH, 1962.

HIGHER & APPLIED AREA MINOR COURSES:

Phys.414 Physics Lab Course 0+4

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Collect data and revise an experimental procedure iteratively and reflectively,
- Evaluate the process and outcomes of an experiment quantitatively and qualitatively,
- Extend the scope of an investigation whether or not results come out as expected,
- Communicate the process and outcomes of an experiment, and
- Conduct an experiment collaboratively and ethically.
- The course is designed to perform experiments and simulations to go hand in hand with the theory courses.

LEARNING OUTCOMES:

By the end of the three-course intro lab sequence, students should be able to:

10. Collect data and revise the experimental procedure iteratively, reflectively, andresponsively.
11. Evaluate the process and outcomes of an experiment quantitatively and qualitatively
12. Extend the scope of an investigation whether or not results come out as expected
13. Conduct an experiment collaboratively and ethically
14. Various experimental and computational tools thereby developing analytical abilities toaddress real world problems.
15. Seminars/presentations related to practical courses.

PRACTICALS(120 Hours)

UNIT 1 **(30 Hours)**

1. Ionization potential by Franck Hertz experiment.
2. Photoelectric effect.
3. Determination of Planck's constant.
4. Bandgap of a semiconductor by Four Probe method.
5. Wavelength measurement of laser using a diffraction grating.
6. Michelson interferometer.
7. Dual nature of electron experiment.
8. Millikan oil-drop experiment
9. Stefan's law.
10. Zeeman effect experiment.
11. Fabry- Perot Interferometer.
12. To measure the dislocation density of a crystal by etching.
13. Study of X-ray diffraction from liquid, amorphous materials.
14. Determination of dislocation density by Reflection X-ray topography.
15. To take Buerger Precession photograph of a crystal and index the reflections.
16. To measure the superconductivity transition temperature and transition width of high temperature superconductors.
17. To determine the optical constants of a metal by reflection of light.
18. Model evaluation of dispersion curves of one-dimensional lattice.

UNIT 2 **(50 Hours)**

1. Power supplies: Bridge rectifier switch capacitive input filters.
2. Power supplies: Shunt Voltage regulator using Zener diode.
3. Clipping and Clamping along with CRO.
4. Common Emitter Amplifier with and without feedback.
5. Determination of h-parameters in the CE configuration using the measured input and output characteristics of a BJT.
6. Common Source and Common Drain Amplifiers using JFET.
7. RC Oscillators:Phase shift oscillator using RC ladder network as the phase shifting network.
8. Wien's Bridge Oscillator.
9. Colpitts Oscillators.
10. Hartley Oscillators.
11. Emitter Coupled Differential Amplifier using BJT's.
12. Multivibrators–Bistable, Monostable and Free Running multivibrators
13. Pulse Amplitude Modulation/Demodulation
14. Pulse position/Pulse Width Modulation/Demodulation
15. FSK Modulation Demodulation using Timer/PLL
16. Microwave characterization and Measurement
17. PLL Circuits and applications

18. Fibre Optics communication
19. Design of Active filters
20. BCD to Seven Segment display
21. A/D and D/A conversion
22. Experiments using various types of memory elements
23. Addition, Subtraction, Multiplication & Division using 8085/8086
24. Wave form generation and storage oscilloscope
25. Frequency, Voltage, Temperature measurements
26. Motor Speed control., Temperature control using 8086.

UNIT 3 **(20 Hours)**

1. Study of the characteristics of a GM tube and determination of its operating voltage, plateau length/ slope etc.
2. Demonstration of nucleonic level gauge principle using G.M counting system and detector.
3. Verification of inverse square law for gamma rays
4. Study of elliptically polarized light.
5. Ultrasonic wave velocity in liquids by ultrasonic diffraction.

UNIT 4 **(20 Hours)**

Computer based experiments using BASIC/ FORTRAN/C/C++:

1. Statistical and error analysis of (a) given data (b) error estimation in computation.
2. (Roots of a quadratic/ cubic equation (b) summation of a series.
3. Numerical differentiation and integration of simple functions.
4. Operations on a matrix (a) inversion (b) diagonalisation (3x3 matrix) (c) solution of simultaneous equations.
5. Plotting and interpolation of a function.
6. Finding the value of Pi using monte carlo method
7. Assemble language programming on PC.
8. Experiments based on computer Aided Design.
9. Trouble shooting using signature analyzer.

SUGGUESTED READINGS:

1. Millman J, Halkias C and Parikh C. (2009). Integrated Electronics: Analog and Digital Circuits and Systems. Noida, India: Tata McGraw-Hill Education.
2. Boyle stad R. L & Nashelsky L. (2009). Electronic Devices and Circuit Theory. New Delhi: Pearson.
3. Theraja B. L. (2010). Basic Electronics: Solid State. New Delhi: S. Chand & Company Ltd.
4. Chattopadhyay D and Rakshit P. C. (2008). Electronics: Fundamentals and Applications. New Delhi, India: New Age International.
5. Saha G, Malvino A.P and Leach D.P. (2011). Digital Principles and Applications. Noida, India: Tata McGraw-Hill Education.
6. Malvino P and Brown J.A. (2011). Digital Computer Electronics Noida, India: Tata McGraw-Hill Education.
7. Hawkins Cand Segura J. (2010). Introduction to Modern Digital Electronics. New York, USA: SciTech Publishing
8. Serway R.A, Moses C.J& Moyer C.A. (2012). Modern physics. Massachusetts, USA: Brooks Cole.
9. Thornton S. T. (2012). A. Rex Modern Physics for Scientists and Engineers.

Phys.415 Material Physics 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:

- To get aware about the all types of materials.
- Classification of materials and to learn various synthesis and characterization technique. Disorder/imperfect materials and their types.
- Idea about thermal studies and phase diagram studies, solidification and various application to devices applications of materials.

LEARNING OUTCOMES:

After completion of course, students will able to:

- Will be able to classify different types materials.
- They will gain knowledge about crystal structures of different crystals.
- Will get knowledge about the preparation of materials and their method of characterization. They will also gain knowledge about the different analysis techniques.
- Will get an in depth knowledge about the various disorder in solids and how to detect them.
- Will get an understanding about Phase diagram and Phase transformations with different examples.
- Will understand about different material devices and their applications.
- Explaining Nuclear magnetic resonance and relaxation times. Analysis of Ferro and antiferromagnetic resonance.
- Definitions and Basic concepts of Phase Diagrams and Phase Transformation, criteria for solubility limit, comparing one-component phase diagrams, Binary phase diagrams: binary isomorphous systems, interpretation of phase diagrams
- Learning Binary eutectic systems and development of microstructure in eutectic alloys, ceramic and ternary phase diagram, the application of Gibbs phase rule Phase transformations: the kinetics of phase transformations, metastable versus equilibrium states, isothermal and continuous cooling transformation diagrams and tempered martensite transformations
- Principles of XPS and AES, Instrumentation, Routine limits of XPS, Applications of XPS & AES. Scanning Tunneling Microscopy: Working principle, Instrumentation Modes of operation Difference between STM and AFM
- X-ray Characteristics and Generation, lattice planes and Braggs law, Powder diffraction, Transmission Electron microscopy: Basic of TEM, Reciprocal Lattice, Specimen Preparation Bright Field and Dark Field Images Electron energy Loss Spectroscopy
- Scanning Electron Microscopy: Introduction,: IR spectroscopy, UV and visible spectroscopy. Mössbauer Spectroscopy Basic theory, experimental set up and Mössbauer parameters

THEORY(45 Hours)

UNIT 1 (10 Hours)

Classification of Materials: Crystalline and amorphous material, semiconductor, metals and alloys; glassy, composites and ceramic materials, polymers, gels & quasi crystals, Structure of Materials: Important crystal structure. NaCl (Rock salt) Wurtzite (ZnS), Fluorite, ($CaF2$) Rutile ($TiO2$).
Preparation of Materials by different techniques: Mechanisum of crystal growth form melt, growth from crucibles, melt spinning and quenching method,

Disorder in Solids: Solid solution –Hume-Rothery rules; substitutional & interstitial solid solution, Point defect, vacancy, interstitial Frenkel & Schottky defects. Line defect edge and screw dislocation, Burger's vector, planer defects (grain boundaries, high and low angle tilt boundaries twin boundaries). short range order, medium range order, long range order, and network modifier/former.

UNIT 2 (10 Hours)

Phase Diagrams and Phase Transformation: Definitions and Basic concepts: solubility limit, phase, microstructure, phase equilibria, one component
phase diagrams, Binary phase diagrams: binary isomorphous systems, interpretation of phase diagrams, development of microstructure in isomorphous alloys and their mechanical properties, binary eutectic systems and development of microstructure in eutectic alloys, equilibrium diagrams having intermediate phases, eutectoid and peritectic reactions, congruent phase transformations, ceramic and ternary phase diagram, the Gibbs phase rule, Phase transformations: basic concepts, the kinetics of phase transformations, metastable versus equilibrium states, isothermal and continuous cooling transformation diagrams and tempered martensite

UNIT 3 (20 Hours)

Materials Characterization Techniques: Principles of X-ray Photometery Spectroscope (XPS) and Anger electron Spectroscopy (AES) , Instrumentation, Routine limits of XPS, Applications of XPS & AES. Scanning Tunneling Microscopy (STM): Working principle, Instrumentation, Modes of operation Atomic Force Microscopy (AFM): Introduction, Working Principle Instrumentation Modes of operation Difference between STM and AFM
X-ray Characteristics and Generation, lattice planes and Braggs law, Powder diffraction, Transmission Electron Microscopy (TEM) : Basic of TEM, Reciprocal Lattice, Specimen Preparation Bright Field and Dark Field Images Electron energy Loss Spectroscopy. Scanning Electron Microscopy: Introduction,: Inferred (IR) spectroscopy, Ultraviolet (UV) and visible spectroscopy. Mössbauer Spectroscopy Basic theory, experimental set up and Mössbauer parameters. Differential scanning calorimetry (DSC), Thermogravimetric analysis (TGA).
Devices: Application to material Devices; Solid state electrochemical devices, Solid State Battery, Fuel cells, Solar cells.

***Tutorial(15 Hours) one hour per week**

SUGGUESTED READINGS:

1. Introduction to Condensed Matter Physics – K.C. Barua (Alpha Science International Ltd.)2006
2. A Basic Course in Crystallography – J.A.K. Tareen & Kutly.Hydrabad (Universities Press, India Pvt.)
3. Material Science and Engineering – A first course V. Raghavan (Prentice Hall, India Pvt.)
4. Introduction of Material Science for Engineers – James F. Shackelford – Macmillan Pub.2006
5. Crystallography Applied to Solid State Physics – A.R. Verma and O. N. Srivastava (New Age International Pub.)2005
6. Physical Properties of Materials – MC Lovell, A.J. Avery. M.W. Vernon (ELBS) Van Nostrad Reinhold UK. Co. Ltd.
7. Principles of Electronics Ceramics –L.L. Hench, and J.K. West. (John-Wiley & Sons) Ist. Editions.
8. Introduction to Ceramics – WD Kingery, HK Bowen, DR Uhlmann (University Press, Cambridge) IInd Edtions.
9. Solid State Physics – N.W. Ashcroft and N.D. Mermin, New York: Holt, Rinehart and Winston.

10. Solid State Physics Solid State Devices and Electronics – CM Kachhava. (New Age International Pub.)
11. Solid state chemistry: An introduction Leslay E smart & Elaine A Moore (Taylor & Francis)
12. Thin film by: K.L. Chopra.(Mc Graw Hill)
13. Material Science and Engineering An Introduction – W.D. Callister, David G. Rethwisch, John Wiley and Sons. 8th Ed.
14. Elements of Material Science and Enginerring – Lawrence H. Van Vlack ,Peasson Education 6th Ed.
15. Physical Metallurgy Principle , Robirt E Reed Hill, D Van Nostrand Company, 2nd Ed.

Phys.416 Plasma Physics 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:

- This course aimed at understanding the plasma state as distinct from other three states, developing concepts of Debye screening collective behavior, quasi neutrality.
- Deriving a set of fluid equations to study plasma properties, Using fluid equations to study plasma waves, equilibrium and stability,
- Understanding concepts of plasma resistivity, diamagnetism, paramagnetisms.

LEARNING OUTCOMES:

After completion of course, students will able to:

- acquainted with the basic principles Plasma Physics, astrophysical plasma and theory of space plasma.
- understand fluid model of plasma system through fluid equations like Vlasov equation and Landau Damping.
- Student shall be to understand electromagnetics of the plasmonic systems.
- They will also be able to explain the propagation of electromagnetic waves and itsdifferent modes through the plasmonic systems.
- Present era is digital and satellite era so the deep knowledge about the transient phenomena occur in space is too much essential to know every student.

THEORY (45 Hours)

UNIT 1 (10 Hours)

Occurrence of plasmas in nature, Definition of plasma, Concept of temperature In plasma, Debye shielding, The plasma parameter, Criteria for plasmas, Application of plasma physics: Gas discharge, Controlled thermonuclear fusion, Space physics, Modern astrophysics, MHD energy conversion and ion propulsion, Solid state plasmas, Gas Lasers

UNIT 2 (10 Hours)

Motion of Charged particles in electromagnetic field: Energy conservation, Motion of charged particle in uniform (i) electrostatic field (ii) magneto static field, Drift due to an external force. Kinetic pressure in a partially ionised gas, Basic concepts related to collision of particles in a plasma: collision cross section, mean free path, collision frequency, collision between charged particles, inelastic collisions: charge transfer, electron attachment, recombination.

UNIT 3 (15 Hours)

Motion of charged particle in non-uniform magnetic field: Spatial variation of the magnetic field: Divergence term, Gradient and curvature term, Shear term, Equation of motion in the first-order approximation, Average force over one gyration period: Parallel force, perpendicular force, total average force, Gradient drift, Parallel acceleration of guiding center: Invariance of the orbital magnetic moment and of the magnetic flux, Magnetic mirror effect, the longitudinal adiabatic invariant, Curvature drift, Combined Gradient and curvature drift, Time varying E field, Time varying **B** field, Adiabatic invariants.

UNIT 4 (10 Hours)

Degree of ionisation and Sahaionisation formula, Methods of plasma production: Classical Townsend mechanism and electrical breakdown of gases, Streamer mechanism and micro discharges, Electrical discharge (Arc discharge and glow discharge) Plasma diagnostics: High frequency current measurement (Rogowski coil), magnetic probe, Electric probes: single (Langumuir) probe, double probe, triple probe, emissive probe, Plasma spectroscopy (Line radiation and continuum radiation)

***Tutorial(15 Hours) one hour per week**

SUGGUESTED READINGS:

1. F. F. Chen, Introduction to Plasma Physics and Controlled fusion (2/e), Springer,2009.
2. J. A. Bittencourt, Fundamentals of Plasma Physics (3/e), Springer, 2013.
3. N. A. Krall and A. W. Travelpiece, Principle of Plasma Physics, San FranciscoPress,(1/e) 1986.
4. R. J. Goldston and P. H. Rutherford, Introduction to Plasma Physics, Institute ofPhysics Publishing, (1/e) 1995.
5. Hans R. Griem, Principles of Plasma Spectroscopy, Cambridge UniversityPress,(1/e) 1997.
6. R. H. Huddlestone and S. L. Leonard, Plasma Diagnostic Techniques, AcademicPress,(1/e) 1965.
7. I. H. Hutchinson, Principles of Plasma Diagnostics, Cambridge University Press(2/e), 2005.

Phys.417 Laser and Spectroscopy 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:

- teach the students the nature of molecular spectra (rotational, vibrational, electronic and Raman) of polyatomic molecules (including diatomic) classified on the basis of their topological symmetry using group theoretical approach.
- The fundamentals and properties of laser as a spectroscopic light source will also be taught.
- Students should be familiar with the applications of laser in various areas like defense, communication, medical etc.

LEARNING OUTCOMES:

After completion of course, students will able to:

- learn to assign the point groups to polyatomic molecules (including diatomic) and to predict the nature of their vibrational spectra depending on their symmetry using group theoretical treatment. The complete picture of rotational, vibrational and electronic spectra of polyatomic molecules will be comprehended.

- This kind of specialization is expected to provide a larger scope for research in the various related and interdisciplinary areas.
- The basics of the laser and some spectroscopic techniques using laser taught in this course will be an added asset.
- able to understand the basic physics behind laser and its parts and their requirement.

THEORY (45 Hours)

UNIT 1 **(5 Hours)**

Molecular symmetry and group theory: Symmetry operations and point groups for molecules, the representation of a point group, matrices and basis sets, reducible and irreducible representations, application to vibrational spectroscopy.

UNIT 2 **(10 Hours)**

Theory: Microwave, Infrared, Raman, far infrared and UV-VIS spectra of diatomic and polyatomic molecules, Quantum theory of Raman effect, rotational, vibrational and rotation-vibration Raman spectra of diatomic and polyatomic molecules, correlation of infrared and Raman spectra, far infrared and UV-VIS spectra of gases, liquids and solids, determination of force constants and force field from isotropic molecules and spectroscopic data, thermodynamic functions from spectroscopic data, determination of partition function, electronic contribution to thermodynamic properties, enthalpy and specific heats from spectroscopic data, spectroscopic instrumentation.

UNIT 3 **(5 Hours)**

Laser fundamentals: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping; population inversion, three level and four level laser system, Rate equations, lasing action, coherence, polarization, width and profile of spectral lines, lasers as spectroscopic sources, spectral characteristics of laser emission, single and multi-mode lasers, laser tenability. and rate equation. Optical resonators, Stability of resonators, Characteristics of Gaussian beam, He-Ne and Ruby Lasers

UNIT 4 **(10 Hours)**

Spectroscopy: Fluorescence and Raman spectroscopy with lasers
Non-linear spectroscopy: Phase matching, second harmonic generation, sum and frequency generating, optical parametric oscillator
Time resolved laser spectroscopy: Generation and measurement of ultra-short pulses and life time measurements with lasers, pump and probe techniques.

UNIT 5 **(5 Hours)**

Optical cooling: Photon recoil, optical molasses, magneto-optical trap, limits of cooling

UNIT 6 **(10 Hours)**

Nuclear Magnetic Resonance Spectroscopy: General theory of high-resolution NMR spectroscopy, experimental technique, analyses of NMR spectra, spin-spin coupling, chemical shift
Electron Spin Resonance Spectroscopy: Experimental methods, derivative spectra, hyperfine structure, anisotropic systems
X-ray Photo-electron Spectroscopy: Instrumentation, XPS spectra and its interpretations, chemical shift, oxidation state analysis

*Tutorial(15 Hours) one hour per week

SUGGUESTED READINGS:

1. Molecular Symmetry, D. J. Willock (John Wiley & Sons, 2009)
2. Molecular Spectra and Molecular Structure, G. Herzberg (Van Nostrand, 1950)
3. Group Theory and Physics, S. Sternberg (Cambridge Univ. Press, 1995)
4. Modern Spectroscopy, J. M. Hollas(4th Ed., John Wiley, 2004)
5. Molecular Quantum Mechanics, P Atkins & R. Friedman (Oxford Univ. Press, 2005)
6. Molecular Physics, W. Demtroder (Wiley-VCH, 2005)
7. Laser Spectroscopy, W. Demtroder (3rd Ed., Springer, 2003)
8. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachain, 2nd Ed. Pearson (2008).
9. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, 4th Ed.,Tata McGraw 2004.
10. Elementary Atomic Structure, G. K. Woodgate, Clarendon Press 1989.
11. Quantum Chemistry, I. N. Levine, PHI 2009.
12. Elementary Quantum Chemistry, F. L. Pilar, McGraw Hill 1990.
13. Essentials of Lasers and Non-Linear Optics,G.D. Baruach, Ist Ed. Pragati Prakashan, 2000.
14. Lasers and Non-Linear Optics- B.B. Laud, 2nd Ed., New age International (P) Ltd. 1996.
15. Introduction to Atomic Spectra, H. E. White, Tata McGraw Hill 1934.
16. Principles of Laser, O. Svelto, 4th Ed. ,Springer , 2008

Phys.424 Nano Physics 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:

- introduce knowledge on basics of nanoscience and the fundamental concepts behind size reduction in various physical properties.
- More specifically, the student will be able to understand the different properties of materials in reduced scales.
- aware and teach about nanomaterials, their different synthesis methods, their properties, introduction with special carbon and their application in various fields.

LEARNING OUTCOMES:

After completion of course, students will able to:

- Realize the impact of development of nanomaterials in everyday life such as in nanoelectronics, energy sector, automobile, defense, space, medical field, several other industries, and future perspectives
- Understand the concepts of bulk and quantum nanostructures.
- Familiar with basic theoretical modeling of nanostructured materials and prediction of their properties.
- Understand the concept of using natural occurring materials as templates for synthesizing nanomaterials.
- Realize the influence of one, two and three dimensional confinements on electronic and other properties of nanostructured materials.
- Will be able to describe different type of nanomaterials and their size and dimensionality effect. Also

- they will gain knowledge about quantum confinement, tunneling of a particle through a potential barrier,
- Will get knowledge about the different Top-down and bottom –up approach for synthesis of nanomaterials.
- Will get to know about different properties of nanomaterials
- Will understand about special carbons and application of carbon nanotubes.
- Will get to about the application of nanotechnology in various fields.

THEORY (45 Hours)

UNIT 1 **(15 Hours)**

Introduction of nano, History of nano- materials (Michael faraday and divided metals, story of Damascus sword, Feynman's Lecture). How nanoworld different from world around us? Matter Waves, Heisenberg's uncertainty principle, Electron confinement

Quantum confined systems: Quantum confinement and its consequences, quantum wells, quantum wires and quantum dots and artificial atoms. Electronic structure from bulk to quantum dot. Electron states in direct and indirect gap semiconductors nanocrystals. Confinement in disordered and amorphous systems.

Carbon Nanomaterials: Special Carbons: Carbon nanotube, fullernece, Type of CNT: SWNT(single wall nano tube), Multi wall nano tubles. 2D nano material, Graphite and Graphene, ordered porous materials using micelles as tempelates, self assembled nanomaterials, core sell particles

Bulk Nanostructured Materials: Solid Disordered Nanostructures: Methods of synthesis, Failure Mechanism of Conventional Grain-Sized Materials, Mechanical Properties, Nanostructured Multilayers, Electrical Properties, Other properties, Metal Nanocluster Composite Glasses, Porous Silicon Nanostructure Crystals: Natural Nanocrystals, Computational Prediction of Cluster Lattices, Arrays of Nanoperticles in Zeolities, Crystals of Metal Nanoparticles, Nanoparticle Lattices in Colloidal Suspensions, Photonic Crystals

UNIT 2 **(15 Hours)**

Nanostructures Ferromagnetism: Basic of ferromagnetism, Effect of Bulk nanostructuring of Magnetic properties, Dynamics of nanomagnets, Nanopore Containment of magnetic particles, Nanocarbon ferromagnets, Giant and colossal Magnetoresistance, Ferrofluids Quantum Wells, Wires, and Dots Introduction, Preparation of Quantum Nanostructures, Size and Dimensionality effects: size effect, conduction electrons and dimensionality, Fermi gas and Density of States, Potential wells. Partial confinement, properties dependent and density of states.

Synthesis of Naomaterials-I (physical methods):

Introduction, Mechanical methods, methods based on evaporation, sputter deposition, chemical vapour deposition, electric arc deposition, ion beam techniques (ion implanataion), Molecular beam epitaxy (MBE)

Synthesis of Naomaterials-I (Chemical methods):

Introduction, Colloids and Collides in solutions, Growth of Nanoparticles, Synthesis of Metal Nanoparticles by Collodal Route, Synthesis of semiconductor nanoparticles by colloidal route, Langmuir-Blodgett (L-B) methods, microemulsions, sol-gel method

UNIT 3 **(15 Hours)**

Dielectric properties: Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons: Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasiparticles and excitons. Charging effects.

Optical properties: Optical properties and radiative processes: General formulation absorption, emission and luminescence; Optical properties of heterostructures and nanostructures. Carrier

transport in nanostructures: Coulomb blockade effect, scattering and tunnelling of 1D particle; applications of tunnelling, single electron transistors. Defects and impurities: Deep level and surface defects.
Applications of Nanomaterials: Solar-cell, thermoelectric, cosmetics, Light emitting diode (LED), Medicine, Bio-marker, Sensors

***Tutorial(15 Hours) one hour per week**

SUGGUESTED READINGS:

1. NANOTECHNOLOGY: PRINCIPLES AND PRACTICES (Sulabha K. Kulkarni, Capital publishing company)
2. INTRODUCTION TO NANOTECHNOLOGY (Charles P. Poole, Jr. Frank J. Owens: Wiley INDIA)
3. Nanostructured Materials (Jackie Y. Ying: Academic Press)
4. Nanostructures-Theory & Modelling, C. Delerue and M. Lannoo (Springer, 2004)
5. Nanostructure, V. A. Shchukin, N. N. Ledentsov and D. Bimberg (Springer, 2004)
6. Characterization of Nanophase Materials, Z. L. Wang (Ed.) (Wiley-VCH, 2000)
7. Semiconductor Nanocrystal Quantum Dots, A. L. Rogach (Ed.) (Springer Wien NY, 2008)
8. Introduction to Nanotechnology, C. P. Poole Jr. & F. J. Owens (Wiley-Interscience, 2003)
9. Nano: The Essentials. T. Pradeep, McGraw Hill Education.20/01/2007
10. Handbook of Nanostructures: Materials and nanotechnology, H.S. Nalwa Vol 1-5, Academic Press, Bostan., I Ed.,Oct., 1999.
11. Nano world An introduction to nanoscience & Technology – CNR Raw,
12. Introduction to Nano Science and Nano Technology – K.K. Chattopadhyay & AN Banerjee PHI Pvt. Ltd.,2009.
13. Nanostructures & Nanomaterials Synthesis Properties & Applications. Guozhong Cao, Imperials College Press London. 2004

Phys.425 Optoelectronics 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:

- understanding basic laws and phenomena in the area of Optoelectronics and Lasers
- theoretical and practical preparation of students to acquire and apply knowledge and skills in Optoelectronics and Lasers
- builds on the basic knowledge of both fundamental physics and state-of-the-art technologies for optoelectronic components and fibre optics, in order to understand their important applications in optical communications and energy conversions that influence our society and everyday life.
- The course will include the introductions to various physical processes for optical transitions, operation principles of key optoelectronic devices including lasers, photodetectors, modulators and solar cells, functionalities of optical interconnect

LEARNING OUTCOMES:

After completion of course, students will be able to

- Define, in depth, the principles/functionality of the most important optoelectronic devices, compare and evaluate the different device designs
- Perform modeling to analyze the physics behind semiconductor optoelectronic devices
- explain fundamental physical and technical base of Optoelectronic systems,
- describe basic laws and phenomena that define behaviour of optoelectronic systems,

- analyse various premises, approaches procedures and results related to optoelectronic systems,
- use optical fibre equipment, and data transfer using optical fiber.
- conduct experiments and measurements in laboratory and on real components, devices, and equipment of optoelectronic systems, 6. interpret the acquired data and measured results,
- describe development and application of optoelectronic systems
- take part in team work and be able to independently present various professional materials.

THEORY(45 Hours)

UNIT 1 (15 Hours)

Optical sources. Radiation and amplification. Optical gain. Optical amplifiers.
Injection luminescence: Recombination processes, the spectrum of recombination radiations, Direct and Indirect band gap Semiconductors, The Internal Quantum Efficiency, The External Quantum Efficiency
The basic principles of laser actions: spontaneous and stimulated emission and absorption, the condition for the laser action, Types of laser, Semiconductor lasers; Theory of Laser action in Semiconductors, condition for gain, The threshold conditions for oscillations, rates of spontaneous and stimulated emission, effect of refractive index, calculation of the gain coefficients, relation of the gain coefficient to current density, Semiconductor Injection Laser :Efficiency, Stripe geometry LED materials, commercial LED materials, LED construction, Response time of LED's, LED derive circuitry.

UNIT 2 (15 Hours)

Optical Detectors: Introduction, Device types, Optical Detection. Principles, Absorption, quantum efficiency, Responsivity, Long wavelength cut off, Photoconductive Detectors, Characteristics of photoconductive materials. Solar cell, Holography and its applications, Liquid crystal displays The Optical Fiber, Multimode and Single Mode Fibers, Glass Fibers, Plastic Optical Fibers, Fiber-Optic Bundle, Fabrication of Optical Fibers ,Preform fabrication, Fiber Fabrication ,Free Space Optics

UNIT 3 (15 Hours)

Junction Detectors: detectors performance parameters Semiconductors p-i-n diodes, General Principle, quantum efficiency, Materials and design for p-i-n photodiodes. Impulse & frequency response of p-i-n photodiodes. Avalanche photodiodes detectors. The multiplication process, Avalanche photodiodes (APD) design, APD bandwidth, phototransistors
Circuits for signal conditioning of optoelectronic sensors.

Electro-optic and opto-electric transducers. Optical bistability., Optoelectronic integrated circuits.

Optical fiber telecommunication. Optical signal processing and computing.

Photonic crystal nanostructures and Nanoplasmonics

***Tutorial(15 Hours) one hour per week**

SUGGUESTED READINGS:

1. Optical communication systems. John Gowar (Prentice Hall of India Pvt.Ltd.New Delhi1987.)
2. Optical fibre communications-Principles and practice John. M. Senior. Prentice HallInternational (1985)
3. Optoelectronics-An Introduction(Second edition) J.Wilson. , J.F.B Hawkes Prentice HallInternational (1989).

4. S.M.Sze Physics of the semiconductor devices. 2nd edition(1983) Wiley Eastern Ltd.
5. Fiber Optics and Lasers -The Two Revolutions AjoyGhatak and K Thyagarajan
6. Instrumentation (Devices and systems) : Ranjan, Mani and Sharma – Tata McGraw Hill, 2nd Ed. , 2000 New Delhi.
7. Electronic Instrumentation: H.S. Kalsi- Tata McGraw Hill, New Delhi.1995 16th reprint 2003.
8. Electronic Devices and Circuits – Millmant Halkia McGraw Hill, New Delhi 2002.
9. Electronic Devices and Circuits – Raju – I.K. International

Phys.426 Communicative and Digital Electronics 3+1*

LEARNING OBJECTIVES:

The primary aim of this course is to:
- describe the concepts of electronics in communication.
- Communication techniques based on analog modulation, analog and digital pulse modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail.
- Communication and Navigation systems such as GPS, satellite and mobile telephony systems are introduced.

LEARNING OUTCOMES:

At the end of this course, students will be able to:
- This paper aims to describe the concepts of electronics in communication. In this course,students will receive an introduction to the principle, performance and applications ofcommunication systems.
- Students will learn the various means and modes of communication. They will gain anunderstanding of fundamentals of electronic communication system and electromagneticcommunication spectrum with an idea of frequency allocation for radio communicationsystem in India.
- They will gain an insight on the use of different modulation and demodulation techniquesused in analog communication
- Students will be able to analyse different parameters of analog communicationtechniques.They will learn the need of sampling and different sampling techniques where they cansample analog signal.
- Students will learn the generation and detection of a signal through pulse and digitalmodulation techniques and multiplexing.They will gain an in-depth understanding of different concepts used in a satellitecommunication system.
- This paper will essentially connect the text book knowledge with the most popularcommunication technology in real world.

THEORY (45 Hours)

UNIT 1 (15 Hours)

Electronic communication: Introduction to communication – means and modes. Power measurements (units of power). Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals.
Analog Modulation: Amplitude Modulation: Frequency spectrum of AM waves, average power, average voltage, modulation index, AM-modulator circuits (collector modulation), AM-demodulator (diode detector), single side band generation and detection.

Angle Modulation: Frequency and phase modulation, frequency spectrum of FM waves, intersystem comparisons (FM and AM), FM generation using VCO, FM detector (slope detector)
Satellite Communication: Introduction, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), Uplink and downlink, path loss, Satellite visibility, Ground and earth stations. Simplified block diagram of the earth station.
Mobile Telephony System: Basic concept of mobile communication, frequency bands used in mobile communication, the concept of cell sectoring and cell splitting, SIM number, IMEI number, GPS navigation system (qualitative idea only).

UNIT 2 **(15 Hours)**

Basics of Logic Gates: Logic gates and the realization using diodes and transistors.
Basics of reduction of logic expressions: Boolean algebra, Boolean equation of logic circuits, de-Morgan theorem, Method of realization a circuit for given truth table, Sum of product (SOP) and product of sum (POS) representation, Karnaugh map and their applications.
Combinational Circuits: Design procedure, Adderssubtractors, Carry look ahead adder, BCD adder, Magnitude comparator, Multiplexer/DE multiplexer, Encoder/decoder, parity checker, Code converters, Implementation of combinational logic.

UNIT 3 **(15 Hours)**

Sequential Circuit – Flip Flop: SR, JK, D and T flipflop, Master slave flipflops, Triggering mechanism of flipflop, Realization of one flip flop using other flipflops.
Asynchronous/ripple counters, Synchronous counters, Shift counters, Shift registers, Universal shift register, MSI and LSI based design, MSI and LSI implementation on sequential circuit.
Programmable logic and Data Converters: Programmable logic device (PLD), Programmable logic array (PLA), Implementation of ROM and PLA, Analog to Digital (A/D) data converters, Digital to analog(D/A) data converters, logic families, microprocessors.

***Tutorial(15 Hours) one hour per week**

SUGGUESTED READINGS:

1. Communication Electronics, Principles and Applications, L. E. Frenzel, Tata McGraw-Hill.
2. Communication Systems: Analog and Digital, R. P. Singh and S. D. Sapre, Tata McGraw-Hill.
3. Analog and Digital Communications, H. Hsu, Schaum's Outline Series, Tata McGraw-Hill.
4. Electronic Communications Systems: Fundamentals Through Advanced, Wayne Tomasi, Fifth Edition, Pearson
5. Electronic Communication, L. Temes and M. Schultz, Schaum's Outline Series, Tata McGraw- Hill.
6. Electronic Communication Systems, G. Kennedy and B. Davis, Tata McGraw-Hill
7. Analog and Digital Communication Systems, M. J. Roden, Prentice Hall of India.
8. SahaG, MalvinoA. Pand Leach D.P. (2011). Digital Principles and Applications. Noida, India: Tata McGraw-Hill Education.
9. Malvino Pand Brown J.A. (2011). Digital Computer Electronics. Noida India: Tata McGraw-Hill Education.
10. Hawkins Cand Segura J. (2010). Introduction to Modern Digital Electronics. New York, USA: SciTech Publishing.

RESEARCH/PROJECT/SEMINAR:

Phys.391 Seminar 0+1

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Identify and compare technical and practical issues related to the area of course specialization.
- Outline annotated bibliography of research demonstrating scholarly skills.
- Prepare a well-organized report employing elements of technical writing and critical thinking.
- Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

LEARNING OUTCOMES:

At the end of this course, students will be able to:

- Establish motivation for any topic of interest and develop a thought process for technical presentation.
- Organize a detailed literature survey and build a document with respect to technical publications.
- Analysis and comprehension of proof-of-concept and related data.
- Effective presentation and improve soft skills.
- Make use of new and recent technology for creating technical reports
- Will be able to present themselves in front of an audience. It will help them to develop skills like speaking ability, gain and express knowledge in different fields and presentation capability. They will also learn to defend themselves in front of a panel of Seminar Committee.

Phys.491 Pre-Research 0+4

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Identifying the Research Problem.
- Performing a Literature Review & Writing a Theoretical/Conceptual/experimental Framework.
- Researching the methods/experiments/Design or Approach to the Problem.

LEARNING OUTCOMES:

At the end of Research Proposal, students will be able to:

- Outline the literature on as Specific research problem.
- Construct objectives and motivations of research problem to be carried out.
- Explain the nuts and bolts of the theoretical concepts of the problem (experimental or theoretical) to be carried out.
- Making research proposal for further research.

Student will prepare a research proposal based on literature review and extensive student-mentor interactions involving discussions, meetings and presentations. Each student will submit a research/dissertation proposal of the research work planned for the research dissertation with origin of the research problem, literature review, hypothesis, objectives and methodology to carry out the planned research work, expected outcomes and bibliography. Research projects can be taken up in collaboration with industry from within the discipline or across the discipline

Phys.492 Research 0+8

LEARNING OBJECTIVES:

The prime aim of this course is to:

- Collecting and Analyzing the Data and/or Designing and Validating the methods/experiments/Design
- Drawing Conclusions and Giving Recommendations
- Prepare dissertation/thesis/report on the proposed research work

LEARNING OUTCOMES:

At the end of Dissertation students will be able to:

- Demonstrate an in-depth knowledge of scientific research pertaining to the area of study
- Demonstrate experimental/theoretical research capabilities based on rigorous hands-on training
- Critically analyze, interpret and present the data in light of existing scientific knowledge to arrive at specific conclusions
- Develop higher order thinking skills required for pursuing higher studies (Ph.D.)/research-oriented career options in respective fields.

Students will carry out their research work under the supervision of a faculty member. Students will interact with the supervisors through meetings and presentations on a regular basis. After completion of the research work, students will complete the dissertation under the guidance of the supervisor. The dissertation will include literature review, hypothesis, objectives, methodology, results, discussion, and bibliography.

Phys.493 Academic Project 0+4

LEARNING OBJECTIVES:

The primary aim of this course is to:

- review the Research in the subject area.
- Analyse data and other research findings.
- Report research findings in written form.

LEARNING OUTCOMES:

After completion of course, students will have hand on experience of

- Literature survey on advanced research topics in Materials Science, Nuclear physics, High Energy Physics and Condensed Matter Physics
- Planning and designing the experiment and theoretical modelling of the research Problem Analysis and evaluation of the experimental data/ theoretical & computational modeling
- Deduction and systematic presentation of the results
- Compilation of the results / information to produce written document
- Defending the results of the project in an open viva–voice through power point presentation

All the Physics honours students will do a supervised Physics Project as an important culmination of training in Physics learning and research. This project shall be a supervised collaborative work in Theoretical Physics (Condensed Matter Physics, Nuclear Physics, Particle Physics), Experimental Physics, Computational Physics. The project will aim to introduce student to the basics and methodology of research in physics, which is done via theory, computation and experiments either all together or separately by one of these approaches. It is intended to give research exposure to students.

MATHEMATICS
(DISCIPLINE – B)

DISCIPLINE SPECIFIC COURSES:

Maths.111 Differential Calculus 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is:
- To introduce the basic tools of calculus, also known as 'science of variation'.
- To provide a way of viewing and analysing the real-world problems.

LEARNING OUTCOMES:

This course will enable the students to understand:
- The notion of limits, continuity, and uniform continuity of functions.
- Geometrical properties of continuous functions on closed and bounded intervals.
- Applications of derivative, relative extrema, and mean value theorems.
- Higher order derivatives, Taylor's theorem, indeterminate forms, and tracing of curves.

THEORY (45 Hours)

UNIT – I: Limits and Continuity (15 Hours)

Limits of functions (ε - δ and sequential approach), Algebra of limits, Squeeze theorem, One-sided limits, Infinite limits, and limits at infinity; Continuous functions and its properties on closed and bounded intervals; Uniform continuity.

UNIT – II: Differentiability and Mean Value Theorems (15 Hours)

Differentiability of a real-valued function, Algebra of differentiable functions, Chain rule, Relative extrema, Interior extremum theorem, Rolle's theorem, Mean-value theorem and its applications, Intermediate value theorem for derivatives.

UNIT – III: (15 Hours)

Successive Differentiation, Taylor's Theorem and Tracing of Plane Curves
Higher order derivatives and calculation of the nth derivative, Leibnitz's theorem; Taylor's theorem, Taylor's series expansions of e^x, $sin\ x$, $cos\ x$. Indeterminate forms, L'Hospital's rule; Concavity and inflexion points; Singular points, Asymptotes, Tracing graphs of rational functions and polar equations; Functions of severable variables (upto three variables), Limit and continuity of these variables.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGUESTED READINGS:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). Calculus (10th ed.). John Wiley & Sons Singapore Pvt. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi.
2. Prasad, Gorakh (2016). Differential Calculus (19th ed.). Pothishala Pvt. Ltd. Allahabad.
3. Ross, Kenneth A. (2013). Elementary Analysis: The Theory of Calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian reprint.
4. Apostol, T. M. (2007). Calculus: One-Variable Calculus with an Introduction to Linear Algebra (2nd ed.). Vol. 1. Wiley India Pvt. Ltd.
5. Ghorpade, Sudhir R. & Limaye, B. V. (2006). A Course in Calculus and Real Analysis. Undergraduate Texts in Mathematics, Springer (SIE). Indian reprint.
6. Shanti Narayan "Differential Calculus" Shyam Lal Charitable Trust, Ram Nagar, New Delhi.
7. Spectrum- Differential Calculus, Sharma Publications, Jalandhar
8. A Text Book of Calculus, S. Dinesh & Co, Jalandhar

Maths.121 Differential Equations 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:
- Ordinary and partial differential equations.
- Basic theory of higher order linear differential equations, Wronskian and its properties.
- Various techniques to find the solutions of above differential equations which provide a basis to model complex real-world situations.

LEARNING OUTCOMES:

This course will enable the students to:
- Solve the exact, linear, Bernoulli equations, find orthogonal trajectories and solve rate

16. problems.
- Apply the method of undetermined coefficients and variation of parameters to solve linear differential equations.
- Solve Cauchy-Euler equations and system of linear differential equations.
- Formulate and solve various types of first and second order partial differential equations.

THEORY (45 Hours)

UNIT- 1 Ordinary Differential Equations (15 Hours)

First order ordinary differential equations: Basic concepts and ideas, First order Exact differential equations, integrating factors and rules to find integrating factors, Linear equations and Bernoulli equations, Initial value problems, Applications of first order differential equations: Orthogonal trajectories and Rate problems; Basic theory of higher order linear differential equations, Wronskian and its properties.

UNIT- 2 Explicit Methods of Solving Higher-Order Linear Differential Equations(12 Hours)

Linear homogeneous equations with constant coefficients, Linear non-homogeneous equations, Method of undetermined coefficients, Method of variation of parameters, Cauchy-Euler equations, System of linear differential equations.

UNIT – 3 First and Second Order Partial Differential Equations (18 Hours)

Classification and Construction of first-order partial differential equations, Method of characteristics and general solutions of first-order partial differential equations, Canonical forms and method of separation of variables for first order partial differential equations; Classification and reduction to canonical forms of second-order linear partial differential equations and their general solutions.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGUESTED READINGS:

1. D.A. Murray: Introductory course in differential equations, Orient Longman (India) 1967
2. J.N. Sharma and Kehar Singh, Partial Differential Equations for Engineers, and Scientists. Narosa Publishing House.
3. S. L. Ross, Differential Equations, John Wiley Student Edition, Third Edition,2004.
4. I.Sneddon,*ElementsofPartialDifferentialEquations*,McGraw-Hill,International Edition,1967.
5. Spectrum-Ordinary Differential Equations, Sharma Publications, Jalandhar
6. A Text Book of Ordinary Differential Equations, S. Dinesh & Co, Jalandhar
7. Spectrum-Partial Differential Equations, Sharma Publications, Jalandhar
8. A Text Book of Partial Differential Equations, S. Dinesh & Co, Jalandhar
9. Myint-U, Tyn and Debnath, Lokenath (2007). Linear Partial Differential Equations for Scientist and Engineers (4th ed.). Birkhäuser. Indian Reprint.
10. Ross, Shepley L. (1984). Differential Equations (3rd ed.). John Wiley & Sons.
11. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equations and Boundary Value Problems: Computing and Modeling (5th ed.). Pearson Education.
12. E. Kreyszig. (2011). Advanced Engineering Mathematics (10th ed.). Wiley India.
13. I. N. Sneddon (2006). Elements of Partial Differential Equations. Dover Publications.

Maths.211 Real Analysis 3+1*

LEARNING OBJECTIVES:

The course will develop a deep and rigorous understanding of:

- Real line $\mathbb{R}$ with algebraic structure.
- Order and completeness properties to prove the results about convergence and divergence of sequences and series of real numbers and real functions.

LEARNING OUTCOMES:

This course will enable the students to:

- Understand the fundamental properties of the real numbers, including completeness and Archimedean, and density property of rational numbers in $\mathbb{R}$.
- Learn to define sequences in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$ and find the limit.
- Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate the limit superior and limit inferior of a bounded sequence.
- Apply limit comparison, ratio, root, and alternating series tests for convergence and absolute convergence of infinite series of real numbers.

THEORY(45 Hours)

UNIT -1 Real Number System (12 Hours)

Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number, Bounded above and bounded below sets, Supremum and infimum of a non-empty subset of $\mathbb{R}$, The completeness property of $\mathbb{R}$, Archimedean property, Density of rational numbers in $\mathbb{R}$.

UNIT - 2 Sequences (15 Hours)

Sequences and their limits, Convergent sequence, Limit theorems, Monotone sequences, Monotone convergence theorem, Subsequence's, Bolzano-Weierstrass theorem for sequences, Limit superior and limit inferior for bounded sequence, Cauchy sequence, Cauchy's convergence criterion.

UNIT -3 Infinite Series (18 Hours)

Convergence and divergence of infinite series of real numbers, Necessary condition for convergence, Cauchy criterion for convergence, Tests for convergence of positive term series, Integral test, comparison test, D'Alembert's ratio test, Cauchy's nth root test, Raabe's test, Alternating series, Leibniz test, Absolute and conditional convergence. Sequencesandseriesoffunctions,Pointwiseanduniformconvergence,M_n-test,M- test,Statementsof theresultsaboutuniformconvergenceandintegrabilityand differentiabilityoffunctions,Powerseriesandradiusofconvergence.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGUESTED READINGS:

1. Bartle, Robert G., & Sherbert, Donald R. (2011). Introduction to Real Analysis (4th ed.). John Wiley & Sons. Wiley India Edition 2015.
2. Bilodeau, Gerald G., Thie, Paul R., & Keough, G. E. (2010). An Introduction to Analysis (2nd ed.). Jones and Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.
3. Denlinger, Charles G. (2011). Elements of Real Analysis. Jones and Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.
4. Aliprantis C. D., & Burkinshaw, O. (1998). Principles of Real Analysis (3rd ed.). Academic Press.
5. Ross, Kenneth A. (2013). Elementary Analysis: The Theory of Calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian reprint.
6. Thomson, B. S., Bruckner, A. M., & Bruckner, J. B. (2001). Elementary Real Analysis. Prentice Hall.
7. Spectrum-Real Analysis, Sharma Publications, Jalandhar
8. A Text Book of Real Analysis, S. Dinesh & Co, Jalandhar
9. Spectrum-Sequences and Series, Sharma Publications, Jalandhar
10. A Text Book of Sequences and Series, S. Dinesh & Co, Jalandhar

Maths.221 Algebra 3+1*

LEARNING OBJECTIVES:

The primary objective of the course is to introduce:

- Modular arithmetic, fundamental theory of groups, rings, integral domains, and fields.
- Symmetry group of a plane figure, and basic concepts of cyclic groups.
- Cosets of a group and its properties, Lagrange's theorem, and quotient groups.

LEARNING OUTCOMES:

This course will enable the students to:

- Appreciate ample types of groups present around us which explains our surrounding

- better, and classify them as abelian, cyclic and permutation groups.
- Explain the significance of the notion of cosets, normal subgroups and homomorphisms.
- Understand the fundamental concepts of rings, subrings, fields, ideals, and factor rings.

THEORY (45 Hours)

UNIT-I: Introduction to Groups (12 Hours)

Modular arithmetic; Definition and examples of groups, Elementary properties of groups, Order of a group and order of an element of a group; Subgroups and its examples, Subgroup tests; Center of a group and centralizer of an element of a group.

UNIT-II: Cyclic Groups, Permutation Groups and Lagrange's Theorem (18 Hours)

Cyclic groups and its properties, Generators of a cyclic group; Group of symmetries; Permutation groups, Cyclic decomposition of permutations and its properties, Even and odd permutations and the alternating group; Cosets and Lagrange's theorem; Definition and examples of normal subgroups, Quotient groups; Group homomorphisms and properties.

UNIT-III: Rings, Integral Domains, and Fields (15 Hours)

Definition, examples and properties of rings, subrings, integral domains, fields, ideals and factor rings; Characteristic of a ring; Ring homomorphisms and properties.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGUESTED READINGS:

1. M.Artin,*AbstractAlgebra*,2ndEd.,Pearson,2011.
2. JosephAGallian,*ContemporaryAbstractAlgebra*,4th Ed.,Narosa,1999.
3. GeorgeEAndrews,*NumberTheory*,HindustanPublishingCorporation,1984.
4. I.N. Herstein: "Topics in Algebra", Wiley Eastern Company, New Delhi, 1975.
5. Hoffman and R. Kunze; Linear Algebra, 2nd Edition, Prentice Hall of India, Delhi.
6. Vivek Shahi and Vikas Bisht: Algebra, Narosa Publishing House.
7. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul; Basic Abstract Algebra (2nd Edition)
8. Spectrum- Abstract Algebra, Sharma Publications, Jalandhar
9. A Text Book of Abstract Algebra, S. Dinesh & Co, Jalandhar

Maths.311 Elementary Linear Algebra 3+1*

LEARNING OBJECTIVES:

The objective of the course is:
- To introduce the concept of vectors in $RRnn$.
- Understanding the nature of solution of system of linear equations.
- To view the $mm\times nn$ matrices as a linear function from $RRnn$ to $RRmm$ and vice versa.
- To introduce the concepts of linear independence and dependence, rank and linear transformations has been explained through matrices.

LEARNING OUTCOMES:

This course will enable the students to:
- Visualize the space $RRnn$ in terms of vectors and the interrelation of vectors with matrices.
- Familiarize with concepts of bases, dimension, and minimal spanning sets in vector spaces.

- Learn about linear transformation and its corresponding matrix.

THEORY (45 Hours)

UNIT – I: Euclidean Space R^n and Matrices (18 Hours)

Fundamental operations with vectors in Euclidean space R^n, Linear combinations of vectors, Dot product and their properties, Cauchy-Schwarz inequality, Triangle inequality, Solving system of linear equations using Gaussian elimination, Application: Curve Fitting, Gauss-Jordan row reduction, Reduced row echelon form, Application: Solving several systems simultaneously, Equivalent systems, Rank and row space of a matrix, Eigenvalues, Eigenvectors, Eigenspace, Diagonalization, Characteristic polynomial of a matrix.

UNIT – II: Introduction to Vector Spaces (12 Hours)

Definition, Examples and some elementary properties of vector spaces, Subspaces, Span, Linear independence and linear dependence of vectors, Basis and dimension of a vector space, Maximal linearly independent sets, Minimal spanning sets.

UNIT – II: Linear Transformations (15 Hours)

Linear transformations**:** Definition, Examples and elementary properties, The matrix of a linear transformation, Kernel and range of a linear transformation, The dimension theorem, one-to-one and onto linear transformations, Invertible linear transformations, Isomorphic vector spaces.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGUESTED READINGS:

1. Andrilli, S., & Hecker, D. (2016). *Elementary Linear Algebr*a (5th ed.). Elsevier India.
2. Lay, David C., Lay, Steven R., & McDonald, Judi J. (2016). *Linear Algebra and its Applications* (5th ed.). Pearson Education.
3. Kolman, Bernard, & Hill, David R. (2001). *Introductory Linear Algebra with Applications* (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.
4. Spectrum- Linear Algebra, Sharma Publications, Jalandhar
5. A Text Book of Linear Algebra, S. Dinesh & Co, Jalandhar

Maths.321 Numerical Analysis 3+1*

LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

- To acquaint students with the techniques that uses algorithms for approximation problems.
- Develop the students' ability to use various numerical method techniques
- To make the students formulate and apply appropriate strategy to solve real world problems.

Learning outcomes

On successful completion of the course, students will be able to:

- Know the basic elements of numerical methods and error analysis
- Learn Iterative methods for finding the roots of the algebraic and transcendental equations
- Apply the numerical methods to solve system of linear equations and understand the methods
  convergence analysis.

- Understand the concepts of finite differences, derive the interpolation formulae, and understand its applications.

THEORY (45 Hours)

UNIT I **(12 Hours)**

Errors: Relative Error, Absolute Error, Round off Error, Truncation Error. Transcendental and Polynomial equations: Bisection method, Newton-Raphson method, Secant method. Method of False Position, Fixed point iterative method, Order, and rate of convergence of these methods.

UNIT II **(9 Hours)**

System of linear equations: Gauss Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.

UNIT III **(9Hours)**

Interpolation: Lagrange Interpolating Polynomial, Newton's Gregory forward and backward difference interpolating polynomial, Newton's Divided Difference Interpolating Polynomial, Error analysis in each method.

UNIT IV **(15 Hours)**

Numerical Integration: Trapezoidal rule, Simpson's rule, Simpson's 1/3rule, Simpsons 3/8th rule. Ordinary Differential Equations: Euler's method, Modified Euler's method, Runge-Kutta method.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGUESTED READINGS:

1. Sastry, S. S. (2012). *Introductory methods of numerical analysis*. PHI Learning Pvt. Ltd..
2. Gerald, C. F., & Wheatley, P. O. (2008). *Applied Numerical Analysis (7th ed.).* Pearson Education. India.
3. Bradie, Brian. (2006). A Friendly Introduction to Numerical Analysis. Pearson
17. Education, India. Dorling Kindersley (India) Pvt. Ltd. Third impression 2011.
4. Mudge, M. R. (2003). An introduction to numerical methods and analysis,(Wiley).
5. Jain, M. K., Iyengar, S. R. K., & Jain, R. K. (2012). *Numerical Methods for Scientific*
18. *and Engineering Computation. (6th ed.).* New Age International Publisher, India, 2016.
6. Spectrum- Numerical Methods, Sharma Publications, Jalandhar

DISCIPLINE ELECTIVE COURSES:

Math.212 Elements of Number Theory 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- The Euclidean algorithm and linear Diophantine equations, the Fundamental theorem of
19. arithmetic and some of the open problems of number theory viz. the Goldbach conjecture.
- The modular arithmetic, linear congruence equations, system of linear congruence
20. equations, arithmetic functions, and multiplicative functions, e.g., Euler's Phi-function.
- Introduction of the simple encryption and decryption techniques, and the numbers of
21. specific forms viz. Mersenne numbers, Fermat numbers etc.

LEARNING OUTCOMES:

This course will enable the students to:

- Get familiar with the basic number-theoretic techniques.
- Comprehend some of the open problems in number theory.
- Learn the properties and use of number-theoretic functions and special types of numbers.
- Acquire knowledge about public-key cryptosystems, particularly RSA.

THEORY (45 Hours)

UNIT – I: Divisibility and Prime Numbers (12 Hours)

The Fundamental theorem of Arithmetic's: Introduction, the division algorithm, divisibility, and the greatest common divisor. Euclid's lemma; The Euclidean algorithm, Linear Diophantine equations; The Fundamental theorem of Arithmetic, The sieve of Eratosthenes, Euclid theorem and the Goldbach conjecture; The Fibonacci sequence and its nature.

UNIT – II: Theory of Congruences and Number-Theoretic Functions (21 Hours)

Congruence relation and its basic properties, Linear congruences and the Chinese remainder theorem, System of linear congruences in two variables; Fermat's little theorem and its generalization, Wilson's theorem, and its converse; Number-theoretic functions for sum and the number of divisors of a positive integer, Multiplicative functions, The greatest integer function; Euler's Phi-function and its properties.

UNIT – III: Public Key Encryption and Numbers of Special Form (12 Hours)

Basics of cryptography, Hill's cipher, Public-key cryptosystems, and RSA encryption and decryption technique; Introduction to perfect numbers, Mersenne numbers and Fermat numbers.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READINGS:

1. Burton, David M. (2011). Elementary Number Theory (7th ed.). McGraw-Hill Education Pvt. Ltd. Indian Reprint 2017.
2. Jones, G. A., & Jones, J. Mary. (2005). Elementary Number Theory. Springer Undergraduate Mathematics Series (SUMS). Indian Reprint.
3. Robbins, Neville (2007). Beginning Number Theory (2nd ed.). Narosa Publishing House Pvt. Ltd. Delhi.
4. Rosen, Kenneth H. (2011). Elementary Number Theory and its Applications (6th ed.) Pearson Education. Indian Reprint 2015.
5. Elementary Number Theory, Sharma Publication, Jalandhar.

Math.213 Combinatorics 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to:

- Introduce various techniques of permutations, combinations, and inclusion-exclusion.
- Learn basic models of generating functions and recurrence relations in their application

22. to the theory of integer partitions.

LEARNING OUTCOMES:

After completing the course, student will:

- Enhance the mathematical logical skills by learning different enumeration techniques.
- Be able to apply these techniques in solving problems in other areas of mathematics.
- Be trained to provide reasoning and arguments to justify conclusions.

THEORY: 45

UNIT - 1 Basics of Combinatorics (15 Hours)

Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial coefficients, Multinomial coefficients, Counting subsets of size *k*; Set-partitions, The inclusion-exclusion principle and applications.

UNIT - 2 Generating Functions and Recurrence Relations (18 Hours)

Generating functions: Generating function models, calculating coefficients of generating functions, Polynomial expansions, Binomial identity, Exponential generating functions. Recurrence relations: Recurrence relation models, Divide-and-conquer relations, Solution of linear recurrence relations, Solutions by generating functions.

UNIT – 3 Partition (12 Hours)

Partition theory of integers: Ordered partition, Unordered partition, Ferrers diagram, Conjugate of partition, Self-conjugate partition, Durfee square, Euler's pentagonal theorem.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READINGS:

1. Sane, Sharad S. (2013). Combinatorial Techniques. Hindustan Book Agency (India).
2. Tucker, Alan (2012). Applied Combinatorics (6th ed.). John Wiley & Sons, Inc.
3. Brualdi, Richard A. (2009). Introductory Combinatorics (5th ed.). Pearson Education Inc.
4. Cameron, Peter J. (1994). Combinatorics: Topics, Techniques, Algorithms. Cambridge University Press.

Math.222 Introduction to Graph Theory 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- Problem-solving techniques using various concepts of graph theory.
- Various properties like planarity and chromaticity of graphs.
- Several applications of these concepts in solving practical problems.

LEARNING OUTCOMES:

This course will enable the students to:

- Good familiarity with all initial notions of graph theory and related results and

23. seeing them used for some real-life problems.

- Learning notion of trees and their enormous usefulness in various problems.
- Learning various algorithms and their applicability.
- Studying planar graphs, Euler theorem associated to such graphs and some

24. useful applications like coloring of graphs.

THEORY (45 Hours)

UNIT-I: Graphs, Types of Graphs and Basic Properties (12 Hours)

Graphs and their representation, Pseudographs, Subgraphs, Degree sequence, Euler's theorem, Isomorphism of graphs, Paths and circuits, Connected graphs, Euler trails and circuits, Hamiltonian paths and cycles, Adjacency matrix, Weighted graphs, Travelling salesman problem, Dijkstra's algorithm.

UNIT-II: Directed Graphs and Applications, Trees (18 Hours)

The Chinese postman problem; Digraphs, Bellman-Ford algorithm, Tournaments, Directed network, Scheduling problem; Trees and their properties, Spanning trees, Kruskal's algorithm, Prim's algorithm, Acyclic digraphs and Bellman's algorithm.

UNIT-III: Planar Graphs, Graph Coloring and Network Flows (15 Hours)

Planar graphs, Euler's formula, Kuratowski theorem, Graph coloring, Applications of graph coloring, Circuit testing and facilities design, Flows and cuts, Max flow-min cut theorem, Matchings, Hall's theorem.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READINGS:

1. Goodaire, Edgar G., & Parmenter, Michael M. (2011). Discrete Mathematics with GraphTheory (3rd ed.). Pearson Education Pvt. Ltd. Indian Reprint.
2. Bondy, J. A. & Murty, U.S.R. (2008), Graph Theory with Applications. Springer.
3. Chartrand, Gary, & Zhang, P. (2012). A First Course in Graph Theory. Dover Publications.
4. Diestel, R. (1997). Graph Theory (Graduate Texts in Mathematics). Springer Verlag.
5. West, Douglas B. (2001). Introduction to graph theory (2nd ed.). Pearson India.

Math.223 Elements of Discrete Mathematics 3+1*

LEARNING OBJECTIVES:

Students are introducing to:

- Order (or partial order) and related properties.
- Notion of a lattice which is also a step towards abstract algebra.
- Concept of Boolean algebra and its applications to minimizing a Boolean polynomial and switching circuits, which has further applications in computer science.

LEARNING OUTCOMES:

This course will enable the students to:

- Understand the basic concepts of sets, relations, functions, and induction.
- Understand mathematical logic and logical operations to various fields.
- Understand the notion of order and maps between partially ordered sets.
- Minimize a Boolean polynomial and apply Boolean algebra techniquesto decode switching circuits.

THEORY (45 Hours)

UNIT-I: Sets, Relations, and Functions (18 Hours)

Sets, Propositions and logical operations, Conditional statements, Mathematical induction, Relations and equivalence relation, Equivalence classes, Partial order relation, Partially ordered set, Hasse diagrams, Chain, Maximal and minimal elements, least and greatest elements, Least upper bound, Greatest lower bound, Zorn's lemma, Functions and bijective functions, Functions between POSETS, Order isomorphism.

UNIT-II: Lattices **(12 Hours)**

Lattice as a POSET, Lattice as an algebra and their equivalence, Bounded lattices, Sublattices, Interval in a lattice, Products and homomorphism of lattices, Isomorphism of lattices; Distributive, Complemented, Partition and pentagonal lattices.

UNIT-III: Boolean Algebra and Switching Circuits **(15 Hours)**

Boolean algebra, De Morgan's laws, Boolean expressions, Truth tables, Logic diagrams, Boolean functions, Disjunctive normal forms (as join of meets), Minimal forms of Boolean polynomials, Quine Mc-Cluskey method, Karnaugh maps, Switching circuits, Applications of switching circuits.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READING:

1. Rudolf Lidl, & Gunter Pilz (2004). Applied Abstract Algebra (2nd ed.). Undergraduate text
2. in Mathematics, Springer (SIE), Indian Reprint.
3. Bernard Kolman, Robert C. Busby, & Sharon Cutler Ross (2009). Discrete Mathematical
4. Structures (6th ed.). Pearson education Inc., Indian reprint.
5. Rosen, Kenneth H. (2017). Discrete Mathematics and its applications with combinatorics and Graph Theory (7th ed.). McGraw Hill Education.

Math.322 Linear Programming 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- The solution of linear programming problem using simplex method.
- The solution of transportation and assignment problems.
- Game theory which makes possible the analysis of the decision-making process of two

25. interdependent subjects.

LEARNING OUTCOMES:

This course will enable the students to:

- Learn about the simplex method used to find optimal solutions of linear optimization
- problems subject to certain constraints.
- Write the dual of a linear programming problem.
- Solve the transportation and assignment problems.
- Learn about solution of rectangular games using graphical method and dominance.
- Formulate game to a pair of associated prima-dual linear programming problems.

THEORY (45 Hours)

UNIT-I: Linear Programming Problem, Simplex Method, and Duality **(18 Hours)**

Standard form of the LPP, graphical method of solution, basic feasible solutions, and convexity; Introduction to the simplex method**:** Optimality criterion and unboundedness, Simplex tableau and examples, Artificial variables; Introduction to duality, Formulation of the dual problem with examples.

UNIT-II: Transportation and Assignment Problems **(15 Hours)**

Definition of transportation problem, finding initial basic feasible solution using Northwest corner method, Least-cost method, and Vogel approximation method; Algorithm for solving transportation problem; Hungarian method of solving assignment problem.

UNIT-III: Two-Person Zero-Sum Games **(12 Hours)**

Introduction to game theory, rectangular games, Mixed strategies, Dominance principle; Formulation of game to primal and dual linear programming problems.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READINGS:

1. Thie, Paul R., & Keough, G. E. (2014). An Introduction to Linear Programming andGame Theory. (3rd ed.). Wiley India Pvt. Ltd.
2. Taha, Hamdy A. (2017). Operations Research: An Introduction (10th ed.). Pearson.
3. Hadley, G. (1997). Linear Programming. Narosa Publishing House. New Delhi.
4. Hillier, F. S., & Lieberman, G. J. (2021). Introduction to Operations Research (11th ed.)McGraw-Hill Education (India) Pvt. Ltd.

Math.323 Complex Analysis 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is:

- To study the techniques of complex variables and functions together with their derivatives, Contour integration and transformations.
- To study complex power series, classification of singularities, calculus of residues and its applications in the evaluation of integrals, and other concepts and properties.

LEARNING OUTCOMES:

This course will enable the students to:

- Understands the fundamental concepts of complex variable theory and skill of contour integration to evaluate complicated real integrals via residue calculus.
- Apply problem-solving using complex analysis techniques applied to diverse situations in physics, engineering, and other mathematical contexts.

THEORY (45 Hours)

UNIT I **(15 Hours)**

Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

UNIT-II **(15 Hours)**

Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions.

UNIT-III **(15 Hours)**

Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem, Cauchy integral formula. Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READINGS:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.
2. Joseph Bak and Donald J. Newman, Complex analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.
3. Walter Ruddin, Real and Complex Analysis, McGraw-Hill International Editions, 3/e, 1987.
4. Ahifors.L. V., Complex Analysis., McGraw Hill, New York, 2/e,1983.
5. S.Ponnusamy : Foundations of Complex Analysis, Narosa Pub, `97.
6. Kasana H.S., Complex Variables: Theory and Applications, Prentice-Hall of India Pvt. Ltd, 2ndedition, 2005.
7. Complex Analysis, Spectrum Publication, Jalandhar.

Math.324 Multivariate Calculus 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- The extension of the studies of single variable differential and integral calculus to functions of two or more independent variables.
- The geometry and visualisation of curves and surfaces in two dimensions (plane) and

26. three dimensions (space).

- The techniques of integration to functions of two and three independent variables.
- The applications of multivariate calculus tools to physics, economics, optimization etc.

LEARNING OUTCOMES:

This course will enable the students to:

- Learn the conceptual variations when advancing in calculus from one variable to multivariable discussion.
- Understand the maximization and minimization of multivariable functions subject to the given constraints on variables.
- Learn about inter-relationship amongst the line integral, double, and triple integral formulations.
- Familiarize with Green's, Stokes' and Gauss divergence theorems, and learn applications.

THEORY (45 Hours)

UNIT – I: Calculus of Functions of Several Variables (18 Hours)

Basic concepts, Limits and continuity, Partial derivatives, Tangent planes, Total differential, Differentiability, Chain rules, Directional derivatives and the gradient, Extrema of functions of two variables, Method of Lagrange multipliers with one constraint.

UNIT – II: Double and Triple Integrals (15 Hours)

Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Triple integrals over a parallelopiped and solid regions, Volume by triple integrals, Triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals.

UNIT – III: Green's, Stokes' and Gauss Divergence Theorem (12 Hours)

Vector field, Divergence and curl, Line integrals and applications to mass and work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral, Surface integrals, Stokes' theorem, Gauss divergence theorem.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READINGS:

1. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). Calculus (3rd ed.). Dorling
27. Kindersley (India) Pvt. Ltd. Pearson Education. Indian Reprint.
2. Marsden, J. E., Tromba, A., & Weinstein, A. (2004). Basic Multivariable Calculus. Springer (SIE). Indian Reprint.

HIGER LEVEL DISCIPLINE SPECIFIC COURSES:

Math.411 Advanced Real Analysis 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- Reimann Stieltjes integrals to relate Riemann-integral and Reimann Stieltjes integral and understand the partial integration theorem to evaluate R-S integrals of functions.
- Knowledge about term-by-term integration and term by term differentiation
- for evaluating uniform convergence of series of real valued functions.
- The methods to examine uniform convergence of sequences and series of real valued functions with idea about the uniform convergence of sequence and series of functions.
- The concepts of complete metric space, perfect set and connected set.

LEARNING OUTCOMES:

On completion of the Course, students will be able to

- Develop the understanding of Reimann Stieltjes integrals to relate Riemann-integral and Reimann Stieltjes integral. Also understand the partial integration theorem to evaluate R-S integrals of functions.
- Acquire knowledge about term-by-term integration and term by term differentiation
- for evaluating uniform convergence of series of real valued functions.
- Have the knowledge of methods to examine uniform convergence of sequences and series of real valued functions with idea about the uniform convergence of sequence and series of functions.
- Acquire knowledge of the concepts of complete metric space, perfect set and connected set.

THEORY (45 Hours)

UNIT I: (15 Hours)

Convergent Sequences. Sub-sequences. Cauchy Sequences (in metric spaces). Absolute Convergence. Addition and Multiplication of Series. Rearrangements of Series of Real Number. Power series, Uniqueness Theorem for Power Series. Abel's and Taylor's Theorems. Continuity, Limits of Functions (in Metric Spaces). Continuous Functions, Continuity, Uniform Continuity and Compactness. Limit Inferior and Limit Superior. Integral Test. Comparison Test.

UNIT II: **(12 Hours)**

Definition and Existence of Riemann-Stieltjes Integral. Properties of The Integral. Integration and Differentiation. The Fundamental Theorem of Calculus. Change of Variable. Rectifiable Curves.

UNIT III: **(18 Hours)**

Problem of Interchange of Limit Processes for Sequences of Functions, Pointwise and Uniform Convergence, Cauchy Criterion for Uniform Convergence. Weierstrass M-Test. Abel's and Dirichlet's Tests for Uniform Convergence. Uniform Convergence and Continuity. Uniform Convergence and Riemann – Stieltjes Integration. Uniform Convergence and Differentiation. The Weierstrass Approximation Theorem.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READINGS:

1. Walter Rudin, Principles of Mathematical Analysis (3rd Edition), McGraw-Hill, Kogakusha, 1976, International Student Edition.
2. T.M. Apostol, Mathematical Analysis, Narosa publishing House, New Delhi, 1985.
3. S. Lang, Analysis-I, Addison – Wesley Publishing Company, Inc. 1969
4. Robert G. Bartle, Donald R. Sherbest, Introduction to Real Analysis (Fourth Edition-(2015), John Wiley & Sons, Inc.
5. S.C. Malik, Savita Arora, Mathematical Analysis (Third edition-2008), New Age International (P) Ltd., New Delhi.

Math.412 Advanced Algebra 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- The concept of group actions on sets, normal series, solvable group, nilpotent group, and their application.
- Finitely generated Abelian groups which are decomposable as a finite direct sum of cyclic groups.
- The ring theory and special classes of rings such as Quotient rings, Euclidean rings, ring of Gaussian integers and Polynomial rings over the Rational fields; Commutative rings.

LEARNING OUTCOMES:

On completion of the course, students shall be able to

- Develop the understanding about the importance of group actions on sets, describe the normal series, solvable groups, nilpotent groups, and their applications to characterize some classes of groups.
- Attain the knowledge about finitely generated Abelian groups which are decomposable as a finite direct sum of cyclic groups which enables the students to find the number of non-isomorphic Abelian groups of given order.
- Provide the comprehensive understanding of ring theory and some special classes of rings such as Quotient rings, Euclidean rings, ring of Gaussian integers and Polynomial rings over the Rational fields; Commutative rings.

THEORY (45 Hours)

UNIT I **(15 Hours)**

Conjugacy and G-Sets. Normal Series, Solvable Groups, Nilpotent Groups, Direct Products, Finitely Generated Abelian Groups, Invariants of a Finite abelian Groups, Sylow Theorems, Groups of Orders p^2, pq.

UNIT II **(15 Hours)**

Definition and Examples of Rings, Some Special Classes of Rings, Homomorphisms, Ideals and Quotient Rings, More Ideals and Quotient Rings and The Field of Quotients of an Integral Domain. Euclidean Rings, a Particular Euclidean Ring, Polynomial Rings, Polynomials over the Rational Field, Polynomial Rings over Commutative Rings.

UNIT III **(15 Hours)**

Definition and examples, Submodules and direct sums, homomorphisms and quotient modules, completely reducible modules, Free modules.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READINGS:

1. P.B. Bhattacharya, S.K. Jain & S.R. Nagpal, Basic Abstract Algebra, 2nd Edition, Cambridge University Press.
2. I.N. Herstein, Topics in Algebra, Second Edition), John Wiley & Sons, New York.
3. Kenneth Hoffman & Ray Kunze, Linear Algebra, Second Edition, Prentice-Hall of India Private Limited, New Delhi.

Math.413 Ordinary Differential Equations 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- The existence and uniqueness of the solution of an initial value problem.
- The Sturm-Liouville Boundary Value Problems and to construct the orthonormal functions.
- Investigate the nonlinear differential equations and the corresponding nonlinear autonomous systems and their critical points which are helpful in predicting the nature of the solution of the nonlinear differential equations.
- Understand the various theoretical concepts of homogeneous and non-homogeneous ordinary differential equations and applications of eigen value problems.

LEARNING OUTCOMES:

On completion of the above course, the students will be able to

- Assure the existence and uniqueness of the solution of an initial value problem
- Handle the Sturm-Liouville Boundary Value Problems and to construct the orthonormal functions which can be used to expand any function as infinite series of these functions.
- Investigate the nonlinear differential equations and the corresponding nonlinear autonomous systems and their critical points which are helpful in predicting the nature of the solution of the nonlinear differential equations.
- Understand the various theoretical concepts of homogeneous and non-homogeneous ordinary differential equations and applications of eigen value problems.

THEORY (45 Hours)

UNIT I **(15 Hours)**

Some Concepts from Real Function theory. The Fundamental Existence and Uniqueness Theorem. Dependence of Solutions on Initial Conditions and on the Function. Existence and Uniqueness Theorems for Systems and Higher-Order equations. Introduction. Basic theory of the Homogeneous Linear System. Further theory of the Homogeneous Linear System. The Nonhomogeneous Linear System. Basic theory of the nth- Order Homogeneous Linear Differential Equation. The nth-Order Nonhomogeneous Linear equation.

UNIT II **(15 Hours)**

Sturm-Liouville Problems. Orthogonality of Characteristic Functions. The Expansion of a Function in a Series of Orthonormal Functions. The separation theorem, Sturm's fundamental theorem Modification due to Picone, Conditions for Oscillatory or non-oscillatory solution, First and Second comparison theorems. Sturm's Oscillation theorems. Application to Sturm Liouville System.

UNIT III **(15 Hours)**

Phase Plane, Paths, and Critical Points. Critical Points and paths of Linear Systems. Critical Points and Paths of Nonlinear Systems. Limit Cycles and Periodic Solutions. The Method of Kryloff and Bogoliuboff.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READING

1. S.L. Ross, Differential Equations, Third Edition, John Wiley & Sons, Inc.
2. E.L. Ince, Ordinary Differential Equations, Dover Publication Inc. 1956.
3. W. Boyce and R. Diprima, Elementary Differential Equations and Boundary value Problems, 3rd Ed. New York, (1977).
4. E.A. Coddington, An Introduction to Ordinary Differential Equations, 2nd Ed. Prentice Hall of India Pvt. Ltd., Delhi, (1974).

Math.421 Field Theory 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- The reducible and irreducible polynomials and their roots and identify the relations of one field to another (known as the concept of field extension).
- The field extensions, Algebraic extensions, Normal extensions, algebraically closed fields, splitting fields and Galosi theory
- The Galois theory which creates a bridge to move from a field to a group, and make some remarkable observations using group theory and acquire knowledge of separable extensions, automorphism group and fixed fields fundamental theorems of Galois theory and algebra.

LEANING OUTCOMES:

On completion of the course, students shall be able to

- Develop the understanding about the reducible and irreducible polynomials and their roots and identify the relations of one field to another (known as the concept of field extension).
- Attain the knowledge of field extensions, Algebraic extensions, Normal extensions, algebraically closed fields, and Splitting fields.
- Understand the Galois theory which creates a bridge to move from a field to a group, and make some remarkable observations using group theory and acquire knowledge of

separable extensions, automorphism group and fixed fields fundamental theorems of Galois theory and algebra.

THEORY (45 Hours)

UNIT I Field Extensions (15 Hours)

Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, algebraically closed fields, Splitting fields, Normal extensions, Multiple roots.

UNIT II Finite Fields (15 Hours)

Prime Fields, Finite fields, Roots of Irreducible Polynomials, Roots of unity and cyclotomic polynomials, Representation of Elements of Finite Fields, Order of Polynomials and Primitive Polynomials, Irreducible Polynomials.

UNIT III Galois Theory and its Applications (15 Hours)

Separable extensions, Automorphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem of algebra.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READING:

1. P.B. Bhattacharya, S.K. Jain & S.R. Nagpaul, 'Basic Abstract Algebra', Second Edition, Cambridge University Press.
2. Rudolf Lidl & Harald Niederreiter, "Finite Fields", Cambridge University Press.

Math.422 Partial Differential Equations 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- The Basic concepts related to partial Differential equations of first order and various methods to solve these equations.
- The classification of second order partial differential equations, their canonical forms and concept of adjoint operators. Derivation of Laplace equation/Poisson equation/ heat equation/wave equations from basic concepts and their basic properties.
- The Laplace equation (elliptic equation), Heat equation (Parabolic equation) and Wave equation (hyperbolic equation) by variable separable method and solve some boundary value problems by some standard methods.
- The Laplace, heat and Wave equations in various coordinate systems and solve them. Learn the use of theory and solutions/tools in solving the dynamical problems arising in engineering and physical sciences

LEARNING OUTCOMES:

After the completion of the course, students will be able to

- Understand the Basic concepts related to partial Differential equations of first order and various methods to solve these equations.
- Understand the classification of second order partial differential equations, their canonical forms and concept of adjoint operators.
- Derivation of Laplace equation/Poisson equation/ heat equation/wave equations from basic concepts and their basic properties.

- Solve the Laplace equation (elliptic equation), Heat equation (Parabolic equation) and Wave equation (hyperbolic equation) by variable separable method and solve some boundary value problems by some standard methods.
- Learn the use of theory and solutions/tools in solving the dynamical problems arising in engineering and physical sciences.

THEORY (45 Hours)

UNIT I **(15 Hours)**

Classification of Second Order Partial Differential Equations. Canonical Forms: Canonical Form for Hyperbolic Equation, Canonical Form for Parabolic Equation, Canonical form for elliptic equation. Adjoint Operators. Occurrence of the Laplace and Poisson Equations: Derivation of Laplace Equation, Derivation of Poisson Equation. Boundary Value Problems (BVPs). Some Important Mathematical Tools. Properties of Harmonic Functions. Separation of Variables, Dirichlet problem for a rectangle, the Neumann problem for rectangle.

UNIT II **(15 Hours)**

Occurrence of the Diffusion Equation. Boundary Conditions. Elementary Solutions of the Diffusion Equation. Dirac Delta Function. Separation of Variables Method. Solution of Diffusion Equation in Cylindrical Coordinates. Solution of Diffusion Equation in Spherical Coordinates. Maximum-Minimum Principle and its Consequences.

UNIT III **(15 Hours)**

Occurrence of the Wave Equation. Derivation of One-dimensional Wave Equation. Solution of One-dimensional Wave Equation by Canonical Reduction. The Initial Value Problem; D'Alembert's Solution. Vibrating String – Variables Separable Solution. Forced Vibrations – Solution of Nonhomogeneous Equation. Boundary and Initial Value Problem for Two-dimensional Wave Equation – Method of Eigenfunction. Periodic Solution of One- dimensional Wave Equation in Cylindrical Coordinates. Periodic Solution of One-dimensional Wave Equation in Spherical Polar Coordinates.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READING:

1. K. Sankara Rao, Introduction to Partial Differential Equations, Prentice Hall of India Private Limited, New Delhi, 1997.
2. Ian Sneddon, Elements of Partial Differential Equations, McGraw-Hill Book Company, 1985.
3. K.S. Bharma, Partial Differential Equations, An Introductory Treatment with Applications, PHI, N. Delhi, 2010.
4. Purna Chandra Biswal, Partial Differential Equations, PHI, Pvt. Ltd, New Delhi, 2015.

Math.423 Linear Algebra and Matrix Analysis 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- The basic idea of operators on finite dimensional vector spaces and the basic properties of Normal operators in the context of spectral theory.
- The diagonalizable matrices and have the basic properties of these matrices.
- The basic concept of matrix norms, their examples, and the unitarily invariant norm.

- The concept of positive definite matrices and have the basic properties of Positive definite matrices.

LEARNING OUTCOMES:

On completion of this course the students shall be able to:

- Assimilate the basic idea of operators on finite dimensional vector spaces and the basic properties of Normal operators in the context of spectral theory.
- Characterize the diagonalizable matrices and have the basic properties of these matrices.
- Acquire the knowledge of the basic concept of matrix norms, their examples, and the unitarily invariant norm.
- Characterize the positive definite matrices and have the basic properties of Positive definite matrices. Attain the working knowledge of inequalities involving positive definite matrices.

THEORY (45 Hours)

UNIT I **(15 Hours)**

Inner product, Inner product spaces, Linear functional and adjoints, orthogonal projections, self-adjoint operators. Unitary operators, Normal operators, Spectral theory, functions of operators. Polar decomposition.

UNIT II **(15 Hours)**

Simultaneously Diagonalizable Matrices, Unitary equivalence, some implication of Schur's theorem, the eigenvalues of sum and product of commuting matrices. Normal matrices, spectral theorem for normal matrices, simultaneously unitarily diagonalizable commuting normal matrices. Matrix norms, Examples, Operator norms, Matrix norms induced by vector norms, The spectral norm, Frobenius norm, Unitary invariant norm, The maximum column sum matrix norms, the maximum row sum matrix norm.

UNIT III **(15 Hours)**

Positive definite matrices, Definitions and properties, Characterizations, The positive semi-definite ordering, Inequalities for the positive definite matrices, Hadamard's inequality, Fischer's inequality, Minkowski's inequality.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READING:

1. Linear Algebra, Kenneth Hoffman and Ray Kunze, Second Edition (2001), Princeton-Hall of India.
2. Matrix Analysis, Roger A. Horn and Charles R. Johnson. Second Edition (2013). Cambridge University Press.
3. Matrix Analysis, Rajendra Bhatia, Springer Verlag, (1997).
4. Positive Definite Matrix, Rajendra Bhatia, Hindustan Book Agency, (2007).

HIGER & APPLIED AREA MINOR COURSES:

Math.414 Fuzzy Set Theory 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is:

- To describe various types of soft computing techniques, and applications of soft computing.
- To describe the fuzzy sets and fuzzy logic.
- To describe the fuzzy controller and fuzzy rule base and approximate reasoning.

LEARNING OUTCOMES:

After the completion of the course, students are able to:

- Understand the basic tools of soft computing.
- Understand the fuzzy sets and crisp sets, fuzzy set theory and operations.
- Understand the fuzzy controller and fuzzy rule base and approximate reasoning.

THEORY (45 Hours)

UNIT I: (15 Hours)

Introduction, soft computing vs. hard computing, various types of soft computing techniques, and applications of soft computing. Basic tools of soft computing - Fuzzy logic, neural network, evolutionary computing. Introduction: Neural networks, application scope of neural networks, fuzzy logic, genetic algorithm, and hybrid systems. Concepts of Fuzzy Set, Standard Operations of Fuzzy Set, Fuzzy Complement, Fuzzy Union, Fuzzy Intersection, Other Operations in Fuzzy Set, T- norms and T- conorms. Interval, Fuzzy Number, Operation of Interval, Operation of - cut Interval, Examples of Fuzzy Number Operation.

UNIT-II: (10 Hours)

Definition of Triangular Fuzzy Number, Operation of Triangular Fuzzy Number, Operation of General Fuzzy Numbers. Approximation of Triangular Fuzzy Number, Operations of Trapezoidal Fuzzy Number, Bell Shape Fuzzy Number. Function with Fuzzy Constraint, Propagation of Fuzziness by Crisp Function, Fuzzifying Function of Crisp Variable, Maximizing and Minimizing Set, Maximum Value of Crisp Function.

UNIT-III: (10 Hours)

Integration and Differentiation of Fuzzy Function Product Set, Definition of Relation, Characteristics of Relation, Representation Methods of Relations, Operations on Relations, Path and Connectivity in Graph, Fundamental Properties, Equivalence Relation, Compatibility Relation, Pre-order Relation, Order Relation, Definition and Examples of Fuzzy Relation, Fuzzy Matrix, Operations on Fuzzy Relation.

UNIT-IV: (10 Hours)

Composition of Fuzzy Relation, - cut of Fuzzy Relation, Projection and Cylindrical Extension, Extension by Relation, Extension Principle, Extension by Fuzzy Relation, Fuzzy distance between Fuzzy Sets. Graph and Fuzzy Graph, Fuzzy Graph and Fuzzy Relation.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READING:

1. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.
2. Chander Mohan , An Introduction to Fuzzy Set Theory and Fuzzy Logic, Anshan Publishers.
3. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 1991.
4. John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education.
5. Stamatios V. Kartalopoulos, Understanding Neural Networks and Fuzzy Logic Basic concepts & Applications, IEEE Press, PHI, New Delhi, 2004.
6. Vojislav Kecman, Learning & Soft Computing Support Vector Machines, Neural Networks, and Fuzzy Logic Models, Pearson Education, New Delhi,2006.

Math.415 Fluid Dynamics 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is:

- To understand the properties of fluids and fluid statics
- To derive the equation of conservation of mass and its application
- To solve kinematic problems such as finding particle paths and stream lines •
- To use important concepts of continuity equation, Bernoulli's equation and turbulence, and apply the same to problems
- To analyze laminar and turbulent flows and to understand the various flow measuring devices.

LEARNING OUTCOMES:

Upon successful completion of this course the students will be able to:

- Understand the various properties of fluids and their influence on fluid motion and analyse a variety of problems in fluid statics and dynamics.
- Calculate the forces that act on submerged planes and curves.
- Identify and analyse various types of fluid flows.
- Apply the integral forms of the three fundamental laws of fluid mechanics to turbulent and laminar flow through pipes and ducts to predict relevant pressures, velocities, and forces

THEORY (45 Hours)

UNIT-I (15 Hours)

Types of fluids, Lagrangian and Eulerian method of describing fluid motion, most general motion of the fluid element: translation, rotation, and deformation. Stream lines, path lines and streak lines, material derivative, acceleration components of fluid particle in cartesian, cylindrical and spherical polar coordinates (without proof), vorticity vector, vortex lines, rotational and irrotational motion. Velocity, potential boundary surface, boundary condition. Irrotational motion in two-dimensional, stream functions, complex velocity potential, sources, sinks, doublets, and their images in two dimensional.

UNIT-II (15 Hours)

Continuum hypothesis, Newton's law of viscosity, some cartesian tensor notations. Stress Analysis: Stress at a point, Stress in a fluid at rest, Stress in a fluid in motion, Relation between stress and rate of strain components (Stokes' Law of Friction), Thermal conductivity, Generalized law of heat conduction. Fundamental Equations of the flow of viscous fluids: Introduction, Equation of State, Equation of continuity, Equations of motion (Navier-Stokes Equations), Equation of energy, Vorticity and Circulation (Kelvin's Circulation Theorem).

UNIT-III **(15 Hours)**

Dynamical similarity (Reynolds law), Inspection analysis, Dimensional analysis, Buckingham π theorem and its application, π product and coefficients, non-dimensional parameter and their physical importance. Exact solution of the N-S Equations, Steady motion between the parallel plates (a) velocity distribution, (b) Temperature distribution, Plane couette flow, Plane Poiseuille flow, Generalized plane Couette flow. Flow in a circular pipe (Hagen-Poiseuille flow) (a) Velocity distribution, (b) temperature distribution. Theory of very slow motion: Flow past a sphere (Stokes' and Oseen' flow.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READINGS:

1. J.L. Bansal, Viscous fluid dynamics, Oxford and IBH Publishing Company Pvt. Ltd., (1977).
2. F. Chorlton, Text book of fluid dynamics, CBS Publishers and distribution. (2000).
3. G.K. Batchelor, An introduction to fluid dynamics, Cambridge University press, (1970).
4. C.S. Yih, Fluid Mechanics, McGraw-Hill Book Company. 3. S.W. Yuan, Foundation of Fluid Mechanics, PHI Pvt Ltd. New Delhi (1969).

Math.416 Mathematical Python 3+1

LEARNING OBJECTIVES:

TheObjectives of this course are as follows:

- To be able to model and solve mathematical problems using Python Programs.
- To experience utility of open-source resources for numerical and symbolic

28. mathematical software systems

LEARNING OUTCOMES:

This course will enable the students to use Python:

- For numerical and symbolic computation in mathematical problems from calculus, algebra, and geometry.
- To tabulate and plot diverse graphs of functions and understand tracing of shapes, geometries, and fractals.
- To prepare smart documents with LaTeX interface.

THEORY (45 Hours)

UNIT – I: Drawing Shapes, Graphing and Visualization **(15 Hours)**

Drawing diverse shapes using code and Turtle; Using matplotlib and NumPy for data organization, Structuring and plotting lines, bars, markers, contours and fields, managing, subplots and axes; Pyplot and subplots, Animations of decay, Bayes update, Random walk.

UNIT – II: Numerical and Symbolic Solutions of Mathematical Problems **(18 Hours)**

NumPy for scalars and linear algebra on n-dimensional arrays; Computing eigenspace, Solving dynamical systems on coupled ordinary differential equations, Functional programming fundamentals using NumPy; Symbolic computation and SymPy: Differentiation and integration of functions, Limits, Solution of ordinary differential equations, Computation of eigenvalues, Solution of expressions at multiple points (lambdify), Simplification of expressions, Factorization, Collecting and canceling terms, Partial fraction decomposition, Trigonometric simplification, Exponential and logarithms, Series expansion and finite differences, Solvers, Recursive equations.

UNIT – III: Document Generation with Python and LaTeX (12 Hours)

Pretty printing using SymPy; Pandas API for IO tools: interfacing Python with text/csv, HTML, LaTeX, XML, MSExcel, OpenDocument, and other such formats; Pylatex and writing document files from Python with auto-computed values, Plots and visualizations.

PRACTICAL (30 Hours)

- Software labs using IDE such as Spyder and Python Libraries.
- Installation, update, and maintenance of code, troubleshooting.
- Implementation of all methods learned in theory.
- Explore and explain API level integration and working of two problems with standard Python code.

SUGGESTED READINGS:

1. Farrell, Peter (2019). Math Adventures with Python. No Starch Press. ISBN Number: 978-1-59327-867-0.
2. Farrell, Peter et al. (2020). The Statistics and Calculus with Python Workshop. Packet Publishing Ltd. ISBN: 978-1-80020-976-3.
3. Saha, Amit (2015). Doing Math with Python. No Starch Press. ISBN: 978-1-59327-640-9
4. Morley, Sam (2022). Applying Math with Python (2nd ed.). Packet Publishing Ltd. ISBN: 978-1-80461-837-0
5. Online resources and documentation on the libraries, such as:
    - https://matplotlib.org
    - https://sympy.org
    - https://pandas.pydata.org
    - https://numpy.org
    - https://pypi.org
    - https://patrickwalls.github.io/mathematicalpython/

Math.424 Integral Equations and Calculus of Variations 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is:

- To describe the methods to reduce Initial value problems associated with linear differential equations to various integral equations.
- To Categorize and solve different integral equations using various techniques.
- To solve the singular integral equations and derivation of Hilbert-Schmidt theorem.
- To know the variational problems, extremum of a functional and necessary conditions for the extremum of a functional.

LEARNING OUTCOMES:

After the completion of the course, students are able to

- Understand the methods to reduce Initial value problems associated with linear differential equations to various integral equations.
- Categorize and solve different integral equations using various techniques.
- Solve the singular integral equations and derivation of Hilbert-Schmidt theorem.
- Know the variational problems, extremum of a functional and necessary conditions for the extremum of a functional.

THEORY (45 Hours)

UNIT I: (15 Hours)

Integral Equations Definitions of Integral Equations and their classification, Eigen values and Eigen functions. Reduction to a system of algebraic equations, An Approximate Method. Fredholm Integral equations of the first kind. Method of Successive Approximations Iterative Scheme for Volterra and Fredholm Integral equations of the second kind. Conditions of uniform convergence and uniqueness of series solution. Resolvent kernel and its results. Application of iterative Scheme to Volterra integral equations of the Second kind. Classical Fredholm Theory Method of solution of Fredholm equations, Fredholm Theorems

UNIT II: (15 Hours)

Symmetric Kernels Introduction to Complex Hilbert Space, Orthonormal system of functions, Riesz-Fischer Theorem, Fundamental properties of Eigen values and Eigen functions for symmetric kernels, Expansion in Eigen function and bilinear form, Hilbert Schmidt Theorem and some immediate consequences, Solutions of integral equations with symmetric kernels. Singular Integral Equations The Abel integral equation, Cauchy principal value for integrals, Cauchy-type integrals, singular integral equation with logarithmic kernel, Hilbert- kernel, solution of Hilbert-type singular integral equation

UNIT III: (15 Hours)

Calculus of Variations Variational problems, the variation of a functional and its properties, Extremum of a functional, Necessary condition for an extremum, Euler's equation and its generalization, Variational derivative, General variation of a function and variable end point problem.

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READINGS:

1. R.P. Kanwal, Linear Integral Equation. Theory and Techniques, Academic Press, New York, 1971.
2. S. G. Mikhlin, Linear Integral Equations (translated from Russian) Hindustan Book Agency, 1960
3. J.M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall, New Jersy, 1963.
4. M. D. Raisinghania, Integral Equations & Boundary Value Problems, Sultan Chand & Sons.

Math.425 Operational Research 3+1*

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- The history and applications and uses of OR techniques in decision making. The convex set theory to find the optimal Basic feasible solution of LPP. Modelled the real-world problems as linear programming problems (LPP) and solve them by different OR techniques and tools

- Use of Simplex Method, Big-M Method, Dual Simplex method. Learn Duality Theory and solution of LPP by duality theory.
- Formulate the Integer Programming, Assignment and Transportation problems models and their solutions by different methods or algorithms.
- The basic concepts and derive results related to Queueing systems, Queueing problem, the Poisson process, and its properties.
- The importance of the Revised Simplex Method, learn the basic concepts of the method to solve the Linear Programming Problem and use the various Operations Research models in solving various decision analysis problems modelled form the real-world domain using different algorithms, OR tools and techniques.

LEARNING OUTCOMES:

After the completion of the course, students are able to

- Understand the history and applications and uses of OR techniques in decision making.
- Understand the convex set theory to find the optimal Basic feasible solution of LPP. Modelled the real-world problems as linear programming problems (LPP) and solve them by different OR techniques and tools
- Solve the LPP graphically, and use of Simplex Method, Big-M Method, Dual Simplex method. Learn Duality theory and solution of LPP by duality theory.
- Formulate the Integer Programming, Assignment and Transportation problems models and their solutions by different methods or algorithms.
- Understand the basic concepts and derive results related to Queueing systems, Queueing problem, the Poisson process, and its properties.
- Understand the importance of the Revised Simplex Method, learn the basic concepts of the method to solve the Linear Programming Problem and use the various Operations Research models in solving various decision analysis problems modelled form the real-world domain using different algorithms, OR tools and techniques.

THEORY (45 Hours)

UNIT I **(15 Hours)**

Brief Idea about: Introduction, origin and History of OR, Scientific Methods, Modelling in OR, OR models, Methodology of OR, OR in Decision making, and Applications of OR. Convex sets and their properties: convex sets, Hyperplane, and hyperspheres, Open and Close half-spaces, Theorem on; Convex sets, Convex polyhedron, feasible, basic feasible and optimal solutions, extreme points. Linear Programming Problem (LPP): Mathematical formulation of LPP, Graphical solution of LPP, Simplex Method, Charnes Big M Method, Two-phase Method, Degeneracy, Unrestricted variables, unbounded solutions, Revised Simples Method (Standard for-I). Duality theory: Concept of duality in LPP, Dual LPP, fundamental properties of Dual problems, Duality theorems, Complementary slackness, Advantages of Duality.

UNIT II **(15 Hours)**

Dual Simplex Method: computational procedure of dual Simplex Method. Integer programming (IPP): Pure and Mixed IPP, Gomory's Method, Geometrical Interpretation of Cutting plane method, Branch, and Bound Method. Transportation Problem (TP): Mathematical formulation, Basic feasible solutions of TPs by North–West corner method, Least cost-Method, Vogel's approximation method. Unbalanced TP, Optimality test of Basic Feasible Solution (BFS) by U-V method, Degeneracy in TP. Assignment Problem (AP): Mathematical formulation, assignment methods, Hungarian method, Unbalanced AP; Rule to draw minimum numbers of lines, illustrative problems, Traveling Salesman Problem

UNIT III **(15 Hours)**

Game theory: Two-person, zero-sum games, The maximin – minimax principle, pure strategies, mixed strategies, Graphical solution of 2xn and mx2 games, Dominance property, General solution of $m \times n$ rectangular games, Linear programming problem of GP. Queueing Theory: Queueing systems, Queueing problem, Transient and steady states, Probability Distributions in Queueing systems. Poisson process (pure birth process), Properties of Poisson's arrivals, Exponential process, Markovian property, Pure death process, Service time distribution, Erlang service time distribution, Solution of Queueing Models: (M |(M |1) : (∞ |FCFS), (Birth and Death Model).

***TUTORIAL (15 Hours (1 Hour per week))**

SUGGESTED READING:

1. S.D. Sharma, Operations Research, Kedar Nath Ram Nath & Co. 14th Edition 2004 .
2. Kanti Swarup, P.K. Gupta and Manmohan, Operations Research, Sultan Chand & Sons 12th Edition, 2004.
3. G. Hadley, Linear Programming, Narosa Publishing House (2002).
4. H.A. Taha, Operations Research: An Introduction, Prentice Hall of India Pvt. Ltd., 7th Edition, 2004.
5. J.K. Sharma, Operations Research, Macmillan India Pvt. Ltd. 2003

RESEARCH/PROJECT/SEMINAR:

Math.391 Seminar 0+1

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Identify the problem related to the area of course specialization.
- Outline annotated bibliography of research demonstrating scholarly skills.
- Prepare a well-organized report employing elements of technical writing and critical thinking.
- Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

LEARNING OUTCOMES:

At the end of this course, students will be able to:

- Establish motivation for any topic of interest and develop a thought process for technical presentation.
- Organize a detailed literature survey and build a document with respect to technical publications.
- Analysis and comprehension of proof-of-concept and related data.
- Effective presentation and improve soft skills.
- Make use of new and recent technology for creating technical reports

- Will be able to present themselves in front of an audience. It will help them to develop skills like speaking ability, gain and express knowledge in different fields and presentation capability.

Math.491 Pre-Research 0+4

LEARNING OUTCOMES:

The students will be able to

- develop interest in theoretical and practical research.
- decide their area of research as per their competency.
- get theoretical and practical knowledge of a specific area of research.
- prepare themselves for quality research in any mathematical discipline and allied areas.

Students will prepare a research proposal based on literature review and extensive student-mentor interactions involving discussions, meetings, and presentations. Each student will submit a research/dissertation proposal of the research work planned for the research dissertation with origin of the research problem, literature review, hypothesis, objectives, and methodology to carry out the planned research work, expected outcomes and bibliography.

Math.492 Research 0+8

LEARNING OUTCOMES:

The students will be able to

- develop interest in theoretical and practical research.
- decide their area of research as per their competency.
- get theoretical and practical knowledge of a specific area of research.
- prepare themselves for quality research in any mathematical discipline and allied areas.

Students will carry out their research work under the supervision of a faculty member. Students will interact with the supervisors through meetings and presentations on a regular basis. After completion of the research work, students will complete the dissertation under the guidance of the supervisor.

Math.493 Academic Project 0+4

LEARNING OUTCOMES:

The students will be able to

- develop interest in research in the field of Mathematics.
- To decide the area of research as per their competency.
- get theoretical and practical knowledge of a specific area of research.
- prepare themselves for quality research in any mathematical discipline and allied areas.

Students will carry out their project work under the supervision of a faculty member. Students will interact with the supervisors through meetings and presentations on a regular basis. After completion of the project, students will submit the project under the guidance of the supervisor. Group project may be opted, with a group consisting of a maximum of four students. These students may work using a single approach or multidisciplinary approach

CHEMISTRY
(DISCIPLINE – C)

DISCIPLINE SPECIFIC COURSES:

Chem.111 Atomic Structure & Chemical Bonding 3+1

LEARNING OBJECTIVES:

Objectives of the course are:

- To review the structure of the atom, as it is a necessary pre-requisite in understanding the nature of chemical bonding in compounds.
- To discuss the periodicity in properties with reference to the s and p block, this is necessary in understanding their group chemistry.
- To provide basic knowledge about different types of bonding present between atoms or ions.

LEARNING OUTCOMES:

The students will be able to:

- Solve the conceptual questions related to quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p, and d orbitals, and periodicity in atomic radii, ionic radii, ionization enthalpy and electron affinity of elements.
- Predict the geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).
- Understand the concept of lattice energy using Born-Landé and Kapustinskii equation.
- Calibrate the apparatus used in titrimetric analysis and prepare standard solutions for titration.
- Understand the theory and application of various acid-base and redox titrations.

THEORY (45 Hours)

UNIT-I: Atomic Structure (15 Hours)

Recapitulation of concept of atom, Bohr's theory & its limitations, atomic spectrum of hydrogen atom.de Broglie concept of dual nature of matter, Heisenberg's Uncertainty Principle, and its significance. Postulates of wave mechanics, Time independent Schrödinger's wave equation, well behaved wave function, significance of ψ and ψ^2. Quantum mechanical treatment of H- atom, Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial function plots, radial probability distribution plots, angular distribution curves. Shapes of *s*, *p*, and *d* orbitals, Relative energies of orbitals. Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity, Aufbau principle and its limitations.

UNIT- II: Periodic properties of Elements & Periodic Trends (6 Hours)

Brief discussion of the following properties of the elements, with reference to *s*- &*p*-block and their trends:

a) Effective nuclear charge, shielding or screening effect and Slater's rules
b) Atomic and ionic radii
c) Ionization enthalpy (Successive ionization enthalpies)
d) Electron gain enthalpy

e) Electronegativity, Pauling's scale of electronegativity. Variation of electronegativity with bond order and hybridization.

UNIT- III: Ionic bond **(12 Hours)**

General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Lattice energy, Born-Landé equation with derivation, Madelung constant, importance of Kapustinskii equation for lattice energy. Born-Haber cycle and its applications. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

UNIT- IV: Covalent bond **(12 Hours)**

Valence shell electron pair repulsion (VSEPR) theory, shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCl_3, PCl_5, SF_6, ClF_3, I_3^-, $BrF_2^{+,}$ PCl_6^-, ICl_2^+, $ICl_4^{-,}$ and SO_4^{2-}. Application of VSEPR theory in predicting trends in bond lengths and bond angles. Valence Bond theory (*Heitler-London* approach). Hybridization, equivalent and non-equivalent hybrid orbitals, Bent's rule.Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. Molecular orbital diagrams of homo & hetero diatomic molecules [N_2, O_2, C_2, B_2, F_2, CO, NO] and their ions; HCl (idea of s-p mixing and orbital interaction to be given).

PRACTICALS (30 Hours)

1. **Titrimetric Analysis:**

(i) Calibration and use of apparatus.

(ii) Preparation of solutions of different Molarity/Normality.

2. **Acid-Base Titrations:** Principles of acid-base titrations are to be discussed.

(i) Estimation of oxalic acid using standardized NaOH solution.

(ii) Estimation of sodium carbonate using standardized HCl.

(iii)Estimation of carbonate and hydroxide present together in a mixture.

(iv)Estimation of carbonate and bicarbonate present together in a mixture.

3. **Redox Titration:** Principles of oxidation-reduction titrations to be discussed.

(i) Estimation of oxalic acid using standardized $KMnO_4$ solution.

(ii) Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

(iii)Estimation of oxalic acid and sodium oxalate in a given mixture.

SUGGUESTED READINGS:

1. Lee, J.D. (2010), Concise Inorganic Chemistry, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), Concepts and Models of Inorganic Chemistry, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
5. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons.
6. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5th Edition, Pearson.
7. Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited.
8. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.
9. Shiver, D.; Weller, M.; Overton, T.; Rourke, J.; Armstrong, F. (2014), Inorganic Chemistry, 6th Edition, Freeman & Company
10. Das, A. K.; Das, M. (2014), Fundamental Concepts of Inorganic Chemistry, 1st Edition, Volume CBS Publishers & Distributors Pvt. Ltd.

11. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.
12. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company

Chem.121 Basic Concepts and Aliphatic Hydrocarbons 3+1

LEARNING OBJECTIVES:

Objectives of the course are:

- To recapitulate of fundamental concepts of organic chemistry and their application in different organic compounds like alkanes, alkenes, alkynes etc.
- To introduce the students to the concept of visualizing the organic molecules in a three-dimensional space.

LEARNING OUTCOMES:

The students will be able to:

- Understand and explain the electronic displacements and reactive intermediates and their applications in basic concepts.
- Formulate the mechanistic route of organic reactions by recalling and correlating the fundamental concepts.
- Identify and comprehend mechanism for free radical substitution, electrophilic addition, nucleophilic substitution, and elimination reactions.
- Understand the fundamental concepts of stereochemistry.

THEORY (45 Hours)

UNIT I: **(9 Hours)**

Basic Concepts of Organic Chemistry:
Electronic displacements and their applications: inductive, electrometric, resonance and mesomeric effects and hyperconjugation. Dipole moment, acidity and basicity.
Homolytic and heterolytic fissions with suitable examples. Types, shape and relative stability of carbocations, carbanions, carbenes and free radicals.
Electrophiles & nucleophiles, and introduction to types of organic reactions: addition, elimination and substitution reactions.

UNIT II: **(18 Hours)**

Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. specific rotation; Configuration and projection formulae: Newman, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration.
Racemic mixture and their resolution. Relative and absolute configuration: D/L and R/S designations (CIP rules).
Geometrical isomerism: *cis-trans*, *syn-anti* and *E/Z* notations.
Conformational Isomerism: Alkanes (Conformations, relative stability and energy diagrams of Ethane, Propane and butane). Relative stability of cycloalkanes (Baeyer strain theory), Cyclohexane conformations with energy diagram. Conformations of monosubstituted cyclohexanes.

UNIT III: **(18 Hours)**

Aliphatic Hydrocarbons Alkanes: Preparation, Halogenation of alkanes, Concept of relative reactivity v/s selectivity.

Alkenes and Alkynes: Methods of preparation of alkenes using Mechanisms of E_1, E_2, E_1cb reactions, Saytzeff and Hoffmann eliminations. Electrophilic additions, mechanism with suitable examples, (Markownikoff/Anti-markownikoff addition), *syn* and *anti*-addition; addition of H_2, X_2, oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, hydroxylation, reaction with NBS, Reactions of alkynes; acidity, Alkylation of terminal alkynes, electrophilic addition: hydration to form carbonyl compounds, Relative reactivity of alkenes and alkynes, 1,2-and 1,4-addition reactions in conjugated dienes, Diels Alder reaction (excluding stereochemistry)

PRACTICAL (30 Hours)

1. Calibration of a thermometer and determination of the melting points of the organic compounds using any one of the following methods-Kjeldahl method, electrically heated melting point apparatus and BODMEL).
2. Concept of melting point and mixed melting point.
3. Concept of recrystallisation using alcohol/water/alcohol-water systems (Any two).
4. Determination of boiling point of liquid compounds (boiling point lower than and more than 100 °C by distillation, capillary method and BODMEL method)
5. Separation of a mixture of two amino acids/sugars by radial/ascending paper chromatography.
6. Separation of a mixture of *o*-and *p*-nitrophenol or *o*-and *p*-aminophenol by thin layer chromatography (TLC).
7. Detection of extra elements.

SUGGUESTED READINGS:

1. Morrison, R.N., Boyd, R.N., Bhattacharjee, S.K. (2010), Organic Chemistry, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
2. Finar, I.L. (2002), Organic Chemistry, Volume 1, 6th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
3. Eliel, E.L., Wilen, S.H. (1994), Stereochemistry of Organic Compounds; Wiley: London.
4. Mann, F.G., Saunders, B.C. (2009), Practical Organic Chemistry, 4th Edition, Pearson Education.
5. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
6. Furniss, B.S., Hannaford, A.J., Smith, P.W.G.; Tatchell, A.R (2004), Vogel's Textbook of Practical Organic Chemistry, Pearson.
7. Leonard, J., Lygo, B., Procter, G. (2013) Advanced Practical Organic Chemistry, 3rd Edition, CRC Press.
8. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi

Chem.211 States of Matter and Chemical Kinetics 3+1

LEARNING OBJECTIVES:

The objective of this course is

- to develop understanding of basic and advanced concepts regarding gases, liquids and solids.
- to study the similarity and differences between the different states of matter and reasons responsible for these.
- to develop skills for working in physical chemistry laboratory.

LEARNING OUTCOMES:

By the end of the course, the students will be able to:

- Derive mathematical expressions for different properties of gas and liquid and understand their physical significance.
- Apply the concepts of gas equations and liquids while studying other chemistry courses and everyday life.
- Handle stalagmometer and Ostwald viscometer properly.
- Determine the density of aqueous solutions.

THEORY (45 Hours)

UNIT – I **(24 Hours)**

Gaseous state

Kinetic Theory of gases- postulates and derivation of kinetic gas equation, Maxwell distribution of molecular velocities and its use in evaluating average, root mean square and most probable velocities and average kinetic energy. Definition, expression, applications and temperature and pressure dependence of each one of the following properties of ideal gases: Collision frequency, Collision diameter, Mean free path. Coefficient of viscosity, definition, units and origin of viscosity of gases, relation between mean free path and coefficient of viscosity, temperature and pressure dependence of viscosity of a gas, calculation of molecular diameter from viscosity

Barometric distribution law, its derivation and applications, alternative forms of barometric distribution law in terms of density and number of molecules per unit volume, effect of height, temperature and molecular mass of the gas on barometric distribution

Behaviour of real gases- Compressibility factor, Z, Variation of compressibility factor with pressure at constant temperature *(plot of Z vs P)* for different gases (H_2, CO_2, CH_4 and NH_3), Cause of deviations from ideal gas behaviour and explanation of the observed behaviour of real gases in the light of molecular interactions

van der Waals equation of state,Limitations of ideal gas equation of state and its modifications in the form of derivation of van der Waal equation, Physical significance of van der Waals constants, application of van der Waal equation to explain the observed behaviour of real gases.

Isotherms of real gases- Critical state, relation between critical constants and van der Waals constants, correlation of critical temperature of gases with intermolecular forces of attraction, Continuity of states, Limitations of van der Waals equation, Reduced equation of state and law of corresponding states (statement only).

Virial equation of state-Physical significance of second and third virial coefficients, van der Waals equation expressed in virial form, Relations between virial coefficients and van der Waals constants

UNIT – II **(6 Hours)**

Liquid state

Nature of liquid state, qualitative treatment of the structure of the liquid state

Physical properties of liquids-vapour pressure, its origin and definition, Vapour pressure of liquids and intermolecular forces, and boiling point

Surface tension, its origin and definition, Capillary action in relation to cohesive and adhesive forces, determination of surface tension by (i) using stalagmometer (drop number and drop mass method both) and (ii) capillary rise method, Effects of addition of sodium chloride, ethanol and detergent on the surface tension of water and its interpretation in terms of molecular interactions, Role of surface tension in the cleansing action of detergents

Coefficient of viscosity and its origin in liquids, Interpretation of viscosity data of pure liquids (water, ethanol, ether and glycerol) in the light of molecular interactions, Effects of addition of sodium chloride, ethanol and polymer on the viscosity of water, relative viscosity, specific viscosity and reduced viscosity of a solution, comparison of the origin of viscosity of liquids and gases, effect of temperature on the viscosity of a liquid and its comparison with that of a gas.

UNIT – III **(6 Hours)**

Solids: Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography- Law of constancy of interfacial angles, Law of rational indices. Miller indices. X-Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

UNIT – IV **(9 Hours)**

Chemical Kinetics: The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half-life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

PRACTICAL (30 Hours)

1. Surface tension measurements using stalagmometer
    a. Determine the surface tension of a liquid by drop number method.
    b. Determine the surface tension of a liquid by drop weight method.
2. Viscosity measurement using Ostwald's viscometer
    a. Determination of co-efficient of viscosity of unknown aqueous solution.
    b. Study the variation of viscosity with different concentration of sugar solutions.
    c. Study the effect of the addition of solutes such as (i) polymer (ii) ethanol (iii) sodium chloride on the viscosity of water at room temperature and explain the observations in terms of molecular interactions
    d. Study the variation of viscosity of water with the amounts of a solute and calculate the intrinsic viscosity at room temperature.
3. **Study the kinetics of the following reactions:**
    a. Acid hydrolysis of methyl acetate with hydrochloric acid.
    b. Saponification of ethyl acetate.
    c. Compare the strengths of HCl / H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

SUGGUESTED READINGS:

1. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
2. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.
4. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 6th Edition, McGraw Hill Education.
5. Moore, W.J. (1972), Physical Chemistry, 5th Edition, Longmans Green & Co. Ltd.
6. Glasstone, S. (1948), Textbook of Physical Chemistry, D. Van Nostrand company, New York.
7. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
8. Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.

9. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York

Chem.221 Chemistry of s-and p-Block Elements 3+1

LEARNING OBJECTIVES:

The objectives of this course are as follows:

- To develop the general principles of metallurgy and s-, p-block elements.
- To introduce the terms minerals, ores, concentration, benefaction, calcination, roasting, refining, etc. and explain the principles of oxidation and reduction as applied to the extraction procedures.
- To make students ware of different methods of purification of metals, such as electrolytic, oxidative refining, VanArkel-De Boer process and Mond's process are discussed and applications of thermodynamic concepts like that of Gibbs energy and entropy to the extraction of metals.
- To familiarize students with the patterns and trends exhibited by s- and p-block elements and their compounds with emphasis on synthesis, structure, bonding and uses.
- To impart information about the fundamentals of internal and external redox indicators, and iodometric/iodimetric titrations.

LEARNING OUTCOMES:

By studying this course, students will be able to:

- Learn the fundamental principles of metallurgy and understand the importance of recovery of by-products during extraction.
- Applications of thermodynamic concepts like that of Gibbs energy and
- entropy to the principles of extraction of metals.
- Learn about the characteristics of s- and p- block elements as well as the synthesis, structure, bonding, and uses of their compounds
- Understand the concept and use of internal and external redox indicators
- Comprehend the theory and application of iodometric and iodimetric titrimetric analysis

THEORY (45 Hours.)

UNIT-I: General Principles of Metallurgy (6 Hours)

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, Van Arkel-De Boer process, Zone refining. Brief discussion of metals and alloys used in ancient and medieval India.

UNIT- II: Chemistry of s- Block Elements (15 Hours)

General characteristics: melting point, flame colouration, reducing nature, diagonal relationships and anomalous behavior of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water.

Common features such as ease of formation, thermal stability, energetics of dissolution, and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates.

Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium. Solutions of alkali metals in liquid ammonia and their properties

UNIT-III: Chemistry of p-Block Elements **(9 Hours)**

Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Catenation, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behaviour of first member of each group.

UNIT – IV: Compounds of p-Block Elements **(15 Hours)**

Acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat on the following:Hydrides of Group 13 (only diborane), Group 14, Group 15 (EH3 where E = N, P,As, Sb, Bi), Group 16 and Group 17, Oxoacids of phosphorus, sulphur and chlorine, Interhalogen and pseudohalogen compound, Clathrate compounds of noble gases, xenon fluorides (MO treatment of XeF2).

PRACTICAL (30 Hours)

1. **Redox Titrations**
   (i) Estimation of Fe(II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.
   (ii) Estimation of Fe(II) with $K_2Cr_2O_7$ using N-phenyl anthranilic acid as internal indicator.
   (iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using external indicator.
2. **Iodo/Iodimetric Titrations**
   (i) Estimation of Cu(II) using sodium thiosulphate solution.
   (ii) Estimation of $K_2Cr_2O_7$using sodium thiosulphate solution
   (iii) Estimation of antimony in tartaremetic iodimetrically.
   (iv) Estimation of Iodine content in iodized salt.

SUGGUESTED READINGS:

THEORY
1. Lee, J. D.; (2010), Concise Inorganic Chemistry, Wiley India.
2. Huheey, J. E.; Keiter, E. A.; Keiter; R.L.; Medhi, O.K. (2009), Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.
3. Atkins, P. W.; Overton, T. L.; Rourke, J. P.; Weller, M. T.; Armstrong, F. A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
4. Miessler, G. L.; Fischer P. J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.
5. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5thEdition, Pearson.
6. Canham, G. R., Overton, T. (2014), Descriptive Inorganic Chemistry, 6th Edition, Freeman and Company.
7. Greenwood, N. N.; Earnsaw, A., (1997), Chemistry of Elements, 2nd Edition, Elsevier.

PRACTICAL
1. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denney, R. C. (1989), Vogel's Text book of Quantitative Chemical Analysis, John Wiley and Sons.
2. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company.
3. Day, R. A.; Underwood, A. L. (2012), Quantitative Analysis, 6th Edition, PHI Learning Private Limited.

Chem.311 Chemistry of Functional Groups 3+1

LEARNING OBJECTIVES:

The objectives of this course are as follows:

- To teach the students about fundamental chemical reactions of organic compounds.
- To provide information about synthesis of various useful organic compounds and their derivatives.

LEARNING OUTCOMES:

By the end of this course, students will be able to:

- Understand the differential behaviour of organic compounds.
- Formulate the mechanism of organic reactions by correlating the fundamental properties of reactants.

THEORY (45 Hours)

UNIT-I: **(8 Hours)**

Alkyl and Aryl Halides:
Alkyl Halides(Upto 5 Carbons)Types Nucleophilic Substitution(SN_1andSN_2) reactions. and SNi) reactions.
Preparation: from alkenes and alcohols.
Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.
Aryl Halides**:** Preparation: (Chloro, bromo and iodo-benzene): from phenol, Sandmeyer & Gattermann reactions.
Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).
Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

UNIT-II: **(14 Hours)**

Alcohols, Phenols and Ethers (Upto 5 Carbons): Alcohols: Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.
Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation. Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.
Phenols: (Phenol) Preparation: Cumene hydroperoxide method, from diazonium salts.
Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben– Hoesch Condensation, Schotten – Baumann Reaction.
Ethers (aliphatic and aromatic): Cleavage of ethers with HI.
Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde)
Preparation: from acid chlorides and from nitriles.
Reactions – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

UNIT-III: **(6 Hours)**

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.Carboxylic acids and their derivatives: Carboxylic acids (aliphatic and aromatic) Preparation: Acidic and Alkaline hydrolysis of esters.Reactions: Hell – Vohlard - Zelinsky Reaction.
Carboxylic acid derivatives (aliphatic): (Upto 5 carbons):
Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion.

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

UNIT- IV: (7 Hours)

Amines and Diazonium Salts: Amines (Aliphatic and Aromatic): (Upto 5 carbons)
Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction.
Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2,Schotten – Baumann Reaction. Electrophilic substitution (aniline): nitration, bromination, sulphonation.
Diazonium salts: Preparation: from aromatic amines.
Reactions: conversion to benzene, phenol, dyes.

UNIT-V: (10 Hours)

Amino Acids, Peptides and Proteins:
Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.
Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.
Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation,
N-terminal and C–terminal (thiohydantoin and with carboxypeptidase enzyme).
Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

PRACTICAL (30 Hours)

1. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.
2. Organic Synthesis:
   (i) Preparation of Iodoform.
   (ii) Preparation of p-bromoacetanilide from acetanilide.
   (iii) Preparation of glucosazone.
   (iv) Preparation of aspirin.
3. Thin Layer Chromatography
   (i) Determination of R_f value and purity of organic compounds by use of thin layer chromatography.
   (ii) To analyze the organic compounds by thin layer chromatography.

SUGGUESTED READINGS:

1. Principles of Physical Chemistry by Puri, Sharma and Pathania.
2. Physical Chemistry by S.C. Khetarpal, G.S, Sharma and R.K. Kalia.
3. Moderns Approach to Physical Chemistry by S. Kiran.
4. A text Book of Physical Chemistry by K.K.Sharma and I.K. Sharma
5. Physical Chemistry by P.N.Kapil and S.K.Guglani.
6. Elements of Physical Chemistry by Puri, Sharma and Pathania.
7. Advance Organic Chemistry Reaction Mechanism and Structure by Jerry March.
8. Organic Chemistry by SM Mukherji, SP Singh and RP Kapoor, Vol. I, II & III, New Age International Publishers
9. Organic Chemistry (Volume II) by I. L Finar

Chem.321 Chemical Thermodynamics and Electrochemistry 3+1

LEARNING OBJECTIVES:

The learning objectives: of this course are as follows:

- To provide basic knowledge about the heat changes taking place during various chemical and physical changes.
- To familiarise the students about the basic concepts of electrical conductivity.

LEARNING OUTCOMES:

By the end of this course, students will be able to:

- apply the fundamental concepts of energy changes taking place in the universe
- Understand the phenomena involved in conductance measurements and its applications.

UNIT-I: (10Hours)

Chemical Thermodynamics: Review of thermodynamics First Law of Thermodynamics, statement, definition of internal energy and enthalpy. Heat capacity, heat capacities at constant volume and pressure and their relationship. Joule's law, Joule-Thomson coefficient, and inversion temperature. Calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.
Thermochemistry: Standard state, standard enthalpy of formation- Hess's Law of heat summation and its applications. Heat of reaction at constant pressure and at constant volume. Enthalpy of neutralization. Bond dissociation energy and its calculation from thermo-chemical data, temperature dependence of enthalpy. Kirchhoff's equation.
Thermodynamics-II: Second law of thermodynamics: Need for the law, different statements of the law. Carnot cycle and its efficiency. Carnot theorem. Thermodynamic scale of temperature. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

UNIT-II: (8 Hours)

Chemical Equilibrium: Equilibrium constant and free energy. Thermodynamic derivation of law of mass action. Le Chatelier's principle Reaction isotherm and reaction isochore- Clapeyron equation and Clausius – Clapeyron equation, applications.

UNIT-III: (12Hours)

Ionic Equilibria: Strong, moderate, and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts, applications of solubility product principle.

UNIT-IV: (6 Hours)

Conductance: Conductivity, equivalent and molar conductivity, and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.
Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

UNIT-V: (9 Hours)

Electrochemistry: Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

PRACTICAL (30 Hours)

1. **Thermochemistry**
   i) Determination of Water Equivalent of a thermos flask.
   ii) Determination of heat of solution of KNO3 and KCl.
   iii) Determine the enthalpy of neutralization between strong acid and strong base.
   iv) Determine the enthalpy of neutralization between strong acid and weak base.
   v) Determine the enthalpy of hydration of CuSO4.
   vi) Determine the enthalpy of neutralization of a weak acid/weak base versus strong base/strong acid
2. pH measurements
   Preparation of buffer solutions:
   i) Sodium acetate-acetic acid
   ii) Ammonium Chloride and Ammonium Hydroxide
3. **Conductance:**
   i) Determination of cell constant
   ii) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
   iii) Perform the following conductometric titrations:
   iv) Strong acid vs. strong base
   v) Weak acid vs. strong base

SUGGUESTED READINGS:

1. Principles of Physical Chemistry by Puri, Sharma and Pathania.
2. Physical Chemistry by S.C. Khetarpal, G.S, Sharma and R.K. Kalia.
3. Modren’s Approach to Physical Chemistry by S. Kiran.
4. A text Book of Physical Chemistry by K.K. Sharma and I.K. Sharma
5. Physical Chemistry by P.N. Kapil and S.K. Guglani.
6. Elements of Physical Chemistry by Puri, Sharma and Pathania.

DISCIPLINE ELECTIVE COURSES:

Chem.212 Basic Quantum Chemistry and Photochemistry 3+1

LEARNING OBJECTIVES:

The learning objectives: of this course are as follows:

- To familiarize the students about structure of atoms and molecules in light of quantum theory.
- To learn about interaction between light radiations and matter.

LEARNING OUTCOMES:

By the end of this course, students will be able to:

- Understand the basic phenomena associated with the formation of molecules.
- Have an insight into the phenomena of fluorescence, phosphorescence, chemiluminescence.

THEORY (45 Hours)

UNIT-I: (12 Hours)

Quantum Chemistry: Black-body radiation, Planck's radiation law, photoelectric effect, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect. de Broglie hypothesis, Heisenberg's uncertainty principle, Sinusoidal wave equation, Schrodinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one-dimensional box.

UNIT-II: (22 Hours)

Chemical bonding:Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.

UNIT-III: (11 Hours)

Photochemistry: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photo stationary states, chemiluminescence.

PRACTICAL (30 Hours)

1. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/ $K_2Cr_2O_7$ in a solution of unknown concentration.
2. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
3. Study the kinetics of iodination of propanone in acidic medium.
4. Determine the amount of iron present in a sample using 1,10-phenathroline.
5. Determine the dissociation constant of an indicator (phenolphthalein).
6. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

SUGGUESTED READINGS:

1. Fundamentals of Molecular Spectroscopy by Banwell, & McCash.
2. Introductory Quantum Chemistry by A. K. Chandra,
3. Principles of Physical Chemistry by Puri, Sharma and Pathania.
4. Physical Chemistry by S.C.Khetarpal, G.S, Sharma and R.K. Kalia.
5. Modren Approach to Physical Chemistry by S. Kiran.
6. A text Book of Physical Chemistry by K.K.Sharma and I.K. Sharma
7. Physical Chemistry by P.N.Kapil and S.K.Guglani.
8. Elements of Physical Chemistry by Puri, Sharma and Pathania.
9. Experimental Physical Chemistry by B.D Khosla
10. Selected experimental in Physical Chemistry, Vol. I by J N Gurtu and R Kapoor.
11. Experimental Physical Chemistry by J C Ghose.

12. Systematic Practical Chemistry for B.Sc 1st, 2ndand 3rd year by P.C Kamboj
13. Vogel's Quantitative Chemical Analysis, by J.Mendham.

Chem.213 Spectroscopy 3+1

LEARNING OBJECTIVES:

The Objectives of this course are as follows:
- To familiarize the student about different kinds of spectroscopic techniques.
- To provide the information about structure elucidation.

LEARNING OUTCOMES:

By the end of this course, students will be able to:
- Have an insight about the different spectroscopic techniques.
- Identify the different kinds of techniques for structure determination.

THEORY (45 Hours)

UNIT-I: (4 Hours)

Molecular Spectroscopy: Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

UNIT-II: (5 Hours)

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

UNIT-III: (10 Hours)

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

UNIT-IV: (4 Hours)

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

UNIT-V: (4 Hours)

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

UNIT-VI: (18 Hours)

Application of Spectroscopy to Simple Organic Molecules: Application of visible, ultraviolet and Infra-red spectroscopy in organic molecules. Electromagnetic radiations and electronic transitions, λ_{max} & ε_{max}, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λ_{max} of conjugated dienes and α, β – unsaturated compounds.
Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding),

aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).
Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin- spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

PRACTICAL (30 Hours)

1. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J $molecule^{-1}$, kJ mol^{-1}, cm^{-1}, eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.
4. Analyse the given vibration-rotation spectrum of HCl(g)

SUGGUESTED READINGS:

For Theory:
1. Fundamentals of Molecular Spectroscopy by Banwell, & Mc Cash.
2. Introductory Quantum Chemistry by A. K. Chandra,
3. Principles of Physical Chemistry by Puri, Sharma and Pathania.
4. Physical Chemistry by S.C. Khetarpal, G.S, Sharma and R.K. Kalia.
5. A text Book of Physical Chemistry by K.K. Sharma and I.K. Sharma
6. Physical Chemistry by P.N. Kapil and S.K. Guglani.
7. Elements of Physical Chemistry by Puri, Sharma and Pathania.

For Lab:
1. Experimental Physical Chemistry by B.D Khosla
2. Selected experimental in Physical Chemistry, Vol. I by J N Gurtu and R Kapoor.
3. Experimental Physical Chemistry by J C Ghose.
4. Systematic Practical Chemistry for B.Sc 1st, 2nd and 3rd year by P.C Kamboj
5. Vogel's Quantitative Chemical Analysis, by J.Mendham.

Chem.222 Analytical Chemistry 3+1

LEARNING OBJECTIVES:

The learning objectives: of this course are as follows:

- To acquire basic knowledge of the analytical chemistry of important techniques that will provide the basis for their industrial production methods.
- To provide an adequate mastery of analytical methods used for the determination of commercial/domestic raw materials and finished product quality.

LEARNING OUTCOMES:

By the end of this course, students will be able to:
- understand the fundamental concepts of partition coefficients and their role in achieving separations across different types of chromatography.
- develop the core skills to parse existing chromatographic protocols and identify the key factors influencing a chromatography experiment.

- Understand the underlying assumptions of the most common chromatographic separation techniques and approaches to method validation.

THEORY (45 Hours)

UNIT – I: (6 Hours)

Qualitative and quantitative aspects of analysis: Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

UNIT-II: (6 Hours)

Optical methods of analysis: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.
UV-Visible Spectrometry*:* Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument.

UNIT-III:. (6 Hours)

Basic principles of quantitative analysis: Estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

UNIT – IV: Chromatography (10 Hours)

Classification of chromatographic methods: Principles of differential migration, description of chromatographic process, distribution coefficients, modes of chromatography, Column chromatography (elution time and volume) capacity factor, column efficiency and resolution, sample preparation.

UNIT – V: Paper Chromatography (05 Hours)

Experimental modifications, various modes of developments, nature of paper, detections of spots, retardation factors, factors that affect reproducibility of Rf values (due to paper, solvent system, sample, development procedures), selection of solvent, quantitative analysis, applications.

UNIT – VI: Thin Layer Chromatography (06 Hours)

Stationary phase, adsorbents, liquid phase support, plate preparation, mobile phase, sample application, development, saturation of chamber, detection of spot, R*f* values (effect of adsorbent, solvent, solute, development process), quantitative analysis, applications.

UNIT – VII: Solvent Extraction (07 Hours)

Distribution law, determination of distribution ratio, batch extraction, continuous extraction, discontinuous extraction, counter-current extraction.

PRACTICAL (30 Hours)

1. Separation and identification of amino acids present in the given mixture by ascendingpaper Chromatography.
2. Separation of ortho-nitrophenol & para-nitrophenol and *o*- and *p*-amino phenol by thin layer chromatography (TLC) and calculation of their R*f* values.
3. Separation of constituents of leaf pigments by thin layer chromatography and paper chromatography.
4. Separation of a mixture of compounds by solvent extraction.
5. Analysis of soil samples (*at least three soil samples to be collected for analysis*).
   i. Determination of pH of soil samples.
   ii. Determination of total soluble salts.

iii. Determination of carbonate and bicarbonate.
iv. Determination of calcium, magnesium and iron.
v. Determination of conductance of the soil samples.

SUGGUESTED READINGS:

1. Fifield ,F. W.; Kealey, D. (2000), Principles and Practice of Analytical Chemistry, Wiley.
2. Harris, D. C. (2007), Exploring Chemical Analysis, W.H. Freeman and Co.
3. Harris, D. C. (2007), Quantitative Chemical Analysis, 6th Edition, Freeman
4. Mikes, O. (2000), Laboratory Handbook of Chromatographic methods, D.Van Nostrand Company Inc.

Chem.223 Organometallics, Heterocyclic and Polynuclear Hydrocarbons 3+1

LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

- To make the students learn about organometallic compounds, an interface between organic and inorganic chemistry.
- To learn about polynuclear hydrocarbons and heterocyclic compounds.

LEARNING OUTCOMES:

By the end of this course, students will be able to:

- Identify the different kinds of organometallic compounds, their structures and nature of bonding.
- Compare the stability of different compounds including metal carbonyls.
- Learn about relative stability, reactivity, and aromatic character of polynuclear hydrocarbons and heterocyclic compounds.

THEORY (45 Hours)

UNIT-I: (10 Hours)

Organometllic Compounds: Definition and Classification with appropriate examples based on nature of metal- carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding, and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach).

UNIT-II: (12 Hours)

Heterocyclic Compounds: Introduction to molecular orbital picture and aromatic characteristics of furan, pyrrole, thiophene, and pyridine.methods of synthesis and chemical reactions (mainly electrophilic substitution with mechanism). mechanism of nucleophilic substitution reactions in pyridine derivatives.comparison of basicity of pyridine, piperidine and pyrrole.

UNIT-III: (12 Hours)

Introduction to condensed five and six membered heterocyclic compounds. Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fischer Indole synthesis, Skraup synthesis and Bischler – Napieralski synthesis. Mechanism of electrophilic substitution reactions of Indole, Quinoline and Isoquinoline.

UNIT-IV: **(6 Hours)**

Polynuclear and heteronuclear aromatic compounds: Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine.

UNIT-V: **(5Hours)**

Active methylene compounds: Preparation: Claisen ester condensation. Keto-enol tautomerism. Reactions:Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon).

PRACTICAL (30 Hours)

1. Section A: Inorganic Chemistry
   Preparation of the of the following complexes.
   (i) tetraamminecarbonatocobalt (III) nitrate
   (ii) tetraamminecopper (II) sulphate
   (iii)potassium trioxalatoferrate (III) trihydrate
2. Section B: Organic Chemistry

Systematic Qualitative Organic Analysis of Organic Compounds possessing functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines, carbohydrates).

SUGGUESTED READINGS:

1. Modern Approach to Inorganic Chemistry for B.Sc 1st year by SP Jauhar.
2. Principles f Inorganic Chemistry By Puri, Sharma and Kalia.
3. Inorganic Chemistry by James E Huhee.
4. Advanced Inorganic Chemistry by F.A.Cotton and G Wilkinson.
5. Modern Approach to Organic Chemistry By B.Sc 1st year by Sahgal.
6. Stereo Chemistry by P.S. Kalsi.
7. Organic Chemistry by Paula Yurkanis Bruice.
8. Reaction Mechanism by O. P. Aggarwal.
9. Modern Organic Chemistry By M.K.Jain and S.C. Sharma.
10. Concise Inorganic Chemistry by J.D. Lee.
11. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

For Lab

1. Vogel's Text Book of Qualitative Inorganic analysis (revised) J. Bassett, R.C. Cdenney, G. H. Jettery and J. Mendhan, ELBS.
2. Standard Methods of Chemical Analysis by W. W. Scott.
3. Experimental inorganic Chemistry by W. G. Paimer.
4. Vogel's Text Book of Qualitative Organic analysis (revised) J. Bassett, R.C Cdenney, G H Jettery and J Mendhan, ELBS.
5. Laboratory Manual in Organic Chemistry, R K Bansal.
6. Experimental Organic Chemistry Vol. I & II, P R Singh, D S Gupta and K S Bajpai.

Chem.322 Chemistry of Polymers 3+1

LEARNING OBJECTIVES:

The learning objectives: of this course are as follows:

- To familiarize the students about the different kinds of polymeric compounds.
- To provide knowledge about different properties of polymers.

LEARNING OUTCOMES:

By the end of this course, students will be able to:

- Compare the structures, properties and uses of various polymers.
- Learn about the kinetic studies of polymers.

THEORY (45 Hours)

UNIT -I: (15 Hours)

Polymers: Introduction and history of polymeric materials:Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. Functionality and its importance: Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems

UNIT -II: (15 Hours)

Kinetics of Polymerization: Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.
Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers-Structure Property relationships.

UNIT -III: (14 Hours)

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties).
Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene).

PRACTICAL (30 Hours)

Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
2. Preparation of nylon 66
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight by viscometry:
   i. Polyacrylamide-aq.$NaNO_2$ solution
   ii. Poly vinyl proplylidine (PVP) in water
2. Determination of the viscosity-average molecular weight of poly (vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

SUGGUESTED READINGS:

1. M.P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed., Oxford University Press, 1999.
2. H.R. Allcock, F.W. Lampe & J.E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall (2003)
3. F.W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
4. J.R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
5. P. Munk & T.M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
6. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
7. M.P. Stevens, Polymer Chemistry: An Introduction 3rd ed. Oxford University Press (2005).
8. Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

Chem.323 Molecules of Life 3+1

LEARNING OBJECTIVES:

The learning objectives of this course are as follows:
• To teach the students about fundamental molecules essential for life.
• To provide information about different classes of organic compounds and their biological uses.

LEARNING OUTCOMES:

By the end of this course, students will be able to:
• Understand the structure and importance of organic compounds for the human beings.
• Gain insight into the mechanism of different biological processes taking place.

THEORY (45 Hours)

UNIT-I: (12 Hours)

Carbohydrates: Classification of carbohydrates, reducing and non-reducing sugars, General properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosachharides, structure of disachharides (sucrose, maltose, lactose) and polysachharides (starch and cellulose) excluding their structure elucidation.

UNIT-II: (13 Hours)

Amino Acids, Peptides, Proteins and Enzymes: Classification of Amino Acids, Zwitterion structure and Isoelectric point. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity),

UNIT-III: (20 Hours)

Nucleic Acids and Lipids: Components of Nucleic acids: Adenine, guanine, thymine and cytosine (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (types of RNA), Genetic code, Biological roles of DNA and RNA: Replication, Transcription and Translation.
Introduction to lipids,classification. Oils and fats: Common fatty acids present in oils and fats, omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

PRACTICAL (30 Hours)

1. Separation of amino acids by paper chromatography
2. Action of salivary amylase on starch
3. Effect of temperature on the action of salivary amylase on starch.
4. To determine the saponification value of an oil/fat.
5. To determine the iodine value of an oil/fat
6. Differentiate between a reducing/non reducing sugar.
7. Extraction of DNA from onion/ cauliflower
8. To synthesize aspirin by acetylation of salicylic acid
9. Comparison of aspirin with the ingredient of an aspirin tablet by TLC.

SUGGUESTED READINGS:

For Theory
1. Modren Approach to Organic Chemistry by Sehgal.
2. Organic Chemistry (Volume 1), by I. L Finar.
3. Organic Chemistry (Volume II), by I. L Finar.
4. Lehninger's Principles of Biochemistry 7th Ed. By D. L. Nelson, & M. M. Cox

For lab
1. Vogel's Textbook of Practical Organic Chemistry by B.S. Furniss, A.J. Hannaford, V. Rogers, P.W.G. Smith, A.R. Tatchell.
2. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia, & R. Aggarwal

HIGHER LEVEL DISCIPLINE SPECIFIC COURSES:

Chem.411 Group Theory and X-ray Crystallography 3+1

LEARNING OBJECTIVES:

Objectives of this course are:
- to disseminate the knowledge of symmetry and its applications in structure determination.
- to provide basic knowledge about symmetry elements, symmetry operations and properties of group multiplication tables.

LEARNING OUTCOMES:

The student will be able to
- to explain IR and Raman spectral features in terms of group theory.
- to apply the study of single crystal X-ray structure its applications to supramolecular chemistry.

THEORY (45 Hours)

UNIT-I: Symmetry and Group Theory (11 Hours)

Fundamentals: Introduction to symmetry and group theory, symmetry operations, symmetry elements, point groups, identification of point group in molecules of special symmetry (linear molecules and molecules with multiple axes) molecules of low symmetry, molecules of high symmetry, notation of point group, assignment of point group, definitions of group, subgroup, class, relation between orders of a finite group and its subgroup

UNIT-II: Applications of Group Theory **(11 Hours)**

Group multiplication tables, conjugacy relation and classes, Schoenflies symbols, representation of groups, character of a representation, reducible and irreducible representations, character tables, the method of finding the number of irreducible representation in a reducible representation, construction of character table, matrix representation of symmetry elements and point groups,normal mode analysis, internal coordinate method, IR and Raman activity

UNIT-III: X-ray Crystallography **(12 Hours)**

X-ray and their properties. Use of X-ray diffraction to find atomic arrangements. Point group, space group and unit cell. Combining waves to obtain an image: Elementary treatment of Structure factor and Fourier synthesis. Crystals and intensity data collection: Fundamental concepts. The phase problem in crystallography: Direct methods of relative phase determination. Patterson method and heavy atom method. R-Factor criterion. Structure completion in practice. Refinement of crystal structure: Mention of refinement by Fourier synthesis. The method of least squares. Goodness of fit parameter, weighting functions.

UNIT-IV: Applications of X-ray Crystallography **(11 Hours)**

a) Derived results and applications: Representation of structural results. Chirality and absolute structure. Packing in crystals. Thermal and Photo-chemical reactions in solid state. Topochemical principle. Conformation of polypeptides: Ramachandran plot.
b) Supramolecular Chemistry: Introduction to supramolecular chemistry: basics and concepts. Non-covalent interactions in supermolecules, their nature type and role in pre-organization andcomplementarity. Introduction to crystal Engineering and supramolecular synthons. Anion binding sites and anon receptors. Applications of supramolecular chemistry.

PRACTICAL (30 Hours)

1. **Volumetric Analysis:**
   (a)Potassium iodate titrations: Determination of iodide, hydrazine, antimony (III) and arsenic (III)
   (b)Potassium bromate titrations
      i) Determination of antimony (III) and arsenic (III) Direct Method)
      ii) Determination of aluminium, cobalt and zinc (by oxine method)
2. **EDTA titrations**
      i) Determination of copper, nickel, magnesium
      ii) Back titration
      iii) Alkalimetric titration
      iv) Titration of mixtures using masking and damasking agents
      v) Determination of hardness of water
3. **Commercial Analysis:**
      i) Determination of available chlorine in bleaching powder
      ii) Determination of Oxygen in hydrogen peroxide.
      iii) Determination of Phosphoric acid in commercial phosphoric acid.
      iv) Determination of Boric acid in borax.
      v) Analysis of Ores (Dolomite, Pyrolusite) and alloys (Coin, Brass, Bronze).

SUGGUESTED READINGS:

1. Hollas J.M., Symmetry in Molecules, Pubs: Chapman and Hall (1972).
2. Harris D.C. and Bortolucci M.D., Symmetry and Spectroscopy, Pubs: Oxford University Press (1978).
3. Pearson R.G., Symmetry Rules for Chemical Reactions, Pubs: John Wiley (1976).
4. Bishop D.M., Group theory and Chemistry, Pubs: Oxford University Press (1973).

5. Vincent Alan, Molecular Symmetry and Group theory A programmed introduction to Chemical Applications, Pubs:John Wiley & Sons Ltd., 1977 (Reprint 1998).
6. Cotton F. A.,Chemical applications of group theory, 3 rd Edition, Pubs: John Wiley New York, 1971 [Indian print by Wiley Eastern, 1999].
7. Jaffe H. H. and Orchin M., Symmetry in Chemistry, Pubs: John Wiley New York, 1965.
8. Stout G.H. and Jeansen L.H., X-ray structure determination a practical guide, Pubs: John Wiley & Sons, New York (1989).
9. Glusker J.P., Lewis M, Crystal structure analysis for chemists and biologists, Pubs: VCH Publisher inc., New York (1994).
10. Steed J. W. and Atwood J. L., Supramolecular Chemistry, John Wiley and Sons, Ltd, (2000)
11. A text Book of Quantitative Inorganic Analysis: A.I. Vogal.
12. Commercial Methods of Analysis: Shell & Biffen

Chem.412 Chemistry of Natural Products 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- to familiarize the students about different classes of natural products.
- to provide basic knowledge about applications of natural products and their derivatives.

LEARNING OUTCOMES:

The student will be able to

- to synthesize different kinds of compounds.
- to apply the study of natural products to prepare different derivatives.

THEORY (45 Hours)

UNIT-I Terpenoids and Carotenoids (11 Hours)

Classification, occurrence, isolation, general methods of structure determination. Biosynthesis and synthesis of citral, geraniol, α -terpineol, menthol, farnesol, zingiberene, santonine, longifolene, abietic acid, and vitamin A. Plant Pigments Occurrence, nomenclature, synthesis of Quercetin myrcetin cyanidine hirsutidin

UNIT-II Steroids (11 Hours)

Occurrence, basic skeleton, stereochemistry, structure determination of cholesterol by degradation experiments, synthesis and biosynthesis of cholesterol, bile acids, and testosterone, estrone(Vollhardt Synthesis), progesterone(Johnsons Synthesis), vitamin D, cortisone.

UNIT-III Alkaloids (11 Hours)

Occurrence, isolation, general method structure elucidtion, degradation, classification based on nitrogen heterocyclic ring structure, stereochemistry andsynthesis of ephedrine, Nicotine, atropine, quinine (Woodward and Storks synthesis), morphine, (±) Strychnine*, chloroquin and primaquin

UNIT-IV Vitamins (12 Hours)

Occurrence, deficiency, physiological effects and synthesis of B complex, E and K. Chemotherapy Antibiotics: General structure determination/elucidation of penicillin and terramycin. Synthesis of penicillin G and V (via APA). Introduction to the structure and function of antibiotics i.e. ampicillin, amoxycillin, chloramphenicol, cephalosporin, tetracycline and streptomycin. Mode of action of antibacterial agents. Sulpha drugs Prostaglandins Biosynthesis, Synthesis of PGE2 and PGF2α.

PRACTICAL (30 Hours)

1. **Qualitative Analysis:** Separation, purification, and identification of binary mixture of organic compounds by chemical tests.
2. **Organic Synthesis:**
   29. Acetylation: - Acetylation of cholesterol and separation of cholesteryl acetate by column chromatography.
   30. Oxidation: Adipic acid by chromic acid oxidation of cyclohexanol.
   31. Grignard reaction: Synthesis of triphenyl methanol from benzoic acid.
   32. Aldol condensation: Dibenzal acetone from benzaldehyde.

SUGGUESTED READINGS:

1. Finar l. L, Organic Chemistry, Vol.1, 2, Pubs: ELBS (1994).
2. Nicolaou K.C. and Sorensen E.J., Classics in Total Synthesis, Pubs: VCHN.Y.(1986).
3. Nicolaou K.C. and Synder, S.A.Classics in Total Synthesis II, Pubs: VCH N.Y.(2003).
4. Akhrem, A.A.Total Steroids Synthesis, Pubs: Plenum Press, New York, (1970)
5. Solomon T.W.G. and Fryhle C.B., Organic Chemistry, 7thEdn., Pubs: John. Wiley & Sons Inc. N.Y. (2000).
6. Manitto P., Biosynthesis of Natural Products, Pubs: Horwood Ltd.(1981).
7. Padwa, A. Org. Lett. 2007, 9(2), 279-282
8. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C.Heath.
9. Systematic Qualitative Organic Analysis, H.Middleton, Adward Arnold.
10. Handbook of Organic Analysis-Qualitative and Quantitative, H.Clark, Adward Arnold.
11. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
12. Experiments and Techniques in Organic Chemistry, D.Pasto, C. Johnson and M.Miller, Prentice Hall.

Chem.413 Statistical Thermodynamics and Quantum Chemistry 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- to teach the fundamental concepts of statistical thermodynamics and quantum chemistry.
- to provide basic knowledge about applications of quantum chemistry

LEARNING OUTCOMES:

The student will be able to

- to understand the concepts of quantum chemistry
- to apply knowledge gained through the course to fundamental structure of atoms and molecules.

THEORY (45 Hours)

UNIT-I **(11 Hours)**

Statistical Thermodynamics:Basic Terminology: probability, phase space, micro and macro states, thermodynamic probability, statistical weight,
assembly, ensemble, The most probable distribution: Maxwell-Boltzmann distribution, quantum statistics: The Bose-Einstein statistics and Fermi- Dirac Statistics. Thermodynamic probability (W) for the three types of statistics. Lagrange's undetermined multipliers. Stirling's approximation, Molecular partition function and its importance.

Applications to ideal gases: The molecular partition function and its factorization. Evaluation of translational, rotational and vibrational partition functions, the electronic and nuclear partition functions for monatomic, diatomic and polyatomic gases.

UNIT-II **(11 Hours)**

Quantum Mechanics: black-body radiation, heat capacities, photoelectric and Compton effects, atomic and molecular spectra, particle diffraction, wave-matter duality.Foundation of Quantum theory Postulates of quantum mechanics. Uncertainty Principle Schrodinger equation and its interpretation.Hermitian operators and their properties. Commutation relations. Linear harmonic oscillator and its solution in terms of ladder operators(factorization method). Selection rules, expectation values.

UNIT –III **(11 Hours)**

Virial theorem. Hydrogen atom and its complete solution (including solution of the radial equation using factorization method). Spherical harmonics as wave functions of a rigid rotor. Total wave function of the hydrogen like atoms, shapes of atomic orbitals, Radial distribution function.Angular momentum, Spin. Coupling of angular momenta; spin-orbit coupling. Molecular term symbols.

UNIT-IV **(12 Hours)**

Approximate Methods: Time-Independent (Non-degenerate, degenerate states) perturbation theory. Application of time-dependent perturbation theory. The variation method. Comparison of perturbation and variation method. Valence-bond and molecular orbital approaches, their comparison and equivalence limit. The pi-electron approximation. Huckel theory of conjugated systems. Applications to ethylene, butadiene and benzene.

PRACTICAL (30 Hours)

1. **Refractive Index (RI) Measurements:** Refractive index measurements of pure solvents and analysis of solvent mixtures in terms of composition from the calibration plot.
2. **Conductometric Measurements:** Determination of cell constant, limiting molar conductance of simple electrolytes in water, verification of Ostwald, dilution law for week acetic acid.
3. **Thermochemistry:** Determination of water equivalent of thermos flask, and estimation of heat of neutralization for strong acid strong base, weak acid strong base or vice – versa, heat of hydration and solution of salts.

SUGGUESTED READINGS:

1. Atkins P.W. and Friedman R.S., Molecular Quantum Mechanics, 4th edition, Pubs: Oxford University Press, (2004).
2. McQuarrie D., Quantum Chemistry, 2nd edition, Pubs: University Science Books (2008).
3. Levine I.N., Quantum Chemistry, 5th edition, Pubs: Prentice Hall (2006).
4. Kreyszig E., Advanced Engineering Mathematics, Pubs: John Wiley, NY (2001).
5. Ayres F.Jr., Matrics, Pubs. McGraw Hill, New Delhi (1974).
6. Pilar F.L., Elementary Quantum Chemistry, Pubs:McGraw Hill (1968).
7. March N.H., Self-Consistent Fields in Atoms, Pubs:Pergamon Press (1975).
8. Chandra A.K., Introductory Quantum Chemistry, Pubs: Tata-McGraw Hill(1988).
9. Pople J.A. and Beveridge D.L., Approximate Molecular-Orbital Theory, Pubs: McGraw Hill, NY (1970).
10. Lowe J.P., Quantum Chemistry, Pubs: Academic Press (1993).
11. Senior Practical Physical Chemistry: B.D. Khosla, V.C. Garg and A. Khosla
12. Experimental Physical Chemistry: V. Athawale and P. Mathur.

Chem.421 Bioinorganic Chemistry 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- to provide deep insights into the chemistry of biological systems.
- to explain the role of metals in chemical reactions involved in these systems.

LEARNING OUTCOMES:

The student will be able to

- to understand the processes associated with heme and non-heme proteins, iron-sulphur proteins, and their role in biological systems.
- to have an insight into the role of metals in the functioning of some enzymes and in nitrogen fixation.

THEORY (45 Hours)

UNIT- I: (11 Hours)

Elementary Cell Biology: Introduction to biomolecules: proteins, enzymes, nucleic acids, porphyrin and corrins. Role of metals in bio-systems: a general survey of the role of main group elements and transition elements in biological systems ionophores, cation transport: Na/K ion pump. Heme and non-heme proteins, Haemoglobin and myoglobin as oxygen carriers, Bohr effect. Coordination chemistry of Fe(II) in haemoglobin and oxyhaemoglobin. Relaxed and tense (R & T) configurations of haemoglobin, electronic formulations and mode of bonding of dioxygen in haemoglobin (modeling), Cytochromes and other natural oxygen carriers such as hemerythrins and hemocyanins. (iv) Iron sulphur proteins and electron transfer agents in biological systems: Systems, synthetic models of 4-fe ferredoxins. (v) Iron supply and transport in biological systems: Ferritin, transferrin and siderophores.

UNIT-II: (12 Hours)

Bio-inorganic chemistry of cobalt, vitamin B12, cobalamins, cobamides and their model compounds. Redox chemistry of B12, mechanisms of reactions catalysed B12 dependent enzymes and model compounds of B12.Role of Metals in Medicine: Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs, selenium and tellurium drugs, cis-platin and analogues, alternatives to cis-platin, adverse effects of anticancer drugs, toxicity due to non-essential metals.

UNIT-III (11Hours)

Metalloenzymes and photosynthesis Metalloenzymes: Carbonic anhydrase and carboxy peptidase, amino peptidase, Alkaline phosphate. Superoxide dismutase; inhibition of metalloenzymes. Photosynthesis: Chloropphyll in photosynthesis, current hpothesis for the photo oxidation of chlorophyl, synthetic leaf, 'Z' diagram for electron transport in PS-I and PS-II photosystem. Model studies of WOC and Photosystems.

UNIT-IV (11 Hours)

Nitrogen fixation: Classification of nitrogen fixing bacteria. Nitrogenase enzymes: EXAFS (Extended X-ray absorption fine structure spectroscopy) for characterization of the cofactor of nitrogenase and its synthetic analogues-double cubane cluster. Vanadium containing nitrogenases, mechanism of nitrogen fixation by nitrogenases and role of ATP in nitrogen fixation. nitrite reductase and nitrate reductase.

PRACTICAL (30 Hours)

1. **Analysis of mixtures by gravimetric and volumetric methods from the mixture solutions:**
   Copper- Nickel
   Copper -Magnesium
   Copper-Zinc
   Iron-Magnesium
   Silver-Zinc
   Copper-Nickel-Zinc
   Fe(II)-Fe(III)
2. **Green methods of Preparation of the following:**
   Bis(acetylacetonato)copper(II)
   Tris(acetylacetonato)iron(III)
   Tris(acetylacetonato)manganese(III)

SUGGUESTED READINGS:

1. Purcell K.F. and Kotz J.C., Inorganic Chemistry, Pubs: W.B. Saunders & Co., London (1977).
2. Jolly W.L., Modern Inorganic Chemistry, Pubs: W.B. Saunders & Co., London (1984).
3. Cotton F.A. and Wilkinson G, Advanced Inorganic Chemistry, 5 th Edition, Pubs:Willey Eastern (1989).
4. Hughes M.N., Inorganic Chemistry of Biological Processes, Pubs: Willey (1972).
5. Dennis, Brown G., Chemistry of Vitamin B-12 and Related Inorganic Model, Systems, Progress in Inorganic Chemistry (Vol.18)

Chem.422 Pericyclic and Asymmetric Synthesis 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- to make students familiar about the concepts and applications of pericyclic reactions and asymmetric organic synthesis.
- to give information about the basic principle of enantioselective reactions and enantiomeric excess determination.

LEARNING OUTCOMES:

The student will be able to

- To apply the information about the synthetic applications of asymmetric organic synthesis
- To understand the mechanisms of various pericyclic reactions.

THEORY (45 Hours)

UNIT-I: Pericyclic Reactions-I (11 Hours)

Classification of pericyclic reactions, Molecular orbital and their symmetry properties, molecular orbitals of ethylene, 1,3-butadiene;1,3,5-hexatriene; allyl system, Woodward-Hoffmann's conservation of orbital symmetry rule; Analysis of pericyclic reactions: FMO approach, correlation diagrams method and Perturbation of molecular orbital approach. Cycloaddition reactions: Supra and antra facial additions, 4n and 4n+2 systems, 2+2 additions of ketenes. Diels-Alder reactions, 1,3-Dipolar cycloaddition and cheletropic reactions, ene reaction, retro-Diels-

Alder reaction, regioselectivity, periselectivity, torque selectivity, site selectivity and effect of substituents in Diels-Alder reactions. Other Cycloaddition Reactions- [4+6] Cycloadditions, Allene Cycloadditions

UNIT-II Pericyclic Reactions-II (11 Hours)

Electrocyclic reactions – controtatory and disrotatory motions, 4n, 4n+2, allyl systems secondary effects. Electrocyclic rearrangement of cyclobutenes and 1,3 cyclohexadienes. Sigmatropic Rearrangements: H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations, detailed treatment of Claisen and Cope rearrangements, fluxional tautomerism, aza-cope rearrangements, introductions to Ene reactions. Formation of Vitamin D from 7-dehydrocholesterol, synthesis of citral using pericyclic reaction, conversion of Endiandric acid E to Endiandric acid A.

UNIT-III Asymmetric synthesis (12 Hours)

Asymmetric synthesis and its need. Basis, principles and strategiesof asymmetric synthesis, Sources of chiral compounds and methods (I-IV generations) of asymmetric synthesis, Enantiomeric excess, Analytical methods for enantiomeric excess determination, Asymmetric synthesis using chiral starting materials: addition to carbonyl compounds (face blocking/ diastereofacial bias, chiral sulfoxides, organometallics, chiral amplification), α-substitution using chiral enolatesand chiral auxiliaries (SAMP, RAMP, SULTAM, EVANS, MASAMUNE).

UNIT-IV Asymmetric synthesis-II (11 Hours)

Enantioselective and diastereoslective aldol reactions, Asymmetric addition to C-C double bond: Asymmetric hydrogenation, Enantioselective epoxidation, Enantioselective hydroxylation, Asymmetric Diels-Alder reaction (use of chiral dienes and dienophiles), Asymmetric hydroboration of alkenes, Asymmetric enzymatic transformations, oxidation, reduction and hydrolysis.

PRACTICAL (30 Hours)

1. **Qualitative Analysis:** Separation, purification, and identification of binary mixture of organic compounds, TLC, column chromatography and IR spectroscopy.
2. **Organic Synthesis:** Sandmeyer reaction: p-chlorotoluene from p-toluidine. Acetoacetic ester condensation: Synthesis of ethyl-n-butylacetoacetate by A.E.E
   Condensation. Preparation of iodoform from acetone (Haloform reaction).
   Preparation of polystyrene, anthranilic acid, fluorosceine-eosin, and methyl orange

SUGGUESTED READINGS:

1. Fleming, I., Pericyclic Reactions, Pubs: Oxford Science Publications (2015).
2. Sankararaman, S. Pericyclic reactions a textbook: reactions, applications and theory, Pubs: Wiley India, New Delhi (2016).
3. Gill, G.B.; Willis, M.R. Pericyclic Reactions, Pubs: London, Chapman & Hall. (1974).
4. Morrison J. D. (eds) Asymmetric Synthesis, Vol. 1 to 5, Pubs: Academic Press.(1992).
5. Aitken R.A. and Kilenyi S.N., Asymmetric Synthesis, Pubs: Academic Press. (1994).
6. Proctor Garry, Asymmetric Synthesis, Pubs: Academic Press (1996)

Chem.423 Surfaces and Macromolecules 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- To teach the fundamental concepts of surface chemistry and their applications.

- To develop requisite intellectual and laboratory skills.

LEARNING OUTCOMES:

The student will be able to

- understand the processes associated with surface chemistry.
- have an insight into the processes involving macromolecules

THEORY (45 Hours)

UNIT-I **(11 Hours)**

Surface tension and surface free energy (theory and measurement methods), Capillarity Contact angle (theory and measurement methods), wetting, Surface forces, Surface films on liquid substrates (surface potential, monomolecular films, Langmuir Blodgett layers), Electrical aspects of surface chemistry (electrical double layer, zeta potential,)Solid liquid interface, stability of dispersions, Adsorption, adsorption isotherms Langmuir and BET adsorption (derivation), Gibbs adsorption equation and its derivation from thermodynamic considerations. Characterization of colloidal particles including Brownian movement, Electrokinetic phenomena, Stabilization of colloidal systems and theories of stability; zeta potential, Coagulation, Flocculation of colloids by electrolytes and its mechanism.

UNIT-II **(11 Hours)**

Precipitation of sols by electrolytes, Hardy Schulz rules, other methods of precipitation. Detergency, surfactants, self-assembly, micelles and vesicles Emulsions, foams, and aerosols Thermodynamics of micellization, Phase separation and Mass action models, Solubilization, Mechanism of formation of microemulsion and their stability, Fish cut and triangular Phase maps (Two component, three component, pseudo-terinary), Applications of colloid and surface science in petroleum recovery, coating and painting, food, pharmaceutical and cosmetic industry Introduction

UNIT-III **(12 Hours)**

Macromolecular concept. Molar mass averages, distribution of molecular mass. Kinetics of Polymerizaton Kinetics of step growth polymerization, size distribution in linear polymers. Kinetics of free radical addition polymerization, distribution of molar masses, effect of temperature. Ionic polymerization, kinetics of cationic and anionic polymerization. Statistics of Linear Polymer Chains Polymer chain flexibility and internal rotation, random flight analysis of end-to end distance for freely jointed chain in one dimension and three dimensions. Effect of bond angle and restricted rotation on chain dimensions. Unperturbed chains. Long-range interactions and effect of solvent. Distribution of chain segments relative to centre of mass.

UNIT-IV **(11 Hours)**

Thermodynamics of Macromolecular Solutions Flory-Huggins theory. Flory-Krigbaum theory of dilute solutions, partial molar quantities. Osmotic pressure. Characterization of Macromolecules Flow properties, generalized flow equation. Frictional co-efficient and flow properties. Determination of molecular size and mass from diffusion, sedimentation velocity, sedimentation equilibrium and viscosity. Light scattering and small angle X-ray scattering.

PRACTICAL (30 Hours)

1. **Surface Tension Measurements:**
   1. Study the variation of surface tension with different concentration of detergent solutions. Determine CMC.
   2. Study the effect of the addition of solutes on the surface tension of water at room temperature and explain the observations in terms of molecular interactions:

a. sugar
b. ethanol
c. sodium chloride

iii. Surface tension of pure solvents, analysis of mixtures of two miscible solvents, verification of Gibb's Thomson Rule of surface tension.

2. **Partition – Coefficient**: Determination of partition – coefficient for I2 and benzoic acid between two immiscible solvents.
3. **Adsorption Measurements:** Verification of Freundlich adsorption isotherm for I2, and acetic acid on charcoal.
4. **Colloidal Solution:** Preparation of sol solution of arsenic sulphide and estimation of flocculation value for NaCl, KCl, $BaCl_2$, $AlCl_3$.

SUGGUESTED READINGS:

1. Young R.J. and Lovell P.A., Introduction to Polymers, Pubs: Chapman and Hall, London, 2nd ed., New Delhi (2004).
2. Billmeyer F.W. Jr., Text book of polymers science, Pubs: Wiley-Interscience, 3rd edn.,(1984).
3. Myers D., Surfactant Science and Technology, Pubs: VCH Publishers (1988).
4. Flory P.J., Principles of polymer chemistry, Pubs: Cornell Univ. Press, (Indian Print 2006).
5. Tager A, Physical Chemistry of polymer, Pubs: Mir Publishers, Moscow (1971).
6. Hunter 3. R.J., Foundations of Colloid Science, Vols. I & II, Pubs: Oxford Science Publications (1989).
7. Rosen M.J., Surfactants and Interfacial Phenomena, Pubs: John Wiley & Sons (1989).

HIGHER & APPLIED AREA LEVEL COURSES:

Chem.414 Advanced Organometallics (3+1)

LEARNING OBJECTIVES:

Objectives of this course are:

- to provide knowledge about the bonding and fluxionality in organometallic compounds of transition elements.
- to explain homogeneous transition metal catalysis
- to give information about metal-metal bonding in metal clusters.

LEARNING OUTCOMES:

The student will be able to

- get information about different aspects the metal-carbon multiple bonded organometallic compounds and their different applications
- apply knowledge of homogeneous transition metal catalysis to explain hydrogenation of organic compounds.
- Explain important homogeneous catalytic reactions and their utility in organic synthesis.

THEORY (45 Hours)

UNIT-I (12 Hours)

Organometallic Compounds of transition elements: Types of ligands and their classifications in organometallic compounds, 16 and 18 electron rule and its limitations. Hapto-nomenclature, synthesis, structure and bonding aspects of following organometallic compounds with carbon- π donor ligands: (a) Two electron donor (olefin and acetylenic complexes of transition metals): (b) Three electron donor (π-allyl complexes of transition metals): (c) Four electron donor (butadiene and cyclobutadiene complexes of transition metals): (d) Five electron donor cyclopentadienyl complexes of transition metals – metallocenes with special emphasis to ferrocenes): (e) Six electron donor [Benzene (arene) complex]. Fluxional Organometallic compounds (classification)

UNIT-II **(12 Hours)**

Homogeneous Transition metal catalysis: General considerations, Reason for selecting transition metals in catalysis (bonding ability, ligand effects, variability of oxidation state and coordination number), basic concept of catalysis (molecular activation by coordination and addition), proximity interaction (insertion/inter-ligand igration and elimination, rearrangement). Phase transfer catalysis. Homogeneous hydrogenation of unsaturated compounds (alkenes, alkynes, aldehydes and ketones). Asymmetric hydrogenation (Olefins).

UNIT-III **(5 Hours)**

Some important homogeneous catalytic reactions: Ziegler Natta polymerization of ethylene and propylene, oligomerisation of alkenes by aluminium alkyl, hydroformylation of unsaturated compounds using cobalt and rhodium complexes, carbonylation of alkenes and alkynes using nickel carbonyl and palladium complexes.

UNIT-IV **(8 Hours)**

Metal-metal bonding in carbonyl and halide clusters Polyhedral model of metal clusters, effect of electronic configuration and coordination number, Structures of metal carbonyl clusters of three atoms $M_3(CO)_{12}$ (M=Fe, Ru & Os), Four metal atoms (tetrahedra) [$M_4(CO)_{12}$ {M= Co, Rh &Ir}] and octahedron of type $M_6(CO)_{16}$ [M= Co & Rh], and halide derivatives of Rhenium (III) triangles, metal carbonyls involving bridged-terminal exchange and scrambling of CO group.

UNIT-V **(8 Hours)**

Transition Metal-Carbon multiple bonded compounds: Metal carbenes and carbines (preparation, reactions, structure, and bonding considerations). Biological and industrial applications and environmental aspects of organometallic compounds.

PRACTICAL (30 HOURS)

1. Preparation of following compounds:
   (i) Tetrapyridine copper (II) persulphate
   (ii) Dinitritotetrapyridine nickel (II)
   (iii) Mercury (tetraisothiocyanato)cobaltate(II).
   (iv) Potassium tris(oxalato)aluminate(III)
   (v) Sodium hexa(nitro)cobaltate(III)
   (vi) Potassium tris(oxalato)cobaltate(III)
2. Characterization of above compounds by the following techniques:
   (i) Elemental analysis
   (ii) Molar conductance values
   (iii) Thermal analysis

SUGGUESTED READINGS:

1. Principles of organometallic compounds – Powell
2. Organometallic chemistry (an Introduction) – Perkin and Pollar
3. Advanced Inorganic Chemistry – Cotton and Wilkinson
4. Organometallic Chemistry-R.C. Mehrotra

5. Organometallic compounds of Transition Metal-Crabtree
6. Chemistry of the Elements – Greenwood and Earnshaw
7. Homogeneous transition metal catalysis – Christopher Masters
8. Homogeneous Catalysis – Parshall
9. Principles and Application of Homogeneous Catalysis – Nakamura and Tsutsui
10. Progress in Inorganic Chemistry Vol. 15 – Lipard. (Transition metal clusters – R.B. King)
11. Text Book of Qualitative Inorganic Analysis – A.I. Vogel
12. Synthetic Coordination Chemistry: Principles and Practice- J.A. Davies, C.M. Hockensmith, V.Y. Kukushkin and Y.N. Kukushkin.

Chem.415 Solutions, Colligative Properties and Chemistry of Nanomaterials 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- to explain various adsorption processes at solid – gas interface and solid-liquid interfaces.
- to give information about the solution properties and interfacial behaviour of surfactants and their practical applications
- to familiarize the students with various theories and laws of electrochemistry

LEARNING OUTCOMES:

The student will be able to

- apply the phenomenon of adsorption to derive various expressions and equations.
- solve problems by using suitable expressions and equations involving adsorption
- understand the applications of nano chemistry in fabricating some useful nanomaterials.

THEORY (45 Hours)

UNIT –I **(11 Hours)**

Dilute solutions: Lowering of vapour pressure, Raoult's and Henry's Law and their applications, Excess thermodynamic functions, thermodynamic derivation using chemical potential to derive relations between the four colligative properties (relative lowering in vapour pressure, elevation in boiling point, depression in freezing point, osmotic pressure) and amount of solute. Applications in calculating molar masses of normal, dissociated, and associated solutes in solution.

UNIT –II **(12 Hours)**

Solution and Interfacial Behaviour of Surfactants: Definition and classification of surfactants. Solution properties of surfactants: micelle formation, critical micelle concentration (CMC), dependence of CMC on chain length of the surfactant, micelle shape and size. Thermodynamics of micelle formation, hydrophobic effect (a qualitative view only). Aggregation at high surfactant concentration (a qualitative aspect) to micelles. Surface tension and detergent. Practical application of surfactants.

UNIT –III **(11 Hours)**

Electrochemistry:Quantitative treatment of Debye - Hückel and Debye-Hückel-Onsagar (D-H-O) theory of conductance of electrolyte solution their limitations and modifications. Pair-wise association of ions (Bjerrum and Fuoss treatment). Determination of association constant (Ka) from Debye – Huckel Limiting Law. Extended Debye – Huckel Law. Qualitative treatment of ion – solvent interactions (ion solvation).

UNIT –IV **(11 Hours)**

Chemistry of nano – materials: Definition and historical perspective. Effect of nanoscience and nanotechnology in various fields. Synthesis of nanoparticles by chemical routs and their characterization techniques. Properties of nanostructured material: optical, magnetic and chemical properties. An overview of applied chemistry of nanometerials.

PRACTICAL (30 Hours)

1. **Adsorption Measurements:** Verification of Freundlich adsorption isotherm for I2, and acetic acid on charcoal.
2. **Colloidal Solution:** Preparation of sol solution of arsenic sulphide and estimation of flocculation value for NaCl, KCl, $BaCl_2$, $AlCl_3$.
3. **Construction of Phase Diagram:** Phase diagram for liquids, (benzene and methanol) and phase diagram for solids, (benzoic acid and cinnamic acid, benzoic acid and naphthalene and acetamide and salicylic acid).
4. **Determination of Molar Mass:** (i) Cryoscopic and Rasts's methods.
5. **Potentiometric Titration:** Titration of HCl with NaOH, determination of dissociation constant of acetic acid and phosphoric acid. Oxidation – reduction titration.
6. **Polarimetry Measurements:** Determination of specific and molecular rotation, percentage of tow optically active substances, kinetics of acid catalysed inversion of cane sugar and comparison of strengths of two acids.

SUGGUESTED READINGS:

1. Physical Chemistry of Surfaces by A.W. Admson
2. Adsorption from Solutions byJ. J. Kipling
3. Micelles (Theoretical and Applied Aspects) by Y. Moroi
4. Foundation of Colloid Science (Vol. I and II) by R.J. Hunter
5. Physical Chemistry by P.W. Atkins
6. Frontiers in Applied Chemistry by A.K. Biswas

Chem.424 Advanced Spectroscopy 3+1*

LEARNING OBJECTIVES:

Objectives of this course are:

- to provide the basic knowledge about the principles and instrumentation of spectroscopic techniques like ultra violet-visible spectroscopy, infrared spectroscopy, nuclear magnetic resonance (NMR) spectroscopy and mass spectrometry
- to apprise the students about the applications of spectroscopic techniques for the structure elucidation of organic compounds.

LEARNING OUTCOMES:

The student will be able to

- Understand the basic principle of IR spectroscopy and its applications.
- Apply the basic concepts of Ultraviolet and Visible Spectroscopy and its applications.
- Apply the concept of mass spectrometry for the determination of structure of organic compounds based on fragmentation.
- Understand the basic principle of NMR spectroscopy and to apply its role for the structure elucidation.

THEORY (45 Hours)

UNIT-I **(11 Hours)**

Ultra Violet and Visible Spectroscopy: Electronic transitions (185-800 nm), Beer- Lambert Law, Effect of solvent on electronic transitions, Ultra Violet bands of carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Steric effect in biphenyls, Fieser- Woodward rules for conjugated dienes and carbonyl compounds, ultra violet spectra of aromatic and heterocyclic compounds. Applications of UV- visible spectroscopy in organic chemistry.

UNIT -II **(11 Hours)**

Infrared Spectroscopy: Principle, Instrumentation and sample handling, Characteristic vibrational frequencies of common organic compounds, Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance. Introduction to Raman spectroscopy. Applications of IR and Raman spectroscopy in organic chemistry.

UNIT –III **(12 Hours)**

Nuclear Magnetic Resonance (NMR) Spectroscopy: General introduction, chemical shift, spin-spin interaction, shielding mechanism, chemical shift values and correlation of protons present in different groups in organic compounds. chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei, virtual coupling. Stereochemistry, hindered rotation, Karplus- relationship of coupling constant with dihedral angle. First and second order spectra, Simplification of complex spectra-nuclear magnetic double resonance, spin tickling, INDOR, contact shift reagents, solvent effects. Fourier transform technique, nuclear Overhauser effect (NOE). Introduction to resonance of other nuclei –^{13}C NMR, 2-D and 3-D NMR, Applications of NMR in organic chemistry.

UNIT -IV **(11 Hours)**

Mass Spectrometry: Introduction, ion production—EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, and ion abundance. Mass spectral fragmentation of organic compounds with common functional groups, Molecular ion peak, Meta-stable peak, McLafferty rearrangement. Nitrogen Rule. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination. Introduction to negative ion Mass spectrometry, TOF-MALDI.

***Tutorial (15 Hours)**

The students will:

- Interpret and analyse spectra of the molecules using rules of various spectroscopic techniques
- Solve problems by choosing suitable spectroscopic methods and interpreting corresponding data
- Solve problems based upon IR, UV, NMR and mass spectroscopy.

SUGGUESTED READINGS:

1. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
2. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley.
3. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley.
4. Application of Spectroscopy of Organic Compounds, J.R. Dyer, Prentice Hall.
5. Spectroscopic Methods in Organic Chemistry by D.H. Williams,I. Fleming, Tata McGraw-Hill.
6. Organic spectroscopy by Jagmohan
7. Organic spectroscopy by W. Kemp.
8. Spectroscopy by Pavia

RESEARCH/PROJECT/SEMINAR:

Chem.391 Seminar 0+1

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Identify and compare technical and practical issues related to the area of course specialization.
- Outline annotated bibliography of research demonstrating scholarly skills.
- Prepare a well-organized report employing elements of technical writing and critical thinking.
- Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

LEARNING OUTCOMES:

At the end of this course, students will be able to:

- Establish motivation for any topic of interest and develop a thought process for technical presentation.
- Organize a detailed literature survey and build a document with respect to technical publications.
- Analysis and comprehension of proof-of-concept and related data.
- Effective presentation and improve soft skills.
- Make use of new and recent technology for creating technical reports
- Will be able to present themselves in front of an audience. It will help them to develop skills like speaking ability, gain and express knowledge in different fields and presentation capability. They will also learn to defend themselves in front of a panel of Seminar Committee.

Chem.491 Pre-Research 0+4

LEARNING OBJECTIVES:

The primary aim of this course is to:

- Identifying the Research Problem.
- Performing a Literature Review & Writing a Theoretical/Conceptual/experimental Framework.
- Researching the methods/experiments/Design or Approach to the Problem.

LEARNING OUTCOMES:

At the end of Research Proposal, students will be able to:

- Outline the literature on as Specific research problem.
- Construct objectives and motivations of research problem to be carried out.
- Explain the nuts and bolts of the theoretical concepts of the problem (experimental or theoretical) to be carried out.
- Making research proposal for further research.

Student will prepare a research proposal based on literature review and extensive student-mentor interactions involving discussions, meetings and presentations. Each student will submit a research/dissertation proposal of the research work planned for the research dissertation with origin of the research problem, literature review, hypothesis, objectives and methodology to carry out the planned research work, expected outcomes and bibliography. Research projects can be taken up in collaboration with industry from within the discipline or across the discipline

Chem.492 Research 0+8

LEARNING OBJECTIVES:

The prime aim of this course is to:

- Collecting and Analyzing the Data and/or Designing and Validating the methods/experiments/Design
- Drawing Conclusions and Giving Recommendations
- Prepare dissertation/thesis/report on the proposed research work

LEARNING OUTCOMES:

At the end of Dissertation students will be able to:

- Demonstrate an in-depth knowledge of scientific research pertaining to the area of study
- Demonstrate experimental/theoretical research capabilities based on rigorous hands-on training
- Critically analyze, interpret and present the data in light of existing scientific knowledge to arrive at specific conclusions
- Develop higher order thinking skills required for pursuing higher studies (Ph.D.)/research-oriented career options in respective fields.

Students will carry out their research work under the supervision of a faculty member. Students will interact with the supervisors through meetings and presentations on a regular basis. After completion of the research work, students will complete the dissertation under the guidance of the supervisor. The dissertation will include literature review, hypothesis, objectives, methodology, results, discussion, and bibliography.

Chem.493 Academic Project 0+4

LEARNING OBJECTIVES:

The primary aim of this course is to:

- review the Research in the subject area.
- Analyse data and other research findings.
- Report research findings in written form.

LEARNING OUTCOMES:

After completion of course, students will have hand on experience of

1. Literature survey on advanced research topics in Chemistry and its allied discipline
2. Planning and designing the experiment and theoretical modelling of the research Problem
3. Analysis and evaluation of the experimental data/ theoretical & computational modelling Deduction and systematic presentation of the results
4. Compilation of the results / information to produce written document
5. Defending the results of the project in an open viva–voice through power point presentation

All the Chemistry honours students will do a supervised Chemistry Project as an important culmination of training in Chemistry learning and research. The project will aim to introduce student to the basics and methodology of research in chemistry, which is done via theory, computation, and experiments either all together or separately by one of these approaches. It is intended to give research exposure to students.

MINOR COURSES:

Minor I

RM.311 Research Methodology 3+0

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:
- Concept of research and research ethics
- The concepts of statistical tools in research.

LEARNING OUTCOMES:

This course will enable the students to:
- Understanding of meaning and role of research.
- Understanding of patents and copy rights and provides the understanding of ethical research.
- Acquires the knowledge to define problems, formulate appropriate and relevant research questions, formulate hypotheses, test hypotheses using quantitative and qualitative data
- Understanding of appropriate methodology and tools for data collection.
- Acquires the knowledge of appropriate use of statistical and other analytical tools and techniques.

THEORY (45 Hours)

UNIT-I Introduction (9 Hours)

33. Meaning of research, purpose of research, research methods scientific methods, experimental methods, theoretical research, observational methods, survey, questionnaires methods, role of theory and characteristics of research. Criteria of good research. Philosophy of Science. Logical reasoning (inductive logic, deductive logic and syllogistic logic).

UNIT-II Ethics in Research (9 Hours)

34. Need for research design. Types of research: fundamental or pure research, applied research, action research, experimental research. History of development of science and the influence of philosophy. Sponsored Research. Ethical Conduct in Science.

UNIT-III Intellectual Property Rights (9 Hours)

35. Patents and copyrights, General Introduction, Design Patents & copyrights, Patent drafting, patent claims and specifications, trademarks, trade integrated circuit. Patent Life and Geographical Boundaries, Utilization of Intellectual Patents, Patent Search, Patent Acts & Rules, Legal Decision making process, Ownership of Patents, Author & ownership of Copyright, Licensing of Copyrights, Infringement of Copyrights and patents, Remedies & Actions for Infringement of Copyrights IPR as Protection Strategy. Patent cooperation treaty (PCT), Indian & US Patent Acts & Latest Amendments.

UNIT-IV Method of Data Collection (9 Hours)

36. Collection of data, observation method, collection of data through questionnaires, schedules, difference between questionnaires and schedules. Data Types Nominal, Ordinal

and Ratio scale; scaling techniques. Classification, analysis and presentation of data. Statistical treatment of collected data. Arithmetic mean, geometric mean and standard deviation.

UNIT-V Testing of Hypothesis **(9 Hours)**

37. Meaning, Characteristics and concepts relating to testing of Hypothesis (Parameter and statistic, Standard error, Level of significance, type-I and Type-II errors, Critical region, one tail and two tail tests); Procedure of testing Hypothesis. Sampling schemes like, simple random sampling without replacement, simple random sampling with replacement and stratified random sampling.

SUGGUESTED READINGS:

1. C.R. Kothari, “Research Methodology”, New Age Publishers, 2004
2. R. Kumar, “Research Methodology”,3rd edition, 2011.
3. A.M. Goon, M.K. Gupta and D. Gupta, “Fundamentals of Statistics”, Vol. I, 8th Edn. The World Press, Kolkata, 2002.
4. S. C. Gupta and V.K. Kapoor, “Fundamentals of Mathematical Statistics”, 4thEdition (Reprint), Sultan Chand &Sons, 2008.

Minor II:

Comp.311 **Programming Using Python** **2+1**

LEARNING OBJECTIVES:

The primary objective of this course is:

- Introduces programming concepts using Python to Computer Science students.
- Focuses on the development of Python programming to solve problems of different domains.
- Introduces the concept of object- oriented programming

LEARNING OUTCOMES:

This course will enable the students:

- Understand the basics of programming language
- Develop, document, and debug modular Python programs.
- Apply suitable programming constructs and built-in data structures to solve a problem.
- Use and apply various data objects in Python.
- Use classes and objects in application programs and handle files.

THEORY (30 Hours)

UNIT I: **(4 Hours)**

Introduction to Programming
Problem solving strategies; Structure of a Python program; Syntax and semantics; Executing simple programs in Python.

UNIT II: **(10 Hours)**

CreatingPythonPrograms

Identifiersandkeywords;Literals,numbers,andstrings;Operators;Expressions;Input/output statements; Defining functions; Control structures (conditional statements, loopcontrolstatements, break, continueand pass, exitfunction), default arguments.

UNIT III: (10 Hours)

Built-inDataStructures
Mutable and immutable objects; Strings, built-in functions for string, string traversal, stringoperators and operations; Lists creation, traversal, slicing and splitting operations, passing listtoafunction; Tuples, sets, dictionaries, andtheiroperations.

UNIT IV: (6 Hours)

ObjectOrientedProgramming
Introductiontoclasses,objects,andmethods;Standardlibraries.
FileandExceptionHandling
Filehandlingthroughlibraries;Errorsand exceptionhandling.

PRACTICAL (15 Hours)

ListofPRACTICALS:

1. WAPtofindtherootsofaquadratic equation
2. WAPtoacceptanumber‘n’and
    a. Check if ’n’ is prime
    b. Generate all prime numbers till ‘n’
    c. Generate first ‘n’ prime numbers This program may be done using functions
3. WAPtocreateapyramidofthecharacter‘*’andareversepyramid

```
    *
   ***
  *****
 *******
*********
*********
 *******
  ******
   ***
    *
```

9. WAPthatacceptsacharacterandperformsthefollowing:
    a. print whether the character is a letter or numeric digit or a special character
    b. if the character is a letter, print whether the letter is uppercase or lowercase
    c. if the character is a numeric digit, prints its name in text (e.g., if input is 9, output is NINE)
    d. WAP to perform the following operations on a string
    e. Find the frequency of a character in a string.
    f. Replace a character by another character in a string.
    g. Remove the first occurrence of a character from a string.
    h. Remove all occurrences of a character from a string.
10. WAPtoswapthefirstncharactersoftwostrings.
11. Write a function thataccepts two strings and returnsthe indicesof all the occurrencesof the second string in the first string as a list. If the second string is not present in thefirststringthenitshouldreturn-1.
12. WAP to create a list of the cubes of only the even integers appearing in the input list(mayhaveelementsofothertypesalso)usingthefollowing:
    a. 'for' loop
    b. list comprehension

13. WAPtoreadafileand
    a. Print the total number of characters, words and lines in the file.
    b. b. Calculate the frequency of each character in the file. Use a variable of dictionary type to maintain the count.
    c. c. Print the words in reverse order.
    d. d. Copy even lines of the file to a file named 'File1' and odd lines to another file named 'File2'.
14. WAPtodefineaclassPointwithcoordinatesxandyasattributes.Createrelevant methods and print the objects. Also define a method distance to calculate thedistancebetweenanytwopointobjects.
15. Writeafunctionthatprintsa dictionary where the keys are numbers between 1 and 5andthevaluesarecubes ofthekeys.
16. Consideratuplet1=(1,2,5,7,9,2,4,6,8,10).WAPtoperformfollowingoperations:
    a. Printhalfthevaluesofthetupleinonelineandtheotherhalfinthenextline.
    b. Printanothertuplewhosevaluesareevennumbersinthegiventuple.
    c. Concatenateatuplet2=(11,13,15)witht1.
    d. Returnmaximumandminimumvaluefromthistuple
17. WAPtoacceptanamefromauser.Raiseandhandleappropriateexception(s) ifthetextenteredbytheusercontainsdigitsand/orspecialcharacters.

SUGGUESTED READINGS:

1. Taneja,S.,Kumar,N.PythonProgramming- AmodularApproach,1stedition,PearsonEducationIndia, 2018.
2. Balaguruswamy E. Introduction to Computing and Problem-Solving using Python, 2ndedition,McGrawHill Education, 2018.
3. Brown,MartinC.Python:TheCompleteReference,2ndedition,McGrawHillEducation, 2018.
4. Guttag,J.V.IntroductiontocomputationandprogrammingusingPython,2ndedition,MITPress, 2016.

Minor III:

Stat.321 Probability and probability distributions 2+1

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- Probability and statistics to the students.
- The concepts of probability and distributions.

LEARNING OUTCOMES:

This course will enable the students to:

- Explain the concept of probability and its applications.
- Analyze random experiments, sample spaces, events and algebra of events.
- Construct random variables, discrete and continuous types, p.m.f., p.d.f., and c.d.f.
- Calculate mathematical expectation and generating functions.
- Evaluate standard discrete and continuous probability distributions.

THEORY (30 Hours)

UNIT-I **(7 Hours)**

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

UNIT-II **(8 Hours)**

Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables.

UNIT-III **(7 Hours)**

Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations.

UNIT-IV **(8 Hours)**

Standard discrete probability distributions: Uniform, Binomial, Poisson, geometric, along with their properties and limiting/approximation cases. Standard continuous probability distributions: uniform, normal, exponential, beta and gamma along with their properties and limiting/approximation cases.

PRACTICAL (30 Hours)

1. Fitting of binomial distributions
2. Fitting of Poisson distributions
3. Fitting of Normal distributions
4. Application problems based on binomial, Poisson, and Normal distribution

SUGGUESTED READINGS:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata.
2. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Mathematical Statistics, 4thEdition (Reprint), Sultan Chand &Sons
3. Hogg, R. V.,Tanis,E.A.andRaoJ.M.(2009):ProbabilityandStatisticalInference, Seventh Ed, Pearson Education, New Delhi.
4. Miller, Irwinand Miller, Marylees (2006): JohnE. Freund's Mathematical Statistics with Applications, (7thEdn.), Pearson Education, Asia.
5. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
6. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi

Env.321 Environmental Science and Impact Assessment 2+1

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- To impart knowledge about the environment importance and to inculcate responsibility towards its protection and maintenance.
- To make individual aware of the issue and understand the reason behind environmental degradation.
- Rationale utilization of a renewable sources
- To encourage individuals to seek out knowledge about environment and all its components.
- Evaluation of environmental measures, skill, and capacity building.

LEARNING OUTCOMES:

This course will enable the students to:
- To prepare students to analyze major environmental concerns and work towards sustainability
- Enable students to develop a sense of belongingness with nature
- Develop critical thinking for scientific, social, economic, and legal strategies for environmental issues
- To analyze how anthropogenic activities affects or cause threat to environment and living conditions of species in the planet.

THEORY (30 Hours)

UNIT I: **(6 Hours)**

Global environmental issues and polices

Climate change, Ozone destruction and global warming, acid rain, ENSO, forest conservation, water conservation, rain water harvesting, watershed management, international programs: earth summit, UNFCCC, Montreal protocol, CBD, Kyoto protocol, International efforts for environmental protection, National action plan on climate change and its major missions, Ramsar convention, Chemical Weapons Convention (CWC). Constitutional Provisions for protecting environment- Articles 48(A), 51 A (g). Environmental laws: EPA, 1986, The Air (Prevention and control of pollution) Act, 1981; The water (Prevention and control of pollution) Act 1974; Forest (Conservation) Act 1980, The wildlife protection act 1972.

UNIT II: **(6 Hours)**

Biodiversity and conservation

Biodiversity: levels of biological diversity, values of biodiversity, Hot-spot of biodiversity, Mega-biodiversity countries, Threat to Biodiversity, Threatened and endemic species of India, IUCN Red list criteria and categories, Conservation of biodiversity: Ecosystem services: ecological, economical, social, ethical, aesthetical and informational values. Case studies: Indian wildlife and biodiversity issues, movements and projects. Project tiger, Project elephant, vulture breeding program, project great Indian Bustard, Silent valley movement, Western Ghats movement.

UNIT III: **(6 Hours)**

Earth and earth surface processes

Origin of earth and system processes, minerals and rocks: rock cycle, lithification and metamorphism; three rock laws; weathering; physical, biogeochemical processes; erosion, atmosphere: evolution of earth's atmosphere, atmosphere ocean interface, atmosphere land interface, ocean land interface, land surface processes, formation of peninsular Indian mountain system, formation of Himalayas, Progression of agriculture in the Indian subcontinent.

UNIT IV: (6 Hours)

Environmental Assessment and Management

Definition and concept of EIA, environmental Impact Statement (EIS) and Environment Management Plan (EMP), EIA guidelines, life cycle analysis, cost benefit analysis, EIA notification, eco-labeling schemes. Natural resources and their assessment. Remote sensing and GIS: Principles and application, Risk assessment.

UNIT V: (6 Hours)

Human Communities and Environment

Human population growth; impact on environment, Population explosion- family welfare programme, Environment, and human health: concept of health and disease; common communicable and non-communicable diseases; public awareness, Environmental movements; Chipko movement, Silent valley Movement, Appiko Movement, Bishnois of Rajasthan, Narmada Bacho Andolan, NGT and its importance, environmental ethics; Role of various religious and cultural practices in environmental conservation. Resettlement and rehabilitation of developmental project affected persons and communities relevant case studies

PRACTICAL (30 Hours)

1. Formulate questionnaire for assessment of the impact of climate change on people.
2. sampling of plant and animal biodiversity of the college campus
3. Determine the water quality parameters of a given area
4. Assess air quality Index
5. Develop and maintain vermicomposting unit using biodegradable waste
6. Assessment of carbon foot-print using mathematical tools
7. Correlation analysis of human population growth and impacts on the environment and human health

SUGGESTED READINGS:

1. Primack, R. B. (2014). Essentials of conservation biology
2. Odum, E.P., Odum, H.T., and Andrews, J. (1971). Fundamentals of Ecology. Saunders, Philadelphia, USA.
3. Singh, J.S., Singh, S.P. and Gupta, S.R. (2017). Ecology, environmental sciences and conservation, S. Chand Publishing, New Delhi.

Biochem.321 General Biochemistry 3+0

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- Importance of Biochemistry in agricultural research.
- Involvement of Biochemical processes in our day-to-day life.
- Introduction to different biomolecules and their composition.

LEARNING OUTCOMES:

This course will enable the students to:

- Understand the importance of discipline of Biochemistry.
- Understand the role of different biomolecules in living systems.
- Understand the structure and composition of different biomolecules.
- Know about the basic metabolic processes in plant system.
- Introduction to molecular biology.

THEORY (45 Hours)

UNIT-I Introduction (9 Hours)

38. Introduction to the scope and importance of biochemistry in agriculture research and in our daily life.

UNIT-II Biomoleculesand cell organelles (9 Hours)

39. Basic biomolecules and their role in living system. structure and function of different cell organelles in living system.

UNIT-III Structure and functions of biomolecules (9 Hours)

40. Structure and functions of carbohydrate, proteins, amino acids, lipids, and nucleic acids. structures and biological functions of vitamins.

UNIT-IVPhotosynthesis, respiration and nitrogen fixation (9 Hours)

41. Photosynthesis: basic mechanism of carbon assimilation, C3 and C4 cycles, photorespiration, Kranz anatomy. Respiration: Aerobic and anaerobic respiration, glycolysis, Krebs cycle, Electron transport system, oxidative phosphorylation**.** Basic steps involved in nitrogen fixation Habers process.

UNIT-V Introduction to molecular biology (9 Hours)

42. Introduction to DNA and RNA, basic steps in DNA replication, transcription, and translation.

SUGGUESTED READINGS:

1. Katoch R. 2017. “Fundamentals of Plant Biochemistry and Biotechnology”. 1st edition, Kalyani Publishers, India.
2. Katoch R. 2017. “Molecular Biology”. 1st edition, Kalyani Publishers, India.
3. Katoch R. 2018. “Macromolecules, Enzymology and Metabolism”. 1st edition, Kalyani Publishers, India.
4. Katoch R. 2019. “Agricultural Biochemistry”. 1st edition, Kalyani Publishers, India.
5. Katoch R.(2019). Principals and techniques in Biochemistry & Molecular Biology: 1st edition. Published by Department of Chemistry and Biochemistry, CSKHPKV, Palampur.

ACADEMIC WRITING

AW.321 Academic Writing 1+1

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- Various academic and research writing techniques

LEARNING OUTCOMES:

This course will enable the students to:

- Understanding of the concept of academic and research writing.
- Understanding and acquire knowledge of research paper writing.
- Understanding and acquire knowledge of thesis writing.
- Acquires knowledge and understanding of various digital tools in academic writing.

THEORY (15 Hours)

UNIT I- Introduction (3 Hours)

Importance of report writing in academics and research. Various kinds of academic and research activities. Necessity of report writing for achievement of academic and research goals. Various kinds of reports/presentations. Characteristics of academic and research reports/presentations. Conclusions.

UNIT II- Research paper writing (3 Hours)

Types of research papers, Structure of research papers, Research paper formats, Abstract writing, Methodology, Results and discussions, Different formats for referencing, Ways of communicating a research paper.

UNIT III- Thesis writing (3 Hours)

Structure of a thesis, Scope of the work, Literature review, Experimental/Computational details, Preliminary studies, Results and Discussions, Figures and Tables preparation, Conclusions and future works, Bibliography, Appendices.

UNIT IV- Tools and Techniques (3 Hours)

Various word processors, e.g., MS Word, Libra-office, Latex etc. Making effective presentations using Power Point and Beamer, Uses of plagiarism detection tools.

UNIT V- Miscellaneous Reports (3 Hours)

Writing research proposals, Writings project proposals, Lecture notes, Progress reports, Utilization reports, Scientific reports etc.

SUGGUESTED READINGS:

1. A. Whitaker, “A Step-by-Step Guide to Writing Academic Papers”, 2009.
2. J. Lambert and C. Frye, “Microsoft Office 2016”, Microsoft Press, Washington 98052-6399
3. C. P. R. Kumar, “On Writing a Thesis”, IETE Journal of Education, 2000.
4. J. Warbrick, M. Goossens, S. Rahtz, A. Clark “Essential LATEX ++”, 1994.

ABILITY ENHANCEMENT COURSES:

AEC I:

Eng.111 General English Language 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To introduce the basic tools of calculus, also known as ‘science of variation’.
- To provide a way of viewing and analysing the real-world problems.

LEARNING OUTCOMES:

- Comprehensive knowledge and coherent understanding of the English Language.
- Practical, professional, and procedural knowledge required for carrying out professionalor highly skilled work/tasks based on English language.
- Create, perform, or think in different and diverse ways about the same objectsorscenarios
- Adopt innovative, imaginative, lateral thinking, interpersonal skills and emotionalintelligence.
- Enhanced comprehension skills for better analysis and interpretation of a body of work
- Inculcate a healthy attitude to be a lifelong learner.

THEORY (30 Hours)

UNIT IFunctional Grammar (10 Hours)

Parts of speech: The Article, The Preposition. Agreement of the verb with the Subject. Analysis, Transformation, Synthesis and Direct-Indirect Speech. Same word used as different parts of speech. Word Building/Word Formation: Compound words, Primary Derivative, Secondary Derivatives (Prefixes, Suffixes), Common Idioms and Verb Phrases. Proverbs.

UNIT II Essential Language Skills (10 Hours)

Summary/Precis Writing. Professional writing. Vocabulary – Antonym, Synonym, Words confused and misused, Homophones, Homonyms.Preparation of CV. Job Application. Formal and Informal letters. Report/Proposal Writing. Essay Writing. Interviews. Figures of speech (Simile, Metaphor, Personification, Oxymoron, Epigram, Pun, Climax, Euphemism, Irony, Rhetoric, Alliteration).

UNIT III Reading and Comprehension (10 Hours)

Effective reading. Reading Techniques. Reading Comprehension. Study of Prose and Short Stories from Brighter English, book of short stories, plays, poems, and essays by C.E. Eckersley. The Bachelor of Arts by R.K. Narayan: Introduction to the work, Discussion of important aspects, Themes, Summary, reading of the text, Vocabulary, Discussing key questions.(10 L)

PRACTICAL (15 Hours)

1. Listening Comprehension: Listening to short talks, lectures, speeches (Scientific, commercial, and general in nature).
2. Oral Communication: Phonetics, Stress, and intonation
3. Mock interviews: Testing initiative, team spirit, leadership, intellectual ability.

4. Group Discussions
5. Conversation Practice
6. Writing practice (paragraphs, essays, stories etc.)
7. Figures of speech and their usage in Writing/Speaking.
8. Use of non-verbal media in communication.

SUGGUESTED READINGS:

1. Business English, Pearson.
2. Jones, Daniel. 1970. An Outline of English Phonetics, Arnold, London.
3. Sharma, S.D. 1984. A Textbook of Spoken and Written English, Vikas, Delhi.
4. Eckersley, C.E. 1984. Brighter English, Orient Longmans, New Delhi.
5. High School English Grammar, Wren and Martin.

AEC II:

Eng.121 English Communication 2+1

LEARNING OBJECTIVES:

- Develop and enhance the linguistic and communicative competence.
- Honing the skills of reading, writing, listening, and speaking.
- Explore various forms of personal and professional communication.
- Enhance effective communication skills in a modern, globalised context.

LEARNING OUTCOMES:

- Listen carefully, read texts and research papers analytically and present complexinformation in a clear and concise manner to different groups/audiences
- Express thoughts and ideas effectively in writing and orally and communicate withothers using appropriate media
- Construct logical arguments using correct technical language related to a field oflearning, work/vocation, or an area of professional practice
- Convey ideas, thoughts, and arguments using language that is respectful and sensitive to gender and other minority groups.
- Demonstrate the ability to identify with or understand the perspective, experiences, or points of view of another individual or group, and to identify and understand other people's emotions.

THEORY (30Hours)

UNIT IIntroduction to Communication (5 Hours)

Need for Effective Communication. The Process of Communication: Levels of communication; Flow of communication; Use of language in communication; Communication networks; Significance of technical communication. Non-verbal Communication and Body Language: Forms of non-verbal communication; Interpreting body language cues; Kinesics; Proxemics; Chronemics; Effective use of body language. Barriers to Communication: Types of barriers; Miscommunication; Noise; Overcoming measures.

UNIT II Reading and Listening Skills (5 Hours)

Reading Skills: Previewing techniques; Skimming; Scanning; Understanding the gist of an argument; Identifying the topic sentence; Inferring lexical and contextual meaning; recognizing coherence and sequencing of sentences; Improving comprehension skills. Listening Skills: Listening as an active skill; Types of Listeners; Listening for general content; Listening to fill up information; Intensive Listening; Listening for specific information; Developing effective listening skills; Barriers to effective listening skills.

UNIT III Writing and Speaking Skills (5 Hours)

Sentence formation; Use of appropriate diction; Paragraph and Essay Writing; Coherence and Cohesion**.** Technical Writing: Differences between technical and literary style, Elements of style; Common Errors. Letter Writing: Formal, informal, and demi-official letters; business letters. Job Application: Cover letter, Differences between bio-data, CV and Resume.Report Writing: Basics of Report Writing; Structure of a report; Types of reports. Interview Skills: Types of Interviews; Ensuring success in job interviews; Appropriate use of non-verbal communication. Group Discussion: Differences between group discussion and debate; Ensuring success in group discussions. Presentation Skills:Oral presentation and public speaking skills; business presentations.

PRACTICAL (15 Hours)

1. Developing Communication skills based on CEFR **(**Common European Framework of Reference for Languages)levels
2. Oral presentation and public speaking skills.
3. Group Discussion.
4. Mock Interviews.
5. Technology-based Communication: Netiquettes: effective e-mail messages; power-point presentation; enhancing editing skills using computer software.
6. Preparing a CV and job application.
7. Paragraph and Essay Writing.
8. Reading Comprehension.
9. Improving listening skills.

SUGGUESTED READINGS:

1. Business English, Pearson, 2008
2. Writing Skills, Dixit Handbook.
3. Bovee, Courtland, L., John V. Thill and Barbara E. Schatzman. Business Communication Today: Seventh Edition. Delhi: Pearson Education, 2004.
4. Lesikar, Raymond V and Marie E. Flatley. Basic Business Communication: Skills for Empowering the Internet Generation: Ninth Edition. New Delhi: Tata McGraw-Hill Publishing Company Ltd., 2002.
5. Pease, Allan and Barbara Pease. The Definitive Book of Body Language. New Delhi: Manjul Publishing House, 2005.

AEC III:

Any Language Course available from the UGC approved platform (Swayam, etc.).

SKILL ENHANCEMENT COURSES:

SEC I:

Comp.111 Computer Applications 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To equip them with basic computing skills that will enhance their employability in general.
- To enable the student to analyse and present information in a meaningful manner.

LEARNING OUTCOMES:

This course will enable the students to:

- to use word-processor to generate documents with appropriate formatting, layout, review and referencing.
- to manage data in worksheets and workbooks and analyze it using spreadsheet functions and inbuilt formulas.
- to make meaningful representations of data in the form of charts and presentations.

THEORY (30 Hours)

UNIT I (6 Hours)

Basics of Computer and Communication Technology, Definition, characteristics, Advantages and Limitations, Computer Organisation, input output and processing units.

UNIT II (8 Hours)

Word Processing: formatting of text, implementation of styles, table of contents, mail merge,

UNIT III (8 Hours)

Spreadsheets: data types, inbuilt and user-defined formulas, arranging data, charts, Presentation: Slides, placeholders, formatting, inbuilt designs.

UNIT IV (4 Hours)

Database Management Systems: Introduction to Databases, Relational databases, basic SQL queries.

UNIT V (4 Hours)

Networking: Basics of Networks, LAN, MAN, WAN, topologies, Internet and email.

PRACTICAL (15 Hours)

1. Formatting of text in Word Processor

2. Implementation of styles and Table of contents
3. Uses of Mail Merge
4. Analyzing Data using Spreadsheets
5. Sorting of Data, using formulas.
6. Creating Charts
7. Creation of Presentations

SUGGUESTED READINGS:

1. P.K. Sinha "Computer Fundaments" BPB Publications
2. R. S. Salaria "Computer Fundamentals" Khanna Publishing House
3. Reema Thareja "Fundamentals Of Computers" Oxford University Press

SEC II:

Stat.121 Elements of Statistics 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To introduce the basic tools of statistics.
- To provide a way of viewing and analysing the real-world problems.

LEARNING OUTCOMES:

This course will enable the students to:

- Explain the definition, scope, and limitations of statistics and to compute frequency distributions and their graphical representations.
- Calculate measures of central tendency, dispersion, skewness, and kurtosis.
- Explain the definition and concept of probability and to find out correlation and fit regression equations
- Describe elements of sampling, sampling distribution, and tests of significance
- Analyze one-way and two-way classified data using analysis of variance.

THEORY (30 Hours)

UNIT I (6 Hours)

Definition, scope and limitations of statistics; presentation and summarization of statistical data; frequency distribution and its graphical representation; measures of central tendency, dispersion, skewness and kurtosis.

UNIT II (6 Hours)

Definition and concept of probability; additive and multiplication law of probability (without proof).

UNIT III (6 Hours)

Correlation: Types of correlation and identification through scatter diagram, computation of correlation coefficient. Linear Regression: Fitting of regression equations; Y on X and X on Y; properties of correlation and regression coefficients.

UNIT IV **(6 Hours)**

Elements of sampling: Simple random sampling, sampling distribution, standard error; tests of significance, large sample test - SND test for means, single sample and two samples; small sample tests for mean: Student's t-test, Fisher's t-test and Paired t-test: F test.

UNIT V **(6 Hours)**

Analysis of variance for one-way and two-way classified data.

PRACTICAL (30 Hours)

1. Construction and graphical representation of frequency distribution.
2. Calculations of measures of central tendency, dispersion, skewness and kurtosis.
3. Correlation and regression analysis.
4. One sample and two sample standard normal deviation tests for mean.
5. Student's t-test, Fisher's t-test and paired t-test; F-test.
6. Analysis of variance – one way and two way classified data.

SUGGUESTED READINGS:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003). An Outline of Statistical Theory, Vol. I, 4th Ed., World Press, Kolkata.
2. Hogg, R.V. and Tanis, E.A. (2009). A Brief Course in Mathematical Statistics. Pearson Education.
3. Johnson, R.A. and Bhattacharya, G.K. (2001). Statistics-Principles and Methods, 4thEd., John Wiley and Sons.
4. Mood, M.A.,Graybill,F.A.and Boes,C.D.(2007). Introduction to the theory of Statistics, 3rd Ed., (Reprint).Tata McGraw-Hill Pub. Co. Ltd.

GIS.121 Geographic Information System 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:

43. To make understand students about basic of Geographic Information System and its applications.

LEARNING OUTCOMES:

- Exposure to Basic Principles of Geographic Information System
- Bringing real world to digital platform
- Understanding and using principles of GIS technology
- Applications

THEORY (30 Hours)

UNIT 1: **(10 Hours)**

Introduction to GIS; Representing a real world in digital space; Data types and data models; Advanced data models in GIS and Data Generation/Collection/Surveys

UNIT 2: **(10 Hours)**

GIS data quality, Global Positioning system, Basics of Remote Sensing, Database and Database Management System– Introduction

UNIT 3: (10 Hours)

Database query and Spatial analysis, Basic and Advanced Spatial analysis of data, Introduction to open source GIS software: ILWIS and Quantum GIS (QGIS)

PRACTICAL (15P)

1. Hands on working with maps, data integration, collection, digitization and extraction
2. Hands on data generation and analysis using various sources
3. Processing satellite imageries and preparation of thematic maps

SUGGESTED READINGS:

1. GIS Fundamentals: A First Text on Geographic Information Systems, Paul Bolstad, XanEdu Publishing Inc; 5th edition;
2. Introduction to Geographic Information Systems, Kang-tsung Chang, McGraw-Hill Education
3. Principles of Geographical Information Systems by Peter A. Burrough
4. Sharda Singh Ranbir Singh Rana, Vaibhav Kalia, Kunal Sood and Arun Kaushal , Centre for Geo-informatics Research & Training, COBS , CSKHPKV, Palampur, Practical Lab Manuals: ‘Introduction to GIS and Hand on Exercises (using ILWIS)’.
5. QGIS documentation (https://qgis.org/en/docs/index.html), ILWIS documentation (https://www.itc.nl/ilwis/users-guide/)
6. Practical Lab Manuals: ‘Introduction to GIS and Hand on Exercises (using ILWIS)’

Biochem.121 Biochemical Constituents of Food Grains, Fruits, and Vegetables 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To acquaint the students about the biochemical composition of food they consume.
- To provide the knowledge on the importance of nutrients.
- Basic knowledge about food composition and analysis of different constituents.

LEARNING OUTCOMES:

This course will enable the students to understand:

- The importance of nutritional constituents in our body.
- Biochemical composition of common food stuffs.
- Disadvantages of anti-nutrients in our body.
- Basic techniques for the assessment of nutritional constituents.

THEORY (30 Hours)

UNIT – I: Fundamentals of nutrition (15 Hours)

Fundamentals of human nutrition; concept of balanced diet, nutrients and antinutrients
.

UNIT – II: Basic composition of major food materials (15 Hours)

Nutritional status and biochemical composition of major food materials *viz*., cereals, pulses oilseeds, fruits and vegetables.

UNIT – III: (15 Hours)

Importance and biological functions of nutritional and anti-nutritional factors
Importance and biological functions of vitamins and minerals; anti-nutritional factors in food stuffs; factors affecting the nutritive value of food grains, fruits and vegetables

PRACTICAL (30 Hours)

Preparation of solutions; qualitative tests for proteins, amino acids, carbohydrates, and lipids; estimation of dietary fibre; estimation of oil, iodine value and saponification value.

SUGGUESTED READINGS:

1. Katoch R. 2019. "Agricultural Biochemistry". 1st edition, Kalyani Publishers, India.
2. Katoch R. 2011. "Analytical Techniques in Biochemistry and Molecular Biology". 1st edition, Springer, New York, USA.
3. Katoch R. 2018. "Macromolecules, Enzymology and Metabolism". 1st edition, Kalyani Publishers, India.
4. Katoch R. (2019). Principals and techniques in Biochemistry: 1st edition. Published by Department of Chemistry and Biochemistry, CSKHPKV, Palampur.

SEC III:

Chem.224 Chemistry of Cosmetics and Perfumes 3+1

LEARNING OBJECTIVES:

Objectives of this course are:

- familiarization of the students with essential oils and their application in Industry.
- to provide basic knowledge about various cosmetic products.

LEARNING OUTCOMES:

The student will be able to

- to understand the methods of preparation of various cosmetic products.
- to apply knowledge gained through the course to different artificial flavours and their uses.

THEORY (30 Hours)

UNIT I: (10 Hours)

A general study including preparation and uses of the following:hair dye, hair spray, shampoo, sun tan lotions, face powder, lipsticks, talcum powder

UNIT-II: (10 Hours)

Study of methods of preparation and uses of the followingnail enamel, creams (cold, vanishing and shaving creams), antiperspirants.

UNIT-III: (10 Hours)

Artificial flavours and their role in industry. Essential oils and their importance in cosmetic products
with reference to Eugenol, Geraniol, sandal wood oil, eucalyptus oil, rose oil, 2-Phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

PRACTICAL (30 Hours)

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of nail enamels.
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of nail polish and nail polish remover.

SUGGUESTED READINGS:

1. Industrial Chemistry by E. Stocchi, vol.I, Ellis Horwood Ltd.UK.
2. Industrial Chemistry by B.K. Sharma and H. Kaur, Goel Publishing House, Meerut.(1996)
3. Engineering Chemistry by P.C. Jain and M. Jain, Dhanpat Rai and Sons, Delhi.
4. Modern Approach to Fuel Chemistry and Chemistry of Cosmetics and Perfumes.

Comp.221 Computer Programming 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:
- To provide exposure to basic problem-solving techniques with computers
- To develop logical thinking abilities and to propose novel solutions for real world problems through programming language constructs.

LEARNING OUTCOMES:

This course will enable the students:
- to interpret the basic representation of the data and sequential programming
- to choose appropriate programming paradigms, interrupt and handle data and propose solutions through programming.
- to implement exemplary applications on real-world problems.

THEORY (30 Hours)

UNIT I (6 Hours)

Introduction to Problem Solving through programs. Variables and Data Types, Arithmetic expressions.

UNIT II (8 Hours)

Relational Operations, Logical expressions; Introduction to Conditional Branching, Conditional Branching and Iterative Loops

UNIT III (8 Hours)

Arranging things: Arrays, 2-D arrays, Character Arrays and Strings

UNIT IV (4 Hours)

Functions and Parameter Passing by Value, Passing Arrays to Functions, Call by Reference, Recursion.

UNIT V **(4 Hours)**

Structures and Pointers, Self-Referential Structures and Introduction to Lists

PRACTICAL (30Hours)

1. Simple Programs
2. Decision making
3. Programs of Loops
4. Array processing
5. Functions and subprograms

SUGGUESTED READINGS:

1. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill
3. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India
4. Herbert Schildt C: The Complete Reference, McGraw Hill Education

Comp.222 Databases and SQL 2+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To equip them with basic data skills that will enhance their employability in general.
- To enable the student to create databases and extract meaningful data from databases

LEARNING OUTCOMES:

This course will enable the students to:

- to convert the ER-model to relational tables, populate relational database and formulate SQL queries on data.
- to use database technology for data resource management.
- to organize, maintain and retrieve - efficiently, and effectively, information from a DBMS

THEORY (30 Hours)

UNIT I **(8 Hours)**

Introduction to Data and Database Management System, Relational Databases, Tables, Data types, primary key.

UNIT II **(10 Hours)**

Structured Query Language (SQL), Create Table, SELECT Query with WHERE, SORT and GROUP BY, UPDATE and INSERT commands. SQL JOINS

UNIT III **(4 Hours)**

Relational Algebra. Entity-Relationship Model, Normalisation of databases.

UNIT IV **(4 Hours)**

Application Development. Case Studies. Storage and File Structure, Indexing and Hashing. Query Processing

UNIT V **(4 Hours)**

Query Optimization. Transactions (Serializability and Recoverability)

PRACTICAL (30Hours)

1. Creation of Simple Database using MS Access
2. Queries using SQL
3. Creation of Relations in Database
4. Simple Joins with SQL

SUGGUESTED READINGS:

1. Abraham Silberschatz, Henry F. Korth, and S. Sudarshan "Database System Concepts" McGraw-Hill Education.
2. Raghu Ramakrishnan and Johannes Gehrke, "Database Management Systems" McGraw Hill,

Micro.221 Techniques in Microbiology 1+2

LEARNING OBJECTIVES:

The primary objective of this course is to introduce:

- Various techniques used for the study of microorganisms.
- The instrumentation methods required for conducting microbiological experiments.

LEARNING OUTCOMES:

This course will enable the students to:

- Appreciate the scientific foundation of general microbiology and relate the key learning to the job of a microbiologist professional.
- Utilise methods and tools for sustainable development of nation through microbiological interventions.
- Increase the probability of use of different microbial cultures for the benefits society.

THEORY (15 Hours)

UNIT-I **(4 Hours)**

History and scope of microbiology. Microorganisms and their natural habitats. Emergence and future of Special Fields of Microbiology.

UNIT-II **(5 Hours)**

Microscopy; Bright field, Dark field, Phase contrast, Confocal, Fluorescence, TEM,SEM – Working Principles and applications; Properties of light; Simple staining, differential and special staining.

UNIT-III **(6 Hours)**

Bacterial Growth, nutrition, and Culture media; Environmental factors affecting bacterial growth: physical chemical, temperature, pH, osmotic pressure, light (UV) and bacteriostatic agents.

PRACTICAL (60Hours)

1. Microbiology laboratory rules, tools equipment's and other requirements in microbiology laboratory.
2. Microscopy: Working with microscope.
3. Preparation of Culture media; Isolation and enumeration of microorganisms; Methods of obtaining Pure culture of microorganisms and their maintenance.
4. Staining methods viz. Simple, Negative, Gram, Spore, Capsule, Flagella, Lactophenol cotton blue etc.
5. Control of Microorganism: Physical agents/Mechanical agents/Chemical Agents.
6. Biochemical/Molecular characterization of Microorganisms
7. Microbiological application experiments viz. Testing microbiological quality of Milk; Antibiotic Sensitivity test etc.

SUGGUESTED READINGS:

1. Brock, T.D. 2008. Biology of microorganisms (Ed.) Madigan MT, Martinko J M, Dunlap P V, Clark D.P., 12th ed. Pearson, New Jersey.
2. Pelczar, M.J. Jr., Chan, E.C.S. and Kreig, N.R. 1997. Microbiology, Concepts and Application, 5th edition, Tata McGraw Hill, New York.
3. Prescott, L.M., Harley and Klein. 2002. Microbiology 5th Edition, Tata McGraw Hill, New York.
4. Bhatia, M.S. 2009. Principles of Microbiology. Swastik Publishers., DeIhi.
5. K.R. Aneja Laboratory Manual of Microbiology and Biotechnology 2nd Edition. Meditech New Delhi.

IAPC (Internship/Apprenticeship/Project/Community Engagement/ Vocational):

IAPC I:

IAPC111/Bio.111 Vermi-composting 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To train students for harvesting and management of Vermi-composting.
- To develop the skills to grow vermi-culture and adopt vermi-composting as entrepreneurship.

LEARNING OUTCOMES:

- Cultivate skills to understand vermi-culture and vermicomposting.
- Learning how to do composting in a limited space.
- Development of Technical skills on harvesting and management of vermicompost.
- Understand the scope of vermi-composting as entrepreneurship.

THEORY (15 Hours)

UNIT 1: (5 Hours)

Introduction to vermicomposting and vermiculture, definition, classification, history, economic importance, its value in maintenance of soil structure. Its role in bio transformation of the residues generated by human activity and production of organic fertilizers. Choosing the right worm. Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Biology of *Pheretima posthuma*. a) Taxonomy, Anatomy, physiology and reproduction. b) life cycle *of Pheretima posthuma*, its fecundity, annual reproducer potential

UNIT 2: (5 Hours)

Limit factors (gases, diet, humidity, temperature, pH , light, and climatic factors). Physio-chemical parameters of vermicompost. Different Methods of Vermicomposting: Small- and large-scale Bed method, Pit method, Small Scale Earthworm farming for home gardens. Conventional commercial composting. Pest and diseases of earthworms. Nutritional Composition of Vermicompost for plants, comparison with other fertilizers.

UNIT 3: (5 Hours)

Earthworm Farming (Vermiculture), vermicompost harvest and processing. Packaging, transport and storage of Vermicompost. Vermicomposting Products and their benefits :Vermiwash, vermicompost-tea and vermicast

PRACTICAL (30 Hours)

1. Scientific classification of Earthworm
2. Study of external morphology of Earthworm.
3. Study of habit and habitat of Earthworm
4. Study of Digestive system of earthworm
5. Study of Reproduction of earthworm
6. Choosing the right worm
7. Hands on vermicomposting by Pit method and Bed method
8. Hands on Vermicompost harvesting
9. Preparation of vermiwash.
10. Vermicompost production, harvesting and packaging.
11. Frequent problems of vermicomposting and how to prevent and fix them.
12. Study of cocoon and vermicast.
13. Study of Pests and diseases of Earthworms

SUGGESTED READINGS:

1. Bhatt J.V. & S.R. Khambata (1959) "Role of Earthworms in Agriculture" Indian Council of Agricultural Research, New Delhi
2. Edwards, C.A. and J.R. Lofty (1977) "Biology of Earthworms" Chapman and Hall Ltd., London.
3. Lee, K.E. (1985) "Earthworms: Their ecology and Relationship with Soils and Land Use" Academic Press, Sydney.
4. Kevin, A and K.E.Lee (1989) " Earthworm for Gardeners and Fisherman" (CSIRO, Australia, Division of Soils)
5. Satchel, J.E. (1983) "Earthworm Ecology" Chapman Hall, London. 8. Wallwork, J.A. (1983) "Earthworm Biology" Edward Arnold (Publishers) Ltd. London.

IAPC112/Zoo.112 Freshwater Aquaculture 1+1

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- To give first-hand training on traditional and technology-based Aquaculture.
- To understand the importance of different types of ponds required for aquaculture.
- To understand the requirement of advanced technology for sustainable development of aquaculture in India.
- To gain experience in the management of optimum water quality in the fish production systems.
- To enhance the quality of fish and increase the production.

LEARNING OUTCOMES:

By the end of the course, the students will be able to:

- Identify the useful aquaculture systems for sustainable aquaculture development.
- Recognize the suitable and economically important aquacultural species.
- Understand the importance of aquaculture in nutrition security, poverty elevation and employment generation.

THEORY (15 Hours)

UNIT I: (5 Hours)

Present global and national scenario; Overview of national and international agricultural systems. Freshwater resources of India: river, reservoir, wetlands, lakes, ponds etc; water resources of Himachal Pradesh.

UNIT II: (5 Hours)

Nursery, Rearing and grow-out ponds management: control of aquatic weed, control of weed & predatory fish, control of aquatic insects, application of lime, fertilizer etc. Advance freshwater aquaculture system; Organic farming; integrated farming: fish cum agriculture & Fish cum animal husbandry; recirculating aquaculture system (RAS); aquaponics, biofloc technology, responsible aquaculture; rotational aquaculture; bioremediation; role of biotechnology; traceability; Sewage-fed fish culture.

UNIT III: (5 Hours)

Water and soil quality management in aquaculture: temperature, dissolved oxygen, hardness, alkalinity, free carbon dioxide, ammonia, transparency, turbidity etc; Seed certification; Eco labelling.

PRACTICAL (30 Hours)

Practices on pre-stocking and post stocking management; Analysis of water and soil samples; Collection, storage and analysis of livestock wastes and crop residues; Study of biogas slurry on water quality, keeping and maintenance of aquarium.

SUGGESTED READINGS:

1. ICAR, Indian Council of Agricultural Research. 2013. Handbook of Fisheries and Aquaculture. Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, New Delhi, India.
2. Rath, R.K., 2011. Fresh water Aquaculture, Scientific publications.
3. E-course ICAR, Indian Council of Agricultural Research.

IAPC II:

IAPC121/Micro.121 Biofertilizer Production 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To familiarize the targeted population with large scale production of different agriculturally important microorganisms which are being used as biofertilizers for maintaining the soil and plant health for sustaining crop productivity and their importance in organic farming.
- To gain employment in biofertilizer industries and set up their own production units at the grass-root level.

LEARNING OUTCOMES:

This course will enable the students to understand:

- The role of biofertilizers in sustainable growth and development of agriculture and role of microorganisms in enhancing soil quality and environmental protection.
- To set up their own facilities for mass production of biofertilizers to improve their social status and helps in managing the menace of chemical fertilizers.
- To set up their own facilities for mass production of biofertilizers to improve their social status and helps in managing the menace of chemical fertilizers.

THEORY (15 Hours)

UNIT 1 Biofertilizers (3 Hours)

Agriculturally important beneficial microorganisms used as biofertilizers for various crop plants, advantages of biofertilizers over chemical fertilizers.

UNIT 2 Symbiotic and Non- Symbiotic N_2 fixers (4 Hours)

***Rhizobium* - Isolation, characteristics, types, inoculum production and field**

application, legume/pulses plants

Frankia - Isolation, characteristics, Alder, Casuarina plants, non-leguminous crop symbiosis.

Cyanobacteria, *Azolla* - Isolation, characterization, mass multiplication, Role in rice cultivation, Crop response, field application.

Free living *Azospirillum*, *Azotobacter* - isolation, characteristics, mass inoculums, production and field application.

UNIT 3 Phosphate Solubilizers (4 Hours)

Microorganisms involved in phosphorus solubilisation: bacteria and fungi - Isolation, characterization, mass inoculum production, field application

UNIT 4 Mycorrhizal Biofertilizers (4 Hours)

Importance of mycorrhizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM, field applications of Ectomycorrhizae and VAM.

PRACTICAL (30 Hours)

1. To study the principle and applications of important instruments used in the microbiology laboratory.
2. Preparation of culture media and sterilization for bacterial cultivation.
2. Sterilization of glassware using Hot Air Oven and assessment for sterility.
3. Isolation of pure cultures of bacteria by streaking method.
4. Preservation of bacterial cultures by various techniques.
5. Estimation of CFU count by spread plate method/pour plate method.
6. Isolation of *Rhizobium* from leguminous plants.
7. Isolation of free living nitrogen fixing bacteria (*Azotobacter*) from soil.
8. Isolation of P-solubilizers from rhizospheric soil.
9. Staining of mycorrhizal fungi colonized roots.
10. Preparation of liquid and carrier based formulations of biofertilizers and their field application.

SUGGESTED READINGS:

1. Mahendra K. Rai. Hand Book of Microbial Biofertilizers. The Haworth Press, Inc. New York. 2005.
2. Shah Fahad, Shah Saud, Fazli Wahid, Muhammad Adnan. Biofertilizers for Sustainable Soil Management. CRC Press. 2023.
3. Coyne MS. Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning. 2001. Print
4. Reddy, S.M. et. al. Bioinoculants for Sustainable Agriculture and Forestry. Scientific Publishers. 2002.
5. Subba Rao NS. Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi, 1999.
6. K. R. Aneja. Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology. New Age International Private Limited. 2022.

IAPC122/ Agron.361 Organic Farming 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To create awareness among the students about organic farming and its importance in sustainable agriculture.
- To provide a skill set of Organic farming to students to help them become self-reliant.

LEARNING OUTCOMES:

This course will enable the students to understand:

- practice organic farming along with application of indigenous knowledge.
- establish entrepreneurial ventures and generate employment (Organic Grower).
- evaluate the organic produce as per FSSAI standards (Government rules).

THEORY (15 Hours)

Organic farming, principles and its scope in India; Initiatives taken by Government (central/state), NGOs and other organizations for promotion of organic agriculture; Organic ecosystem and their concepts; Organic nutrient resources and its fortification; Restrictions to nutrient use in organic farming; Choice of crops and varieties in organic farming; Fundamentals of insect-pest, disease and weed management under organic mode of production; Operational structure of NPOP; Certification process and standards of organic farming; Processing, levelling, economic considerations and viability, marketing and export potential of organic products.

PRACTICAL (30 Hours)

1. Visit of organic farms to study the various components and their utilization
2. Preparation of enriched compost, vermicompost, bio-fertilizers/bio-inoculants and their quality analysis.
3. Indigenous Technology Knowledge (ITK) for nutrient, insect-pest, disease and weed management.
4. Cost of organic production system
5. Post-harvest management
6. Quality aspect, grading, packaging, and handling.

SUGGESTED READINGS:

1. Dhama, A.K. (2014). Organic Farming for Sustainable Agriculture (2nd edition), Agrobios (India), Jodhpur.
2. Sharma, Arun K. (2013). A Handbook of Organic Farming, Agrobios (India), Jodhpur
3. Palaniappan, S.P. and Anandurai, K. (1999). Organic Farming – Theory and Practice. Scientific Pub. Jodhpur
4. Thapa, U and Tripathy, P. (2006). Organic Farming in India, Problems and prospects, Agritech, Publising Academy, Udaipur.
5. Jaivik Kheti Sahayak Pustika- National Centre for Organic and Natural Farming, Department of Agriculture & Farmers Welfare, GoI.
6. National Program for Organic Production-APEDA, Ministry of Commerce & Industry, GoI.

IAPC122 /EECM 368 Community Organization 2+0

LEARNING OBJECTIVES:

The primary objective of this course is:
- Develop through understanding about the relevance of community organization as a method.
- To introduce students to the theory and practice community organizing in India.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Will have the basic knowledge of methods and models of community organization.
- Students will have the understanding about the scope of

THEORY (30 Hours)

Basic Conceptual Framework of Community - concept of community in Social Work; Common terminologies- Community organization, community work, community development; Community Organization skills of Community Organizer; Role of Community Organizer- Approaches , Strategies of Community Organization will have the basic and people's Participation; Interventions of NGO's and Government in community organization; Social Action -Concept , objectives and scope ; Tactics and methods of social action in Community Organization.

SUGGESTED READINGS:

1. Community Organization and Development: An Indian Perspective. By Patil A.R
2. Social Work and Community Development, 2011 by Krishna Kant Singh and Ram Shankar Singh.
3. Social Work: An Integrated Approach, 2003 by S. Bhattacharya
4. Community Organization in Social Work, 2016 by Sheeba Joseph

IAPC III:

IAPC211/Zoo.214 Finfish Breeding and Hatchery Management 1+1

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- To give first-hand training on various aspects of brood stock maintenance of carps.
- To understand the breeding techniques for carps.
- To understand the larviculture techniques for carps.
- To gather knowledge in the management of optimum water quality for fish seed.
- To gather knowledge on the nutritional requirements of the cultivable species.

LEARNING OUTCOMES:

By the end of the course, the students will be able to:

- Produce seeds of carps and air breathing fishes.
- Start the Fish hatchery business.
- Start fish-food production.
- Initiate entrepreneurship in fish seeds production

THEORY (15 Hours)

UNIT I: (5 Hours)

Freshwater fish seed resources and natural breeding of finfishes, Riverine fish seed collection

Sexual maturity, breeding season and development of gonads.

UNIT II: (5 Hours)

Methods of breeding carps in bundhs; Induced breeding of warm water finfishes and environmental factors affecting spawning; Synthetic hormones for induced breeding of fishes; Induced breeding of Indian major carps & exotic carps (silver carp and grass carp); Different types of fish hatcheries.

UNIT III: (5 Hours)

Packing and transportation of fish seed and use of anaesthetics and disinfectants in fish breeding and transport; Breeding of common carp, mahseers, trouts etc; Cryopreservation of fish gametes.

PRACTICAL (30 Hours)

Study of maturity stages in fish; Collection and preservation of fish pituitary gland; Calculation of fecundity; Different fish hatchery systems; study of fish eggs and embryonic developmental stage; Identification of eggs, spawn, fry and fingerlings of different species; Preparation and management of fish nursery; Fish seed and brood stock transportation.

SUGGESTED READINGS:

1. ICAR, Indian Council of Agricultural Research. 2013. Handbook of Fisheries and Aquaculture. Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, New Delhi, India.
2. PC Thomas, Finfish breeding and hatchery management, Blackwell Publishing, New Delhi, India.
3. Pillay, T. V. R. 2005. Aquaculture. Principles and Practices. Blackwell Publishing, New Delhi, India.

IAPC212/HHA 117 Personality Development and Communication Skills 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To develop inter personal and effective communication skills.
- To develop problem solving skills and understand its influence on behaviour and attitudes of individuals.

LEARNING OUTCOMES:

This course will enable the students to:

- After studying this course, students will be able to understand the importance of oral and written communication in day-to-day working of the organisation.
- After studying this course, students will be able to develop inter personal skills androblem-solving skills.
- After studying this course, students will be able to understand the role of body language in effective communication.

THEORY (15 Hours) PRACTICALS (30 Hours)

(a) Personality Enrichment Grooming, Personal hygiene, Social and Business and Dining Etiquettes, Body language, Art of good Conversation, Art of Intelligent Listening (b) Etiquettes & Manners Social & Business Dinning Etiquettes, Social &Travel Etiquettes (c) Personality Development Strategies Communication Skills, Presentation Skills, Public Speaking, Extempore Speaking, importance and art of 'Small Talk' before serious business (d) Interpersonal Skills Dealing with seniors, colleagues, juniors, customers, suppliers, contract workers, owners etc at work place (e) Group Discussion Team Behaviors, how to effectively conduct yourself during GD, do's and don'ts, clarity of thoughts and its expression (f) Telephone conversation Thumb rules, voice modulation, tone, do's & don'ts, manners and accent (g) Presentation Presentation skills, seminars skills role – plays (h) Electronic Communication Techniques: E mail, Fax.

SUGGESTED READINGS:

1. Kushal Jin – Business Communication, VK India.
2. Krishnamacharyulu, C. S. G, Ramakrishnan Lalitha – Personality Development, Interpersonal Skills and Career Management, Himalaya Publishing.
3. Corvette Budjac – Conflict Management: A Practical Guide to Developing
4. Negotiation Strategies, Pearson Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015).
5. Mitra, B. K., Personality Development and Soft Skills, Oxford University Press.
6. Kumar Sanjay and Pushplata, Communication Skills, Oxford University Press.
7. Mandal S. K., Effective Communication and Public Speaking, Jaico Publishing.

IAPC213/HHA 237 Event Management 0+2

LEARNING OBJECTIVES:

The primary objective of this course is:

- introduce the tools to conceptualize, plan and promote and manage events of varying scales and purposes.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Analyse the role of events in image building
- Explain all the steps of planning and organizing the events
- Discuss ways of strategic marketing and media planning for events

THEORY (30 Hours)

Roleofeventsforpromotionoftourism, TypesofEvents-Cultural,festivals,religious,businessetc. Needofeventmanagement,keyfactorsforbesteventmanagement, Casestudyofsomeculturalevents(GangaMahotsava,SurajkundFairandTaj Mahotsava and G20 meet)Concept ofMice. Introduction of meetings, incentives, conference/ conventions, and exhibitions.Conferenceandthecomponentsoftheconferencemarket. Thenatureofconferencemarketsanddemandforconferencefacilities. RoleoftravelAgencyinthemanagementofconferences. Theimpactofconventionsonlocalandnationalcommunities Introduction of meetings, incentives, conference/ conventions, and exhibitions.conferenceandthecomponentsoftheconferencemarket. Thenatureofconferencemarketsanddemandforconferencefacilities. RoleoftravelAgencyinthemanagementofconferences.

Theimpactofconventionsonlocalandnationalcommunities. Management of conference at site tradeshowsandexhibitions, principalpurpose, Types ofshows, Benefits, Majorparticipants, Organization andmembership, Evaluation ofattendees. Convention/exhibitionfacilities;Benefitsofconventionsfacilities, Interrelatedvenues,Projectplanninganddevelopment

SUGGESTED READINGS:

1. Event Planning: Management & Marketing For Successful Events: Become an event planning pro & create a successful event series, by Alex Genadinik
2. Art of Event Management: A complete guide to plan and execute the event Kindle Edition by Dr. Vineet Gera
3. Event is Life : Mini Event Management Kindle Edition by Piyush Matta
4. A Book of Event Management, by Bhavana Chaudhari and Dr. Hoshi bhiwandiwalla

IAPC214/ Hort.111 Fundamentals of Horticulture 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- To acquaint students with the basic, principles, concepts and importance of Horticulture
- To train students in lawn designing, species selection for lawns, parks, home gardens and terrace gardens.
- To provide information about the employment and business opportunities and other avenues in the horticulture sector

LEARNING OUTCOMES:

This course will enable the students to understand:

- design gardens and learn the art of landscape design.
- describe and implement methods of preparing soil, cultivation and propagation for growing hedges, climbers, vegetables, and fruit yielding plants
- create and maintain nurseries, green houses and implement innovative practices in maintenance, harvesting and storage of horticultural produce.
- apply the skills for enhancing the job opportunities (Horticulturist) as well as self-employment.

THEORY (15 Hours)

Horticulture-Its definition and branches, importance and scope; horticultural and botanical classification; climate and soil for horticultural crops; Plant propagation-methods and propagating structures; principles of orchard establishment; Principles and methods of training and pruning, juvenility and flower bud differentiation; unfruitfulness; pollination, pollinizers and pollinators; fertilization and parthenocarpy; kitchen gardening; garden types and parts; lawn making; medicinal and aromatic plants; species and condiments; use of plant bio-regulators in horticulture. Irrigation & fertilizers application-method and quantity.

PRACTICAL (30 Hours)

1. Identification of garden tools.
2. Identification of horticultural crops.
3. Preparation of seed bed/nursery bed.
4. Practice of sexual and asexual methods of propagation.

5. Layout and planting of orchard plants.
6. Training and pruning of fruit trees.
7. Transplanting and care of vegetable seedlings.
8. Making of herbaceous and shrubbery borders.
9. Preparation of potting mixture, potting and repotting.
10. Fertilizer application in different crops.
11. Visits to commercial nurseries/orchard.

SUGGESTED READINGS:

1. Edmondson, J.L., Cunningham, H., Densley Tingley, D.O. et al. (2020). The hidden potential of urban horticulture. Nat Food 1, 155–159.
2. Musser E., Andres. (2005). Fundamentals of Horticulture. New Delhi, Delhi: McGraw Hill Book Co. 2.
3. Sandhu, M.K. (1989). Plant Propagation. Madras, Bangalore: Wile Eastern Ltd.
4. Bird, C. (Ed.). (2014). The fundamentals of horticulture: Theory and practice. Cambridge University Press.
5. The Practical Gardener (1994). Reader's Digest Special Volume.

VALUE ADDED COURSES (VAC):

VAC I:

Env.111 Introduction to Environmental Sciences 2+0

LEARNING OBJECTIVES:

The primary objective of this course is:
- To provide the understanding of natural processes and resources.
- To provide the understanding of critical thinking of environmental issues and environmental challenges.

LEARNING OUTCOMES:

By the end of the course, the students will be able to:
- Understanding the natural processes and resources that sustain life and govern economy.
- Develop critical thinking for scientific, social, economic, and legal strategies for environmental issues
- Study the consequences of human activities on sustainable development and economy
- Understand the current environmental challenges and active participation in solving current problems

THEORY (30 Hours)

UNIT I Fundamental of Environmental Sciences (6 Hours)

Definition, Principles and Scope of Environmental Science, Components of environment: Atmosphere, Hydrosphere, Lithosphere and Biosphere, Agro-climatic Zone of India, concept of sustainable development, Environmental education, Environmental ethics, Brief history environmentalism

UNIT II Ecosystems (7 Hours)

Definition and concept of Ecosystem, Structure of ecosystem (biotic and abiotic components); Functions of ecosystem: Physical (energy flow models), Biological (Food chains, food web, ecological succession) and biogeochemical cycles (nutrient cycling), ecological pyramids and homeostasis, Ecosystem services (Provisioning, Regulating, Cultural and Supporting); Ecosystem preservation and conservation strategies: Basic of ecosystem restoration. Basic of ecosystem classification, types of ecosystems: desert, forest, rangeland wetlands, lotic, lentic, estuarine (mangrove), oceanic. Biomes: Concept, classification, and distribution. Characteristics of different biomes, community ecology

UNIT III Environmental Pollution and Control (6 Hours)

Environmental Pollution (Air, water, soil, noise, thermal, marine and Radioactive pollution): cause, effects and control, Ambient air quality standards and Indian standards for drinking water, Primary and secondary air pollutants, Photochemical smog, waste water treatment, Nuclear hazards and human health risks, Solid waste- types and sources. Solid waste characteristics, solid waste processing and recovery, hazardous waste, E-waste: classification, methods of handling and disposal, Biomedical waste generation and management, Pollution case studies: Ganga Action Plan, air pollution and public health issues, Bhopal gas tragedy

UNIT IV Natural Resources (6 Hours)

Land resources: minerals, soil, agricultural crops, natural forest products, medicinal plants and forest-based industries and livelihoods, land degradation, man-induced land-slides, soil erosion and desertification. Forest resources: use and over-exploitation, deforestation, case studies, timber extraction, mining, dams and their effects on forests and tribal people. Water resources: use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams- benefits and problems. Mineral resources: use and exploitation, environmental effects of extracting and using mineral resources, case studies. Energy resources: Increasing energy needs, renewable/non-renewable, use of alternate energy sources, case studies.

UNIT V Natural Hazards and disaster management (5 hours)

Definition, cause, classification and impacts of: Hydrological, atmospheric, and geological hazards; Earthquake, volcanoes, Floods, Landslides, Drought, Tornadoes, Cyclones and Hurricanes, tsunamis, coastal erosion, Risk and vulnerability assessment, disaster management in India

SUGGESTED READINGS:

1. Singh, J.S., Singh, S.P. and Gupta, S.R. (2017). Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi
2. Odum, E.P., Odum, H.T., and Andrews, J. (1971). Fundamentals of Ecology. Saunders, Philadelphia, USA.
3. Carson, R. (2002). Silent Spring. Houghton Mifflin Harcourt, USA.

VAC II:

Soc.121 Human Values and Ethics 2+0

LEARNING OBJECTIVES:

The primary objective of this course is:

- To help students distinguish between values and skills, and understand the need, basic guidelines, content and process of value education.
- To help students initiate a process of dialog within themselves to know what they 'really want to be' in their life and profession
- To help students understand the meaning of happiness and prosperity for a human being.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Understand the significance of values, distinguish between values and skills, understand the need, basic guidelines, content and process of value education,
- Explore the meaning of happiness and prosperity and do a correct appraisal of the current scenario in the society
- Distinguish between the Self and the Body, understand the meaning of Harmony in the Self the Co-existence of Self and Body.
- Understand the value of harmonious relationship based on trust, respect and other naturally acceptable feelings in human-human relationships and explore their role in ensuring a harmonious society

THEORY (30 Hours)

UNIT – I (20 Hours)

Values and Ethics-An Introduction. Goal and Mission of Life. Vision of Life. Principles and Philosophy. Self Exploration. Self Awareness. Self Satisfaction. Decision Making. Motivation. Sensitivity. Success. Selfless Service. Case Study of Ethical Lives.

UNIT – II (10 Hours)

Positive Spirit. Body, Mind and Soul. Attachment and Detachment. Spirituality Quotient.

SUGGESTED READINGS:

1. A Textbook on Human Values and Ethics m by Debabrata Basu and Samarpan Chakraborty
2. Human Values and Professional Ethics, 2003 by Jayshree Suresh, B S Raghavan.
3. Human Values And Ethics - As per ICAR syllabus, 2022 by Bhanwar lal Dhaka, Kirti, Pankaj Kumar ojha.

VAC III:

VAC 211/Zoo.215 Ornamental Fish Production and Management 1+1

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:
- To give first-hand training on Aquarium preparation and decoration.
- To gain hands-on training on breeding and culture of various Ornamental fishes.
- To gain experience in the management of optimum water quality in the fish aquarium.
- To gather knowledge on the nutritional requirements of the cultivable species.

LEARNING OUTCOMES:

By the end of the course, the students will be able to:
- Prepare and decorate ornamental fish aquarium.
- Identify the suitable and economically important Ornamental fish species.
- Initiate entrepreneurship on Aquarium making and Ornamental fish production

THEORY (15 Hours)

UNIT I: (8 Hours)

World trade of ornamental fish and export potential. Different varieties of exotic and indigenous fishes. Principles of a balanced aquarium. Fabrication, setting up and maintenance of freshwater and marine aquarium. Water quality management. Water filtration system – biological, mechanical and chemical. Types of filters, Lighting and aeration. Aquarium accessories and decoratives. Aquarium fish feeds and their preparation. Dry, wet and live feeds.

UNIT II: (7 Hours)

Breeding and rearing of ornamental fish: guppy, molly, platy, swordtail, gold fish, angel fish etc.; Broodstock management; Conditioning, packing, transport and quarantine methods. Diseases of ornamental fishes.

PRACTICAL (30 Hours)

Identification of common ornamental fishes and plants; Fabrication of all glass aquarium; Setting-up and maintenance; Aquarium accessories and equipments; Conditioning and packing of ornamental fishes. Identification of ornamental fish diseases and prophylactic measures, Fish seed and brood stock transportation.

SUGGESTED READINGS:

1. ICAR, Indian Council of Agricultural Research. 2013. Handbook of Fisheries and Aquaculture. Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, New Delhi, India. 143

2. Pillay, T. V. R. 2005. Aquaculture. Principles and Practices. Blackwell Publishing, New Delhi, India.
3. Swain, S. K., Sarangi, N. and Ayyapan, S. 2010. Ornamental Fish Farming. DIPAS, Indian Council of Agricultural Research, New Delhi, India.

VAC212/HHA 355 Food Safety and Quality 2+0

LEARNING OBJECTIVES:

The primary objective of this course is:

- The present course is designed to address the issues of food safety and quality. It's a multidisciplinary subject which can be taken by students of varied background.
- To improve students' understanding of basic food industry.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Students will be aware about different legislations regarding the food safety.
- Understand the food borne diseases and adulterants.

THEORY (30 Hours)

UNIT – I (15 hours)

Basic introduction to food safety, food hazards & risks, contaminants and food hygiene; micro-organisms in food : general characteristics of micro-organisms based on their occurrence and structure, factors affecting their growth in food (intrinsic and extrinsic), common food borne micro-organisms: bacteria (spores/capsules), fungi, viruses, parasites; Food spoilage & food preservation : types & causes of spoilage, sources of contamination, spoilage of different products (milk and milk products, cereals and cereal, products, meat, eggs, fruits and vegetables, canned products), basic principles of food preservation, methods of preservation (high temperature, low temperature, drying, preservatives & irradiation); Beneficial role of micro-organisms : fermentation & role of lactic and bacteria, fermentation in foods (dairy foods, vegetable, Indian foods, bakery products and alcoholic beverages), miscellaneous (vinegar & anti-biotics; Food borne diseases : types (infections and intoxications), common diseases caused by food borne pathogens, preventive measures; Food additives : introduction, types (preservatives, anti-oxidants, sweeteners, food colours and flavours, stabilizers and emulsifiers); Food contaminants & adulterants : introduction to food standards, types of food contaminants (pesticide residues, bacterial toxins, mycotoxins, seafood toxins, metallic contaminants, residues from packaging material), common adulterants in food, method of their detection (basic principle).

UNIT – II (15 hours)

Food laws and regulations : national - PFA essential commodities act (FPO, MPO etc.), international - codex alimentarius, ISO, regulatory agencies - WTO, consumer protection act; Quality assurance : introduction to concept of TQM, GMP and risk assessment, relevance of microbiological standards for food safety, HACCP (basic principle and implementation); Hygiene and sanitation in food sector : general principles of food hygiene, GHP for commodities, equipment, work area and personnel, cleaning and disinfect ion (methods and agents commonly used in the hospitality industry), safety aspects of processing water (uses & standards), waste water & waste disposal; Recent concerns : emerging pathogens, genetically modified foods, food labeling, newer trends in food packaging and technology, BSE (bovine serum encephthalopathy).

SUGGESTED READINGS:

1. Encyclopedia of Food Safety by Yasmine Motarjemi
2. Encyclopedia of Food Microbiology by Carl A. Batt; Pradip Patel; Richard K. Robinson

VAC IV:

VAC213/Zoo.216 Fish Products and By-products Technology 1+1

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

- To give first-hand training on fish production and by-products.
- To gather knowledge on the how to prepare products.
- To enhance the quality of fish product.

LEARNING OUTCOMES:

- By the end of the course, the students will be able to:
- Start the Fish processing industry.
- Initiate entrepreneurship on processing

THEORY (15 Hours)

UNIT I: (5 Hours)

Principle of fish preservation and processing; Processing of fish by traditional methods salting, sun drying, smoking, marinading and fermentation; Theory of salting, methods of salting –wet salting and dry salting.

UNIT II: (5 Hours)

Fish and prawn pickles, fish sauce and Fish paste, traditional Indian fermented products; Principles and methods of preparation of various fish paste products like fish sausage, fish ham, surimi, fish cake, kamaboko etc. Preparation of salted fish, dried fish and smoked fish by different methods; Preparation of fish manure, fishmeal, fish body oil, fish liver oil; Preparation of prawn & fish pickles. Preparation of fermented fish sauces

UNIT III: (5 Hours)

Canning as a method of preservation; Unit operations in canning; Thermal process for canned foods; Changes in canned foods and spoilage; Canning of commercially important fish.

Fish Packaging method; Use of Metal Containers in packaging; Plastics for Packaging; Manufacture of plastic packages; Heat Sealing; Additives in plastics; Paper and Board; Glass containers and Closures.

PRACTICAL (30 Hours)

Preparation of salted fish, dried fish and smoked fish by different methods; Preparation of fish manure, fishmeal, fish body oil, fish liver oil; Preparation of prawn & fish pickles. Preparation of fermented fish sauces.

Canning Machineries and Equipments, Retorts and its operation; Examination of can double seam; Study of relationship between head space and resultant vacuum; study of different fish packaging methods

SUGGESTED READINGS:

1. Brody. J. Fishery By-products Technology. AVI Publishing Company.
2. Velayutham, P. and Indira Jasmine, G. 1996.Manual on Fishery By-Products, Tamilnadu Veterinary and Animal Sciences University, Chennai.
3. Gopa kumar, K. 1997.Tropical Fishery Products. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

VAC214 Drone Technology 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- Introduction of the students to the basics of Drone and Ariel fights systems.
- Introduction to Multirotor Unmanned Aerial System (UAS), Unmanned Aerial Vehicle (UAV), power system, flight controller, attitude sensing
- UAV positioning and navigation based on Global Navigation Satellite System (GNSS)
- UAS wireless communication systems
- UAS safety & risk assessment

LEARNING OUTCOMES:

This course will enable the students to understand:

- Use a drone for your application or challenge.
- Understanding about the available airborne technology.
- Overview of legislation and regulations concerning drones.
- Flight preparations and create- and execute a safe mission setup.
- Define a mission planning with the available open source and commercial tools.
- Discuss the potential of image product delivery for different purposes.
- Examine drone data and derive information from it.

THEORY (30 Hours)

UNIT I Fundamentals of Drones and Autonomous Systems (5 Hours)

History and Introduction, Types of Drones and classifications, Critical Technologies and equirements, Aviation, Theory of flight, Stake holders and Laws, DGCA Rules of Drones 2021, Drone flying requirements, Type certifications, Operations of Drones

UNIT II Remote Sensing, UAV's and Applications (5 Hours)

Fundamentals of Flight, Aerodynamics, Air traffic procedures, Mission and Flight planning, Field operation and Reece techniques, Introduction to Sensors and Cameras, Weather and Meteorology, UAVs as tool, Introduction of Applications in Agriculture and allied sectors

UNIT III Planning, Acquisition to visualization (5 Hours)

Types of Imagery Products, Manual Flight Profiles, Sample Image Lists Introduction Selection of the drone, Mission Planning, Dos and Donts of flight, Prechecks and Flight operation compliance, Agriculture drones, Surveillance drones, Digital imaging, Crop damage identification, Crop irrigation, Crop Observation

PRACTICAL (30 Hours)

1. Introduction drones equipment and other components
2. Check list and Pre flight operation Checks and Drone equipment maintenance
3. Risk Assesment & Analysis – Failure, Drone stray controls and other emergencies
4. Nozzle selection and Spray patterns
5. Payload installation and utilization
6. Refills
7. Load calculations
8. Hands on flying with instructor
9. Mission planning and operations

SUGGESTED READINGS:

1. K. R. Krishna, "Agricultural Drones A Peaceful Pursuit", Apple Academic Press Inc. Canada, 2018.
2. K S Subramanian, S Pazhanivelan, R Santhi and G Srinivasan, "Drones in Digital Agriculture", Om Publications 2783, Bhagat Singh gali no. 6, Pahar ganj, New Delhi, 2022.

VAC215 Digital Empowerment 1+1

LEARNING OBJECTIVES:

The primary objective of this course is:

- Understand the digital world and need for digital empowerment
- Create awareness about Digital India.
- Explore, communicate, and collaborate in cyberspace.
- Imparting awareness on cyber safety and security.

LEARNING OUTCOMES:

This course will enable the students to understand:

- Use ICT and digital services in daily life.
- Communicate and collaborate in cyberspace using social platforms, teaching/learning tools.
- Understand the significance of security and privacy in the digital world.
- Recognise ethical issues in the cyber world.

THEORY and PRACTICAL(45 Hours)

UNIT I Digital inclusion and Digital Empowerment (12 Hours)

1. Needs and challenges
2. Vision of Digital India: DigiLocker, E-Hospitals, e-Pathshala, BHIM, e-Kranti (Electronic Delivery of Services), e-Health Campaigns
3. Public utility portals of Govt. of India such as RTI, Health, Finance, Income Tax filing, Education

UNIT II Communication and Collaboration in the Cyberspace (12 Hours)

1. Electronic Communication: electronic mail, blogs, social media
2. Collaborative Digital platforms
3. Tools/platforms for online learning
4. Collaboration using file sharing, messaging, video conferencing

UNIT III Towards Safe and Secure Cyberspace (12 Hours)

1. Online security and privacy
2. Threats in the digital world: Data breach and Cyber Attacks
3. Blockchain Technology
4. Security Initiatives by the Govt of India

UNIT IV Ethical Issues in Digital World (09 Hours)

1. Netiquettes
2. Ethics in digital communication
3. Ethics in Cyberspace

SUGGESTED READINGS:

1. Cyber Security: A practitioner's guide, 2017 by David Sutton.
2. Digital Empowerment: A Cornerstone for eGovernance, 2018, by K. S. Vijaya Sekhar, G. P. Sahu and Prabhu Gollamudi.
3. Digital Empowerment: A Concerstone for E-Governance by Sekhar, BSP.

OTHER ACTIVITIES:

NCC 0+12(NC)

[(0+4) for First Year, (0+4) for Second Year and, (0+4) for Third Year]

Introduction to: Defence services, system of NCC training, Leadership and NCC song, Foot drill, sizing, getting on parade, dismissing and falling out, saluting, marching, weapon training. Introduction and characteristics of weapons, judging distance, five discipline and five control orders, field signals, description of ground; conventional signs, general principles, First aid, Hygiene, and sanitation; Camouflage and concealment, NCC annual training camp.

Forming up in three ranks, open and close order march, dressing; Arms drill, shoulder arm, order arm, present arm, Guard of honour; Ceremonial; Weapon training-rife bayonet, light machine gun, sten machine carbine, introduction and characteristics stripping, assembling and cleaning, loading, uploading and firing; Field craft, visual training, targets, battle craft; Section formation, section battle drill; scouts and patrols, ambush, field engineering; Map reading, grid systems, use of service protractor, prismatic compass and its use, Self-defence, precautions and training, attach and counter attacks, marching and searching, Civil defence, NCC annual training camp. Note: One annual training camp is compulsory for award of degree.

NSS **0+12(NC)**

[(0+4) for First Year, (0+4) for Second Year and, (0+4) for Third Year]

Orientation of NSS volunteers regarding National Service Scheme; formation of group/houses; Adoption of villages; Strategic Frame work: Communication for HIV/AIDS; Environment concerns and strategies in new millennium; Drug abuse, social policing in conflict situation; Role of youth: Disaster management through NSS; Understanding gender; Combating female foeticide; Deadly human diseases; Appointment of office bearers; visit to adopted villages and interaction with villagers to identify the needs and problems of the community; involving the community in the solutions of their problems; Campus beautification drive; Celebration of important days; Van mahotsava.

Study of philosophy of NSS; Fundamental rights; Socio-economic structure of Indian society; Population problems; Brief of five year plan; Eradication of social evils; Awareness programmes related to HIV/AIDS; Chronic diseases, Cancer, TB etc.; Consumer acts and rights; Disaster management; Motivation of donation of blood and eyes etc.; Campus beautification; Environment enrichment and conservation; Celebration of important days; Van mahotsava; Health, Family welfare and nutrition.

Note: One NSS special camp is compulsory for award of degree.

NSS Special Camping Programme

Activities in the adopted villages:

- Environment enrichment and conservation:
- Water Conservation
- Health, family welfare and nutrition programme
- Water conservation
- Health, family welfare and nutrition programme
- Literacy programme (adult education)
- Creating awareness for improvement of the status of women
- Assistance and guidance in poultry farming animal husbandry, care of animal health
- Self-employment programme.

CHAPTER XXIII

System of Examination for Four Years Undergraduate Programme(s)of Basic Sciences under National Education Policy

Type of Courses **23.1.1**

- DSC: Discipline Specific Course
- DSE: Discipline Specific Elective
- HLDSC: Higher Level Discipline Specific Course
- HAA: Higher and Applied Area Minor
- AEC: Ability Enhancement Course
- SEC: Skill Enhancement Course
- IAPC:Internship/Apprenticeship/Project/Community Engagement
    - Int: Internship
    - CE: Community Engagement
    - AW: Academic Writing
    - AP: Academic Project
    - R-I: Pre-Research
    - R-II: Research
    - VOC: Vocational Courses
    - Seminar
- VAC: Value Added Courses
- Other Activities (NC:Non Creditable Courses)
    - NCC: National Cadet Corps
    - NSS: National Service Scheme

Evaluation of Course Work **23.2.1** The evaluation of a student's achievement in a course shall be based on performance in

(i) Mid-term Examination
(ii) Practical
(iii) Tutorials/Assignments
(iv) End-term Examination
(v) Seminars/Presentations
(vi) Research/ Dissertation/Project

All examinations shall be monitored by the Dean of the College. It shall be the responsibility of the teacher(s) /Instructor(s) to ensure that the topics to be covered in the theory and practical in each course in a semester shall be recorded through a teaching schedule and distributed to the students at the beginning of each course alongwith a copy of the same to the concerned Head of Department and Dean.

Different type of Examinations which will be employed are described below:

Mid-term Examination: On completion of tenth week of the semester, there shall be an examination in each course lasting for atleast one and half hour, but not more than two hours. This examination shall be scheduled by the Dean concerned during each semester and shall be centrally conducted.
(Question paper and Answer Books shall be prepared and evaluated

by the concerned course instructor)

Tutorial: *DSC/DSE / HLDSC / HAA Minor courses having no practical will have Tutorials of one credit of* ***one contact hour*** and will consist of quizzes, solving problems, clarifying conceptual difficulties, delivering seminar, making presentations, home assignments, discussions, articulating alternative points of view, encouraging creative thought and application, etc. These factors will be taken as the criteria for the award of marks for tutorials by the concerned course instructor.

Assignment: It will consist of seminar, home assignments, discussions, etc. and it will be the criteria for award of marks for Assignments and shall be evaluated by the concerned course instructor.

Practical Examination: All practical examinations shall normally be completed before the commencement of the End-term examination and shall be evaluated by the concerned course instructor. However, the dates for practical examination of the courses will be notified by the Dean concerned.

End-term Examination: Towards the end of the semester there shall be one examination in each course, which shall be of three hours and shall cover the entire syllabi of the course. This examination shall be centrally conducted as per the schedule notified by the Dean concerned.

Seminars: Towards the end of the semester the students shall be giving a presentation of the work done and shall be evaluated by group of faculty members present and the concerned faculty (Course Instructor) of the discipline will tabulate the result and submit it to the Dean through Head of the Department.

Academic Project

i. Student who is admitted for B.Sc. (Hons.) will have to register for Academic Project of four credit during VIII semester and submit Academic Project Report for external evaluation in VIII semester.
ii. After the registration of VII semester, a Project Supervisor shall be notified by the Head of the concerned department.
iii. After the allotment of the Project Supervisor, a committee comprising of minimum three advisory members will be constituted (**Acad.Form.9(a)**)by the Head of the department and further approved by Dean, COBS.
iv. Within two weeks from the date of registration, the Academic Project proposal on **Acad Form 37(a)** shall be submitted through Course Advisor/Instructor to the respective Head of the department of the discipline for final approval.
v. The evaluation of Academic Project in VIII semester shall be

50% internal. The average of marks of the advisory committee shall be calculated and then the project supervisor shall submit the same to the Dean through the Head of the concerned department in **Acad.Form.26(c)**

vi. 50% of the evaluation shall be taken up by the external examiner appointed by the concerned Dean out of the panel submitted in **Acad.From. 25(b)**. The external Examiner shall submit the report in **Acad.Form. 26(d)** to the Head of the Department who will further send it to the Dean.

Research Dissertation

i. Student who is admitted for B.Sc. (Hons. with Research) will have to register for four credits in VII semester and eight credits in VIII semester for Research dissertation.
ii. After registration, a Research Advisor shall be allotted by the Head of the concerned department.
iii. After the allotment of the Research Advisor, a committee comprising of minimum three advisory members (pertaining to the relevance of the title and objectives of Research dissertation) will be constituted (**Acad.Form.9(a)**) by the Head of the department and further approved by Dean, COBS.
iv. Before Mid term of VII semester, the Research dissertation proposal shall be submitted through the Head of the department to the Dean, COBS for final approval in **Acad Form. 37(a)**.
v. The Research Dissertation in VII semester shall be evaluated by the internal advisory committee at the end of the semester. The average of marks of the advisory committee shall be calculated and then the research advisor shall submit the same to the Dean through the Head of the concerned department in **Acad.Form.26(c)**
vi. The evaluation of Research Dissertation in VIII semester shall be 50% internal as per point v given above and 50% shall be evaluated by external examiner appointed by the concerned Dean out of the panel submitted in **Acad.Form. 25(b)**. The external Examiner shall submit the report in **Acad.Form. 26(d)** to the Head of the Department who will further send it to the Dean.

Academic Bank Credits (ABC)	**23.3.1**	All the students need to become academic account holder and should have ABC ID. The student will submit his/her Academic Bank of Credit ID to the Dean office through Advisor before the start of Mid-term examination of the First Semester.
Research Advisor/ Project Supervisor	**23.4.1**	A faculty member having atleastone research paper in NAAS/UGC/WOS shall be eligible to be Research Major Advisor. Any faculty member can be the Project Supervisor.

Advisory Committee

23.5.1 At the start of VII (VIII semester in case of Academic Project) semester the student will be allotted an Advisory Committee for the supervision of research/project work to be taken up by the student.

The Committee shall be comprised of:

i. Research Advisor/Project Supervisor
ii. Students' Advisor/Tutorallotted at the enrollment of the student
iii. Any faculty member of the discipline/ related discipline.

Online Courses

23.6.1 A student may be allowed to take maximum of 40 per cent of the total credits of each category offered in a particular programme in a semester through the online learning courses.

A student will have the option to earn creditby completing quality-assured MOOC programmes offered on the SWAYAM portal or any otheronlineeducationalplatformapprovedbytheUGC/regulatorybodyfromtimetotime.

23.6.2 The system of evaluation for online courses shall be as per the terms and conditions of SWAYAM portal/any other online educational platform approved by the UGC/regulatory body from time to time.

23.6.3 At the time of offering of the courses of each semester, the Head of the Departmentshall notify the list of online courses in consultation with the concerned faculty members.

Distribution of Marks

23.7.1 The performance shall be judged out of 100 marks in a course as per the following distribution:

Type of Course	**Course Credit**	**Mid-term**	**Assign-ment/ Tutorial**	**Pract-ical**	**End-term**
Core Courses (DSC/DSE/HLDSC/HAA Minor)	3+1	25	-	25	50
	3+1*	25	15	-	60
Skill Enhancement/ AEC/ VAC/VOC/IPAC/Minor	1+0/2+0/ 3+0	25	15	-	60
	1+1	20	-	30	50
	0+1/0+2	30	-	70	-
	2+1	25	-	25	50
Pre-Research/Research/ Academic Project/Seminars	0+4/0+8/ 0+1				100

*Course with Tutorial

Note: The online courses for which the students enroll shall be evaluated as per the schedule of the online portal from which the courses are offered. The grade/marks of such courses shall be taken up and included in the transcript/DMC as per the information in the Academic Bank of Credit. The system of evaluation for online courses shall be as per the terms and conditions of SWAYAM portal/any other online educational platform approved by the UGC/regulatory body from time to time.

23.7.2 The Dean shall nominate a teacher to act as 'Coordinator Examination' who shall be responsible for smooth conduct and supervision of examination and shall obey the instructions issued by the authorities from time to time.

23.7.3 The Dean shall nominate a teacher to act at as 'Superintendent Examination' on day to day basis, who shall be responsible for smooth conduct and supervision of examination and shall obey the instructions issued by the authorities from time to time.

23.7.4 The Evaluation of Academic Project shall be taken up at the end of the VIII semester. Fifty percent of the evaluation shall be made by the internal Advisory Committee and fifty percent of the evaluation shall be taken up by the external examiner.

23.7.5 i) The Evaluation of Pre-Research shall be taken up at the end of the VII semester and shall be carried out at the end of the semester by the internal advisory committee.

ii) The evaluation of Dissertation of Research shall be taken up at the end of VIII semester and 50% of the evaluation shall be made by the internal Advisory Committee and 50% of the evaluation shall be taken up by the external examiner.

23.7.6 (i) For conducting End-term (External) examination of theory, two question papers for each course will be procured by the Coordinator separately from each of the two external paper setters. One of the question papers, randomly selected by the Dean (Coordinator in case any student is close relative of the Dean), will be used for conducting the examination.

(ii) For conducting End-term (Internal) examination of theory the Course Instructor shall set two separate question papers for each course covering the entire syllabus and handover the same to the Coordinator through the concerned Head of the Department atleast two weeks before the commencement of End-term examination. The question papers shall accompany a certificate from the Instructor(s), countersigned by Head of Department, that the papers have been set from the entire syllabus. On the day of scheduled date of examination, the Dean shall pick-up randomly one paper out of the two and handover the same to the Coordinator for conducting the examination.

23.7.7 The concerned Instructor shall also act as Invigilator and shall reach the place of examination atleast 20 minutes before the commencement of the examination concerned.

23.7.8 In case any Instructor goes on leave during the examination the Head of the Department concerned shall be responsible to make necessary arrangements to hold that examination as per schedule under intimation to Coordinator Examination and concerned Dean of the College.

23.7.9 In the College, one room called 'Confidential Room' shall be earmarked where the examination material shall be available under control of Coordinator who shall be responsible for safe custody of all examination materials, multiplication of the question papers and maintenance of record, etc.

23.7.10 All examination materials such as answer books, twine, drawing papers, log tables, graph paper, etc. will be supplied by the Central Store to the Coordinator Examination.

23.7.11 Invigilator shall take attendance of the students 15 minutes after the commencement of each examination, on the sheet to be provided by Superintendent Examination. Absent student from the examination shall be deemed to have scored 'Zero' in that particular examination.

23.7.12 At the end of the examination answer books shall be collected from all the students by the Invigilators and handed over to the Superintendent Examination who will deposit blank and used answer books, etc. to the Coordinator Examination immediately after the examination is over. The Instructor concerned shall pick up the used answer books from the Coordinator on the date of Mid-term examination itself. In case of End-term Examination, the Coordinator will send the answer books to the Examiner (External/Internal) under '**CONFIDENTIAL**' sealed cover for evaluation.

23.7.13 Invigilator(s) finding any student resorting to unfair means in the examination or creating disturbance or acting in any manner as to cause any inconvenience to other students in the examination hall, shall report the matter at once to the Dean, through Superintendent Examination for suitable action as per Chapter XI of Academic Regulations.

23.7.14 Candidates coming late by more than 15 minutes in Mid-term/End-term examinations shall not be allowed to appear in that examination and no examinee shall be allowed to go out of the examination hall before first 30 minutes.

Typing and Xeroxing

23.8.1 All the officials assigned the work of typing/Xeroxing shall not leave the "Confidential Room" till the commencement of the examination.

23.8.2 Typing and Xeroxing work shall be taken in hand in the presence of Coordinator who is also the Incharge of Confidential Room. All the typed material including spoiled question papers shall be destroyed in his/her presence. However, in case of Mid-term examination, the concerned Course Instructor can bring himself/herself the multiple copies of the question paper.

23.8.3 All Xeroxing work of the question papers shall be completed atleast half an hour before the commencement of examination.

Make-Up Examination

23.9.1 Normally, no make-up examination shall be allowed in lieu of the missed examinations. However, Head of Department may consider to allow make-up examination only for missed Mid-Term Examination and the Dean may allow End-term (Internal) examination under the following very exceptional circumstances:

i) Demise of mother, father, spouse, brother or sister.
ii) Student's own hospitalization/temporary disability on account of serious illness.
iii) Natural calamity in the home town/village.
iv) Attending interviews conducted by PSC/SSB/ASRB/ or other recruiting bodies as approved by the Vice-Chancellor.
v) If the student has been permitted attendance as per Academic

Regulation 4.1.4.

23.9.2 The Head of Department after being satisfied with the veracity of the reason(s) for missing the Mid-term examinations may instruct the concerned Instructor to take make up examination under intimation to the Dean. In case of End-term & Practical (both internal) examination, the Dean may instruct the concerned Instructor to take make-up examination under intimation to the Registrar.

23.9.3 The application for make-up examination must be made by the student, through his/her Advisor and Instructor to the Head of Department within 5 days of holding of the examination.

23.9.4 If the student fails to take the make-up examination within 15 days from the date of missed examination or from the date of fitness incase of 23.9.1(ii), he/she shall be awarded 'Zero' marks in that examination.

Appointment of External Examiner

23.10.1 The course instructor in consultation with the Head of Department shall submit a panel of four External Examiners for each course on **Acad. Form-25(b)** within four weeks of the commencement of semester to the Dean. No person below the rank of Lecturer/Assistant Professor or equivalent shall be included in the panel.

23.10.2 The External Examiner shall be appointed by the Dean out of the panel submitted by the concerned Head of the Department. In case of urgency, the Dean concerned may appoint a substitute out of the panel of names available with him/her.

23.10.3 External Examiner may ordinarily be appointed for two years and shall be eligible for reappointment after a gap of one year.

23.10.4 External Examiner shall be supplied with detailed instructions including copy of course content, course outline and model question paper.

Paper Setting

23.11.1 The question paper covering the entire syllabus shall consist of following types of questions:

Test Type	Parameter	Answer skill
Objective (MCQ, True/false, fill in the blanks, etc.) (0.5 – 1 mark)	Information, Understanding, Application	Recognize, Differentiate, See Relation
Short (answer not more than 10 lines) (3 – 5 marks)	Attentiveness, Understanding, Application	Re-call, Reasoning, Find Relation
Long (Subjective) (5 – 8 marks)	Aptitude, Ability, Application	Draw Inference, provide critical analysis & views, Establish relation with case study

In the objective type, there shall not be any choice whereas, in short/long questions, choice of 1 – 2 questions may be given

23.11. In Mid-term examination also, the system of question paper should

2 preferably be the same as above.

23.11.3 The instructor(s) shall review the question paper (End-term examination) on the day of examination after it has been distributed. Any correction needed therein will be conveyed to the examinees immediately and any discrepancy noticed in the question paper with regards to syllabus, will be conveyed to the Coordinator Examination through the Superintendent Examination in writing. Thereafter, the Coordinator Examination will write to the External Examiner to ignore the question concerned or part thereof, as the case may be, while evaluating the answer books and the result, in such a case, be prepared by adjusting the weightage.

Evaluation

23.12.1 The entire evaluation process for courses other than mentioned in 23.12.2 and Research Dissertation or Academic Project in VIII semester shall be undertaken by the concerned Course Instructor.

23.12.2 In case of core and elective (DSC/DSE/HLDSC/HAA) courses offered in the programme across the disciplines, the assessment of the theoretical component towards the end of the semester will be undertaken by external examiners from outside the University, who will be appointed by the Dean of the College or by the Coordinator Examination in case any student is close relative of the Dean. In such courses, the question papers will be set as well as assessed by external examiners.

23.12.3 The External Examiner shall return the answer books after evaluation and supply the result of theory examination on the **Acad. Form-26(d)** in duplicate under confidential cover to the Coordinator Examination by name within two weeks from the date of dispatch and the latter will send the same to the Dean immediately

23.12.4 Practical examination of all courses shall be conducted internally. Absent student from the examination shall be deemed to have scored 'Zero' in that particular examination.

23.12.5 Each instructor shall be required to submit four copies of the report of Mid-term, Tutorials/Assignments, Practical & End-term (in case of internally evaluated course) examinations on the **Acad. Form-27(c)** to the Dean concerned duly countersigned by the Head of the department within seven days from the date of conduct of End-of-term examinations.

Each Instructor shall also be required to submit three copies of the Instructor's Report of Mid-term examination with seven days of the conduct of Mid-term examination to the Dean concerned duly countersigned by the Head of the Department on the same Academic form.

23.12.6 One copy of each final Instructor's Grade Report shall be forwarded by the Dean to the Registrar, Head of the Department concerned and Course Instructor.

23.12.8 The marks award lists for the theory (External) received from the Coordinator examination shall also be forwarded by the Dean concerned to the Registrar for tabulation, as per schedule given in

		Academic Calendar.
	23.12.9	The student shall submit the result of the online course to the Dean office through his/her Advisor
Tabulation of Results	**23.13.1**	Tabulation of the results shall be done from the examiners' reports (Internal and External examination) in the office of the Dean and the Registrar separately, simultaneously and independently of each other within four days from the last date of the receipt of the report.
	23.13.2	Each tabulation sheet shall be signed by the concerned official.
	23.13.3	After collation of the results, the office of the Registrar shall transcribe the grades on the individual student's transcript each semester on the **Acad. Form-28(c)** to be called as 'Detailed Marks Certificate'.
	23.13.4	The Credits and Grades earned from online courses shall be also tabulated and included in 'Detailed Marks Certificate'. The online course should be indicated by affixing '#' against the Course No in the 'Detailed Marks Certificate'.
Preparation of Detailed Marks Certificate	**23.14.1**	After collation of the results, the office of the Registrar shall transcribe the grades on the individual student's transcript each semester on the **Acad. Form-28(c)**to be called as 'Detailed Marks Certificate'.
	23.14.2	The persons deputed for this purpose shall further check the transcribed grades on the transcript and sign them individually.
	23.14.3	After final declaration of results of the semester the credits earned by the students shall be credited to the students account in the Academic Bank of Credit.
Significance of Grade	**23.15.1**	Each course will have examinations as laid down in Academic Regulations and evaluation will be made for each component, and marks so obtained will be added and converted to percentage of marks which will be divided by 10 to calculate grade point in 10 point scale system. This shall be restricted to one decimal place.
	23.15.2	For non-credit courses 'S' or 'US' letter grade shall be awarded to indicate 'Satisfactory' OR "Unsatisfactory', respectively and this will not be counted for computation of SGPA/CGPA/OCGPA.
	23.15.3	A student obtaining Grade 'F' or 'US' shall be considered as failed and will be required to reappear in the examination.
Scrutiny of Answer Books and Rectification of Errors	**23.16.1**	There shall be provision of scrutiny of answerbook(s) of Theory (external examination) for which a fee of Rs.200/- per paper shall be charged. The student shall have to apply for scrutiny on the **Acad. Form-29(d)**alongwith the prescribed fee within 10 days of the declaration of the results.
	23.16.2	The Dean shall arrange the scrutiny of answerbook(s) by a committee consisting of three faculty members.
	23.16.	Scrutiny means re-totaling of the marks, and examination of

3 unmarked question(s), if any.

23.16.4 The answerbook(s) of End-term examination shall not be shown to the student under any circumstances.

23.16.5 In case, the total marks are found to be incorrect on scrutiny, the same will be corrected and the result shall be revised accordingly (even if it is towards lower side) by the Dean concerned. If, however, any question is found to be unchecked by the External Examiner, the answerbook(s) shall be sent to the External Examiner for doing the needful and the result(s) shall be revised accordingly.

23.16.6 No representation by the student(s) shall be entertained regarding the outcome of the result after scrutiny.

Re-evaluation

23.17.1 If a student feels that his/her answer book of a course(s) for external examination (except Re-examination) has not been fairly evaluated, he/she may apply in the **Acad. Form-29(e)** complete in all respect alongwith the necessary fee of Rs.1000/- per course to the office of the Dean by the due date as laid down in the Academic Calendar for the year or notified separately. The re-evaluation fee once deposited with the University shall not be refunded.

23.17.2 Coordinator examination shall act as Incharge of re-evaluation work and shall get such answerbook(s) of the course evaluated and revised result shall be determined in the following manner:

1. An external examiner other than the one who had originally evaluated answerbook(s) will re-evaluate the same and the higher of the two awards shall be the final award. In case the variation is not more than 15% of the external examination.
2. The answerbook shall be referred to the third examiner in case variation is more than 15% of the two awards and the average of two higher awards (out of the three) shall be the final award.
3. The fraction of 0.5 and above will be rounded off to the next whole integer.
4. The detailed marks certificate of the semester shall be revised accordingly and the same shall be conveyed to the student.

23.17.3 The time required for re-evaluation shall be 30 days from the last date of receipt of application. Further, the declaration of results of re-evaluation can be delayed for reasons beyond the control of University.

23.17.4 If a student simultaneously applies for re-evaluation and re-examination of a course, then in such case, out of the two results, one which is higher shall be considered for declaring the result.

23.17.5 A student whose answerbook is not available for reasons beyond the control of the University, may be permitted by the Vice-Chancellor on the recommendations of the Dean concerned either to re-appear in the same paper in the next examination without payment of registration/examination fee or he/she may opt for award of marks on the basis of his/her CGPA till the previous semester examination.

23.17.6 In case of any representation, the grant of scholarship/award/medal, etc. may be withheld till declaration of result of re-evaluation.

Re-

23.18. The Re-examination shall be permitted only for End-term theory

examination	**1**	examination in core courses (DSC/DSE/HLDSC/HAA Minor) which are offered by the student during a semester.
	23.18.2	A student shall be eligible to appear in Re-examination of a course if he/she has actually appeared in the external examination of the course and obtained 'F' grade. He/she may apply to the Dean of the College concerned in the **Acad. Form-29(e)** complete in all respects alongwith the necessary fee of Rs.1000/- per course by the due date as laid down in the Academic Calendar for the year or notified separately. The re-examination fee once deposited shall not be refunded.
	23.18.3	Re-examination shall be completed within two weeks after the date of declaration of result or as per the date as laid down in the Academic Calendar or notified separately.
	23.18.4	The question paper for the Re-examination shall be used from the question paper bank for that course available with the Coordinator examination or may seek new set of question paper with the permission of the Dean.
	23.18.5	The answer book(s) for Re-examination shall be evaluated by the External Examiner.
	23.18.6	The date of declaration of result shall be within one month of conducting the re-examination. However, it may be delayed for reasons beyond the control of University.
	23.18.7	The marks obtained in Mid-term, tutorials/practical for a course in the previous semester shall be used for the computation of revised grade based on the performance in re-examination.
	23.18.8	Once a student failed to clear a course after re-examination, he she shall have to register that course again in accordance with schedule indicated in the course catalogue like a fresh student. However, it may not be necessary for him to attend the classes after registering the course.
	23.18.9	A student, who has applied for re-examination in a course and fails to appear, shall be awarded "F' grade.
	23.18.10	The student taking re-examination will be allowed provisional registration for the next semester.
	23.18.11	Re-evaluation of the answer books of re-examination shall not be permitted.
Nomenclature, Credit and other Requirements of degree	**23.19.1**	The programme with multiple entry and exit option, may permit the student to exit as: i. The student may exit after second semester of the programme with certificate in respective programme {**Certificate in Life Sciences/Physical Sciences**} if he/she has cleared all the courses till second semester and has accumulated a total 44 credits alongwith "S" grade in additional courses having a total of 4 Non Credit hours (44+4NC). ii. The student may exit after fourth semester of the programme with UG Diploma in respective programme {**Undergraduate Diploma in Life Sciences/Physical Sciences}** if he/she has cleared all the courses till fourth semester and has accumulated a total of 88 credits alongwith "S" grade in additional courses having a total of

8 Non Credit hours (88+8NC).

iii. The student may exit after sixth semester of the programme withUG Degree in the respective programme{**B.Sc. Life Sciences/Physical Sciences**} provided he/she has cleared all the courses till sixth semester and has accumulated a total of 128 credits alongwith "S" grade in additional courses having a total of 12 Non Credit hours (128+12NC). However, the proportion of Credit Hours of various courses should be in accordance with Acad.Reg.23.19.3.

iv. The student shall be admitted to the fourth year (VII semester) on the basis of his/her OCGPA in V semester and shall be awarded UG (Honours) Degree {**B.Sc. (Hons.) in Life Sciences/Physical Sciences (Discipline/Subject)**} or UG Degree with (Honours with Research) {**B.Sc. (Hons. With Research) in Life Sciences/Physical Sciences (Discipline/Subject)**} provided he/she has cleared all the courses till eighth semester and has accumulated a total of 168 credits alongwith "S" grade in additional courses having a total of 12 Non Credit hours. However, the proportion of Credit Hours of various courses should be in accordance with Acad.Reg.23.19.4/ 23.19.5.

23.19.2 Minimum CGPA/OCGPA to exit the programme at any level shall be 5.00

23.19.3 An Undergraduate degree as per 23.19.1 (iii) will be awarded if a student has earned 24 credits of DSC each of the three disciplines, 12 credits in Discipline specific electives and 9 credits of minor courses along with other credits required for degree.

23.19.4 An Undergraduate (Hons.) degree as per 23.19.1 (iv) will be awarded if a student has earned 24 credits of DSC each of the three disciplines, 12 credits in Discipline specific electives, 9 credits of minor courses, 24 credits of HLDSC, 12 credits of HHA minor and Academic Project of 4 Credits along with other credits required for degree.

23.19.5 An Undergraduate (Hons. with Research) degree as per 23.19.1 (iv) will be awarded if a student has earned 24 credits of DSC each of the three disciplines, 12 credits in Discipline specific electives, 9 credits of minor courses, 20 credits of HLDSC, 8 credits of HHA minor and Research of 12 Credits along with other credits required for degree.

23.19.6 The scheme, credits and syllabi of courses for different undergraduate programme are given separately in Course Catalogue.

Lateral Entry in the programme

23.20.1 The lateral entry/Re-entry may be permitted at the start of each Academic Year (III/V/VII semester) subject to the availability of seats in the respective programmes/discipline.

23.20. The Dean of the College will send the position of the vacant seats to

	2	the Registrar well before the start of the Academic year. The Registrar will notify the vacant seats in the respective programme/years for lateral entry separately.
	23.20.3	An applicant shall be eligible for lateral entry if he/she has earned 44/88/128 credits with minimum of 4/8/12 Non Creditsfor entry to Second/Third/Fourth year respectively and the courses studied must be in accordance to the courses in the course catalogue of these programme of this University.The Dean concerned shall notify a committeeto verify the equivalence of major subjects with the requisite programme.
	23.20.4	There should not be a gap of more than two years of study for lateral entry.
	23.20.5	The seats shall be filled strictly according to the merit of the applicants.
Repeating of Course(s) for award of degree.	**23.21.1**	A student who has passed all the courses but has secured an OCGPA less than 5.00 in undergraduate programme shall be allowed to repeat one/two course to make up the deficiency with the prior permission of the Dean subject to the following conditions: i. The repetition shall be allowed only once in a course. ii. The repetition shall be permitted only to enable the student to fulfill the minimum OCGPA requirement and not for the improvement of the OCGPA for enabling him/her to qualify for the award of scholarship, fellowship or for competing for a 'Certificate of Honour' or for a position in the University. iii. When a student is permitted to repeat a course after getting OCGPA less than 5.00 in undergraduate programme, the credit hours and credit points corresponding to that course shall be counted only one for the degree requirements. iv. For computing the overall grade point average, the better of the two grades after repeating, shall be taken into account. But in personal record of the student, maintained in the Registrar's Office, other the earlier grade and the grade obtained after repetition shall be recorded and the act that repeated course shall be indicated by the letter 'r' superscripted on the grade obtained after such repetition. However, till such time as the student repeats the course, the original grade and credits shall be used to compute the overall cumulative grade point average. v. Student, repeating any of the courses, shall be required to study that course in regular semester with the next batch within the prescribed load limit and shall appear in all the examinations, complete tutorial/assignment. The rule for minimum attendance shall not apply to undergraduate student repeating a course. However, if a student desires, he/she may attend the entire course to make up for the deficiency, if any.
Dropping from the University	**23.22.1**	The student registered in any degree programme, shall be required to earn his/her degree within double the duration of normal period of that particular degree irrespective of registered or unregistered semester. A student who fails to obtain his/her degree within the

		above stipulated period, shall be dropped from the University and shall have no right to petition.
Conversion formula for conversion of OCGPA to percentage	**23.23.1**	“Percentage = OCGPA x 10” for determining the equivalence (percentage) under Overall Cumulative Grade Point Average (OCGPA)

Annexure V

Annexure-V(a)

Acad. Form-9(b)

Format for appointment of Advisory Committee for Basic Sciences under National Education Policy

(See Academic Regulation No. 23.2.1)

1. Name of the student :
2. Admission No :
3. Programme :
4. Major Discipline :
5. Details of Committee Members :

Sr. No.	Name and Designation	Discipline	Signature
1			
2			
3			

Signature of Major Advisor

Endst. No. Dated:

Recommended and forwarded to the Dean, College of Basic Sciences, CSKHPKV, Palampur for information & necessary action please.

Head of the Department

Annexure-V(b)

Acad. Form-25(b)

Confidential

Panel for appointment of External Examiner for Undergraduate Programmes of Basic Sciences under National Education Policy

(See Academic Regulation No. 23.10.1)

1. Name of the Department :
2. Course No. & Title :
3. Session :
4. Semester :
5. Number of student(s) :
6. Details of Examiners :

Sr. No.	Name and Designation of the Examiner	Address (including contact number & email ID)
1		
2		
3		
4		

Certified that the above panel is in accordance with the Academic Regulation 23.10.1 governing Appointment of External Examiner in System of Examination for Undergraduate Programmes under National Education Policy.

Signature of Course Instructor (with Date)

Endst. No. Dated:

Forwarded to the Dean, College of Basic Sciences, CSKHPKV, Palampur for information & necessary action please.

Head of the Department

Annexure-V(c)

Acad. Form-26(c)

Result of Internal Evaluation of Academic Project/Pre-Research/Research of Basic Sciences under National Education Policy

(See Academic Regulation No. 23.12.3)

Name of Examiner: Course No:

Class: Course Title:

Session: Credit Hours:

Date of Examination:

Sr.No.	Admission No.	Theory	
		Figures	Words

All cuttings to be initialized

Signature of Advisory Committee (with date):

1. 2. 3.

Name: Name: Name:

It is to certify that all the students who were registered for the ibid course have appeared in the examination except at Sr.No.__________________ who was/were absent as per attendance sheet (copy attached) and accordingly awarded 'Zero' in this examination (Academic Regulation 23.7.11)

Countersigned

Dean (with date)

Annexure-V(d)

Acad. Form-26(d)

Result of External Evaluation of Theory/Academic Project/Research Dissertation of Basic Sciences under National Education Policy

(See Academic Regulation No. 23.12.3)

Name of External Examiner: Course No:

Class: Course Title:

Session: Credit Hours:

Date of Examination:

Sr.No.	Admission No.	Theory	
		Figures	Words

All cuttings to be initialized

Signature of External Examiner (with date)

It is to certify that all the students who were registered for the ibid course have appeared in the examination except at Sr.No.__________________ who was/were absent as per attendance sheet (copy attached) and accordingly awarded 'Zero' in this examination (Academic Regulation 23.7.11)

Countersigned

Dean (with date)

Annexure-V(e) :*Acad. Form-27(c)*

Instructor's Report for Internal Examination under National Educational Policy

(See Academic Regulation No. 23.12.5)

Name of Course Instructor(s):
Class:
Session :
Date of Examination:

Course No. :
Course Title:
Credit Hours:
Course Category:

S.No.	Name of Student	Admission No.	Grade Points	Mid Term Marks Max:	Tutorial/ Assignment Marks Max:	Practical Marks Max:	End-term Marks Max:	Total Marks Max:	Remarks

Note: All corrections and cuttings be initialized.

CERTIFICATE

Certified that:

i. Students mentioned above except at Sr. No. _____________ have completed attendance requirement as per Academic Regulation No. 4.1.1

ii. All the students mentioned above except at Sr. No._______________ appeared in the examination as per Academic Regulation No. 23.7.11. Absent student (s) has/ have been awarded 'Zero'.

Signature of Course Instructor (with date)

Head of Department (with date)

Dean (with date)

Annexure-V(f) :Acad.Form.-28(c)

Detailed Marks Certificate for Undergraduate Programmes under National Education Policy

(See Academic Regulations 23.13.3)

Ragging is banned and is a cognizable offence and the Institution does not hesitate to take stern action against offenders

CSK HIMACHAL PRADESH KRISHI VISHVAVIDYALAYA, PALAMPUR (HP) 176 062

Programme:
Name :
Admission No.:
Academic Bank of Credit ID:

Class:
Session :
Semester:

DETAIL MARK CERTIFICATE

Sr. No.	Course No.	Type of Course	Course Title	Credit Hours	Mid-term	Assign-ment/ Tutorial	Practical	End-term		Total	Grade Point	Credit points
								Int.	Ext.			

Total Credit Hours :
Prev. Credit Hours:
Cum Credit Hours:

Total Credit Point:
Prev. Credit Point:
Cum Credit Point:

SGPA:

OCGPA/ CGPA:

Prepared by: ____________

Checked by: ____________

DATED:

REGISTRAR

Annexure-V(g)

Acad. Form-29(d)

Application for Scrutiny of Answer Book(s) for Basic Sciences under National Education Policy

(See Academic Regulation No. 23.16.1)

Name:		Detail of Fee received:	
Admission No.:		University Receipt No.:	
Session/Semester:		Date:	
Class:		Signature of Official:	

Sr.No.	Course No	Course Title	Cr.Hrs.	Core/Elective/Other Course	Date of End-of-term Examination

Note: Scrutiny is allowed only for answer book(s) of Theory (external examination) in Core and elective courses.

Students' Signature (with Date)

Recommendation of the Advisor

Signature of Advisor (with date)

Order of the Dean

Annexure-V(h)

Acad. Form-29(e)

Application for Re-evaluation of Answer Book(s)/Re-examination of Basic Sciences under National Education Policy

(See Academic Regulation No. 23.17.1/23.18.1)

Application for ____

(Re-evaluation of Answer Book(s)/Re-examination)

Name:		Detail of Fee received:	
Admission No.:		University Receipt No.:	
Session/Semester:		Date:	
Class:		Signature of Official:	

Sr.No.	Course No	Course Title	Cr.Hrs.	Core/Elective/Other Course	Date of End-of-term Examination

Note: Application for Re-evaluation of answer book(s)/Re-examination should be made separately.

Students' Signature (with Date)

Recommendation of the Advisor

Signature of Advisor (with date)

Order of the Dean

Annexure-V(i)

Acad.Form.37(a)

Format for submission of Project /Research Proposal for Basic Sciences under National Education Policy

(See Academic Regulation No. 23.2.1)

1. Name of the student :
2. Admission No :
3. Programme :
4. Major Discipline :
5. Tentative Title of the Project/Research :
5. Brief detail of Project/Research :

Signature of the student   Signature of Major Advisor

Endst. No.   Dated:

Recommended and forwarded to the Dean, College of Basic Sciences, CSKHPKV, Palampur for information please.

Head of the Department

Annexure-V(j)

Acad. Form-32(d)

Provisional Degree Certificate for Undergraduate Programmes of Basic Sciences under National Education Policy

(See Academic Regulation No. 13.7.1)

Admission Number ………………. Serial Number…………….

Academic Bank of Credit ID ……………………………..

C.S.K. H.P.KRISHI VISHVAVIDYALAYA PALAMPUR

Provisional Degree Certificate

This is to certify that ________________________________ Son/Daughter of Smt._________________________________ and Shri ____________________________ has successfully completed the requirements for award of Degree in ______________________ ________________________ from this Krishi Vishvavidyalaya in the month of ____________. His/Her Overall Cumulative Grade Point Average is _________________ out of 10.00 with _____________per cent marks. He/She is academically graded as ______________________.

PALAMPUR REGISTRAR

Dated: _______________

Annexure-V(k)

Acad. Form-33(e)

Transcript of Academic Record for Undergraduate Programmes of Basic Sciences under National Education Policy

(See Academic Regulation No. 13.7.1)

Front Page

Serial Number……………………

CHAUDHARY SARWAN KUMARH.P.KRISHI VISHVAVIDYALAYA
PALAMPUR (H.P.) 176062

PHOTO

COLLEGE OF BASIC SCIENCES

TRANSCRIPT OF ACADEMIC RECORD

FOR

CERTIFICATE / DIPLOMA / DEGREE IN BACHELOR OF SCIENCE(B.SC.)/ HONOURS DEGREE IN BACHELOR OF SCIENCE (B.SC. (HONS.)) / HONOURS DEGREE WITH RESEARCH IN BACHELOR OF SCIENCE (B.SC. (HONS. WITH RESEARCH))

IN

LIFE SCIENCES / PHYSICAL SCIENCES/ ____________________ (DISCIPLINE/SUBJECT)

IN RESPECT OF

Admission Number ………………………………..

Name……………………………………………………………………………………………….

Father's Name Shri………………………………………………………………………….

Mother's Name Smt. …………………………………………………………………………

Academic Bank of Credit ID: ……………………………………………………………..

Year of Admission ……………………….. Year of successful completion…………………..

OVERALL GRADE POINT AVERAGE OBTAINED………………………………………………. (10.00 basis)

Which is equivalent to ………………………………… percent marks.

(Semester wise Overall Grade point average as per course schedule)

First Year (Academic Year)

First Semester Admission No:

S. No.	Course Title	Course No.	Credit Hours	Grade Points	Credit Points
1.					
2.					
3.					
4.					
.					
.					

Second Semester

S. No.	Course Title	Course No.	Credit Hours	Grade Points	Credit Points
1.					
2.					
3.					
4.					
.					
.					

Second Year (Academic Year)

First Semester Admission No:

S. No.	Course Title	Course No.	Credit Hours	Grade Points	Credit Points
1.					
2.					
3.					
4.					
.					
.					

Second Semester

S. No.	Course Title	Course No.	Credit Hours	Grade Points	Credit Points
1.					
2.					
3.					
4.					
.					
.					

Third Year (Academic Year)

First Semester Admission No:

S. No.	Course Title	Course No.	Credit Hours	Grade Points	Credit Points
1.					
2.					
3.					
4.					
.					
.					

Second Semester

S. No.	Course Title	Course No.	Credit Hours	Grade Points	Credit Points
1.					
2.					
3.					
4.					
.					
.					

Fourth Year (Academic Year)

First Semester Admission No:

S. No.	Course Title	Course No.	Credit Hours	Grade Points	Credit Points
1.					
2.					
3.					
4.					
.					
.					

Second Semester

S. No.	Course Title	Course No.	Credit Hours	Grade Points	Credit Points
1.					
2.					
3.					
4.					
.					
.					

OVER ALL PERFORMANCE

Total CreditHours:___________ Total Credit Points:______

Overall Cumulative Grade Point Average: _________ Equivalent to : _______

NCC /NSS Grading_________________

Placed in _______Division

Registrar

THE SYSTEM OF GRADING ON 10-POINT SCALE UNDER NATIONAL EDUCATION POLICY

The Academic Session (July to June) is divided into two Academic Semesters of 15-18 week each. The curriculum is divided into number of units of instruction called COURSE and course may be cleared by a student at the end of semester in which it is taught/registered/offered.

Course: A course is a unit of instruction or a segment of subject matter to be covered in a semester. It has a course number, title and specified number of credits.The online course should be indicated by affixing '#' against the Course No in the 'Detailed Marks Certificate'.

Type of Courses

- DSC: Discipline Specific Course
- DSE: Discipline Specific Elective
- HLDSC: Higher Level Discipline Specific Course
- HAA: Higher and Applied Area Minor
- AEC: Ability Enhancement Course
- SEC: Skill Enhancement Course
- IAPC:Internship/Apprenticeship/Project/Community Engagement
    - Int: Internship
    - CE: Community Engagement
    - AW: Academic Writing
    - AP: Academic Project
    - R-I: Pre-Research
    - R-II: Research
    - VOC: Vocational Courses
    - Seminar
- VAC: Value Added Courses
- Other Activities (NC:Non Creditable Courses)
    - NCC: National Cadet Corps
    - NSS: National Service Scheme

Distribution of Marks

The performance shall be judged out of 100 marks in a course as per the following distribution:

Type of Course	Course Credit	Mid-term	Assign-ment/ Tutorial	Pract-ical	End-term
Core Courses (DSC/DSE/HLDSC/ HAA Minor)	3+1	25	-	25	50
	3+1*	25	15	-	60
Skill Enhancement/ AEC/ VAC/VOC/IPAC/ Minor	1+0/2+0/ 3+0	25	15	-	60
	1+1	20	-	30	50
	0+1/0+2	30	-	70	-
	2+1	25	-	25	50
Pre-Research/Research/ Academic Project/ Seminars	0+4/0+8/ 0+1				100

*Course with Tutorial

Note: The online courses for which the students enroll shall be evaluated as per the schedule of the online portal from which the courses are offered. The grade/marks of such courses shall be taken up and included in the transcript/DMC as per the information in the Academic Bank of Credit. The system of evaluation for online courses shall be as per the terms and conditions of SWAYAM portal/any other online educational platform approved by the UGC/regulatory body from time to time.

Evaluation System

Credit Hour (CH): one credit hour represents a theory of one hour or practical/tutorial of two hours;

Grade Point (GP): it is a numerical weight allotted to each letter grade on a 10-point scale;

Credit Point (CP): It is equal to GP received in a course multiplied by the CH of that course. The credit points earned will be zero if the GP in a paper is less than 4.00;

A student obtaining Grade 'F' shall be considered as failed and will be required to reappear in the examination.

For non-credit courses (NC) 'S' or 'US' letter grade shall be awarded to indicate 'Satisfactory' or "Unsatisfactory', respectively and this will not be counted for computation of SGPA/CGPA. A student obtaining US letter grade will be required to reappear in the said examination.

Total credit points: It is the sum of the credit points secured;

Semester Grade Point Average (SGPA): Itis a measure of performance of work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester and is expressed on a 10.00 point scale up to two decimal places;

Cumulative Grade Point Average (CGPA):) It is a measure of cumulative performance of a student up to a specific semester. It is the quotient of cumulative credit points obtained by a student in all the courses from the beginning of the first semester divided by the total credit hours of all the courses which have been completed upto the end of the specified semester. The CGPA is to be expressed upto second decimal place without rounding off;

Overall Cumulative Grade Point Average (OCGPA): It is a measure of overall cumulative performance of a student in all semesters. The OCGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places.

Formula for conversion of OCGPA to percentage: "Percentage = OCGPA x 10" for determining the equivalence (percentage) under Overall Cumulative Grade Point Average (OCGPA)