REGULATIONS FOR M.Sc. PROGRAMME (5-Years Integrated)
(Applicable for students admitted from the session 2015 onwards)

The Postgraduate degree in Science shall be called Master of Science (M.Sc. Integrated) in appropriate discipline. This degree shall be awarded by Mahatma Gandhi University, Kottayam. There will be a provision for award of B.Sc (Hons) in appropriate discipline on succesful completion of VIth semetser/or at the end of Integrated programme. This Degree shall be awarded by Mahatma Gandhi University. Unless otherwise mentioned all rules and regulations for this programme will be governed by the CSS Rules and Regulations of the Mahatma Gandhi University

1. Introduction

1.1. The provisions contained in these regulations govern the conditions for imparting courses of instruction, conducting examinations and evaluation of student's performance leading to the Degree of Master of Science (M. Sc Integrated). These regulations are effective for the batches of students admitted in the Academic Session 2016 and onwards.

1.2. Disciplines:
The disciplines in which the courses of study are available and degrees will be offered are:

a) Chemistry (CH)
b) Life Sciences (LS)(Botony, Zoology)
c) Physics (PH)

New disciplines may be added in future with approval of the Academic Council, Mahatma Gandhi University, Kottayam. The medium of instruction for both the M.Sc. Integrated programme is English.

1.3. The provisions of these regulations shall also be applicable to any new discipline(s) that is (are) introduced from time to time and added to the list in Section 1.2.

1.4. Duration: The duration of the Integrated M.Sc programme shall be of 5 years (10 semesters) duration. At the end of the programme a student shall be awarded two degrees - B.Sc. degree in the appropriate discipline and M.Sc (Integrated) in the same discipline in which B.Sc degree was awarded, with two grade cards, one for the 3 year B.Sc and one for the 5 year integrated programme. The B.Sc. grade card shall have mentions that the B.Sc. programme is a portion of the Integrated M.Sc. Programme for which a complete grade card is issued separately.

2. Admission Requirement

2.1 Eligibility: To be eligible for admission to the 5 year Integrated M.Sc. course, a student must have passed +2 science or equivalent with concerned subject.

2.2 At the time of admission, the student is required to Provide the following documents:

a) A certificate for proof of age (Birth certificate or Board certificate).
b) Pass certificates and grade cards (or mark sheets) of all the examination passed.
c) School leaving certificate and conduct certificate.

d) 2 recent passport size colour photographs

3. Academic Calendar: Will be as per CSS Regulations of Mahatma gandhi University, Kottayam

4. Course Structure: The duration of the integrated M.Sc. course is 5 years, the maximum duration allowed being seven years. The curricula to be followed in the first two semesters by the students of the integrated programme of all disciplines shall be almost common. Students pursuing 5-year integrated M.Sc programme, may be allowed a change of discipline in the University after completion of course requirements for the first and second semesters of the first year programme, subject to availability of seats in the discipline (Physics/ Chemistry/ Life Sciences). The selection shall be on the basis of merit, assessed through the combined results of the first and second semester examinations declared in the form of Cumulative Grade Point Average (CGPA) at the end of the first year. The change of discipline shall be accorded to only such students who have cleared all examination of both the semesters in the first attempt, in examinations held during academic session of his / her first admission to the course. Change of discipline may be accorded subject to the condition that the consequent total student strength in the 'gainer' programme shall not exceed by 10% of the approved seats and the net student strength in the loser programme shall not deplete by more than 10% of the sanctioned student strength which will be mentioned in the notification for the programme .

5. Examination

5.1 Each discipline consists of the following items:

a) Theory
b) Practical
c) Sessional
d) Project
e) Seminar
f) Comprehensive Viva Voce and
g) Project Presentation

The schedule for these items along with their credit points for each Semester shall be as per CSS Rules and Regulations approved by Academic Council of Mahatma Gandhi University, Kottayam,and modified from time to time.

5.2 At the end of each Semester, there shall be an examination herein after called End Semester Examination as per the programme announced at the beginning of each academic semester / year. As a part of continuous evaluation process, Internal Assessment of the students shall be done. End semester Examinations and Internal Assessment of students will be as per CSS Rules and Regulations of Mahatma Gandhi University, Kottayam.

6. Evaluation:

The University shall have continuous evaluation system for each theory, practical, Sessional, Seminar, Viva-Voce and Project papers as per CSS Rules and Regulations of Mahatma Gandhi University, Kottayam.

SCHEME FOR M.Sc INTEGRATED COURSE IN CHEMISTRY, PHYSICS & LIFE SCIENCES

SUBJECTS		PAPER	INSTRUCTION HRS/WEEK	DURATION OF EXAM (Hours)	MARKS			CREDITS/ SEMESTER	TOTAL CREDITS
					I.A	END	TOTAL		
A. I, II,III, IV, V and VI Semesters; B.Sc Degree Part of Integrated Programme, SEMESTER I and II, COMMON TO ALL									
1.	SEMESTER I	Gen.Mathematics Paper 1	3	3	25	50	75	3	22
		Chemistry 1	3	3	25	50	75	3	
		Physics 1	3	3	25	50	75	3	
		Life Sciences 1	3	3	25	50	75	3	
		Maths Lab 1	4	3	25	25	50	2	
		Chem Lab 1	4	3	25	25	50	2	
		Physics Lab 1	4	3	25	25	50	2	
		Life Science Lab 1	4	3	25	25	50	2	
		Communicative English 1	2	3	25	50	75	2	
2.	SEMESTER II	Gen.Mathematics Paper 2	3	3	25	50	75	3	22
		Chemistry 2	3	3	25	50	75	3	
		Physics 2	3	3	25	50	75	3	
		Life Sciences 2	3	3	25	50	75	3	
		Maths Lab 2	4	3	25	25	50	2	
		Chem Lab 2	4	3	25	25	50	2	
		Physics Lab 2	4	3	25	25	50	2	
		Life Science Lab 2	4	3	25	25	50	2	
		Communicative English	2	3	25	50	75	2	

		2							
3.	SEMESTER III	Mathematics paper 3 / Life Sciences paper 3	3	3	25	50	75	3	21
		Chemistry 3	3	3	25	50	75	3	
		Physics 3	3	3	25	50	75	3	
		Chem Lab 3	5	3	25	25	50	2	
		Physics Lab 3/ Life Science Lab 3	4	3	25	25	50	2	
		2 X OUT STREAM COURSE Paper 1 & 2	2 X 3 = 6	3 hours each	25	50	75 x2	2X 2 = 4	
		2 X IN STREAM ELECTIVES Paper 1 & 2	2 X 3 = 6	3 hours each	25	50	75 x2	2 X 2 = 4	
4.	SEMESTER IV	Mathematics paper 4 / Life Sciences Paper 4	3	3	25	50	75	3	21
		Chemistry 4	3	3	25	50	75	3	
		Physics 4	3	3	25	50	75	3	
		Chem Lab 4	4	3	25	25	50	2	
		Physics Lab 4 / Life Science Lab 4	5	3	25	25	50	2	

		2 X OUT STREAM COURSE Paper 3 & 4	2 X 3=6	3 hours each	25	50	75 x 2	2X 2 = 4	
		2 X IN STREAM ELECTIVES Paper 3 & 4	2 X 3 =6	3 hours each	25	50	75 x 2	2 X 2 = 4	
5.	SEMESTER V	Core I,II, III	3 x 4 = 12	3 hours each	25	50	75 x 3	3 X 4 = 12	22
		Core Lab course I	8	3	25	50	75	4	
		2 x IN STERAM ELECTIVES	2 x 4 = 8	3 hours each	25	50	75 x 2	2 X 3 = 6	
6.		Project (to be continued to Semester VI)	2						
	SEMESTER VI	Core IV, V, VI, VII	4 x 4 = 16	3 hours each	25	50	75 x 4	4 X 4 = 16	24
		Core Lab course II, III	2 x 4 = 8	3 ,, ,,	25	50	75 x 2	2 x 2 = 4	
		Project	6			100	100	4	
Total							**3400**		132
SEMESTER VII, VIII, IX & X ,M.Sc Degree Part of Integrated Programme									
7.	SEMESTER VII	Core I, II, III, IV,V	5 x 4 =20	3 x 5	50	50	100 x 4	5 x 4 = 20	24
		Core Lab course I	10	3	50	50	100	4	
8.	SEMESTER VIII	Core VI, VII, VIII,IX, X	5x 4 =20	3 hours	50	50	100 x 5	5 x 4= 20	24
		Core Lab course II	10	3	50	50	100	4	
9.	SEMESTER IX	Core XI	1x 4 =4	3 hours	50	50	100	4	12
		Elective I AND II	2x4 =8	3 hours each	50	50	100 x 2	2 x4 = 8	
		MAJOR PROJECT	CONTINUE TO TENTH SEMESTER						

			(18)						
10.	SEMESTER X	MAJOR PROJECT & VIVA VOCE	30		50	50	400		20
Total Marks							1800		80

For Post graduate levels (from Semester VII, VII, IX) the Electives that are offered can be either In -stream elective or Out stream electives or a combination of them which would be in line of Interdisciplinary nature

MAHATMA GANDHI UNIVERSITY

PRIYADARSINI HILLS
KOTTAYAM - 686560

Institute for Intensive Research in Basic Sciences (IIRBS)

Integrated Interdisciplinary Programme

(5 – years Integrated)

SYLLABUS
For
B.Sc. Dgree Part - LIFE SCIENCES PROGRAMME
(BOTANY – ZOOLOGY)
(for Semesters I, II, III, IV, V, VI)

SEMESTER I

Life Sciences Paper - 1

Basic Cell Biology

(3 Hrs. / Week, Total content 54 Hrs.) **Credits - 3**

Module I. History of cell and molecular biology **4 Hrs.**

History and scope of cell biology, Cell theory, Prokaryotes, Eukaryotes, Actinomycetes, Mycoplasmas, Virus, Virion and Viroids, Prions.

Module II. Cell membrane & Permeability **6 Hrs.**

Molecular models of cell membrane - Sandwich model, Unit membrane model, Fluid mosaic model)

Modifications of plasma membrane - Microvilli, tight junction, gap junction, desmosomes. Cell coat and Cell recognition.

Cell permeability - Diffusion, Osmosis, Passive transport, Active transport

Module III. Cell Organelles – Structure and Functions **20 Hrs.**

Endoplasmic reticulum –Types, Structure and functions

Ribosomes - Prokaryotic and Eukaryotic, functions

Golgi Complex - Structure and functions.

Lysosomes - Polymorphism - functions, Peroxisomes, Proteosomes

Mitochondria - Structure and functions, Symbiont hypothesis

Plastids, Chloroplast – Structure and role in Photosynthesis

Centrioles and basal bodies- structure and functions.

Cytoskeleton - Microtubules, microfilaments, intermediate filaments.

Module IV. Nucleus **8 Hrs.**

Structure and functions of interphase nucleus, Nuclear membrane, pore complex, Nucleolus -Structure and functions, nucleolar organizer

Chromatin - euchromatin and heterochromatin, nucleosomes, unit fibre,solenoid fibre, and higher order of organization, condensation and coiling

Chromosome - structure of a typical metaphase chromosome; giant chromosomes- polytene chromosomes, lamp brush chromosomes; endomitosis.

Module V. Cell Division **6 Hrs.**

Cell cycle - G_1, S, G_2 and M phases

Mitosis – Stages. Meiosis – Stages, Significance

Module VI. Cell Communication **5 Hrs.**

Cell signalling - Signalling molelcules (neuro- transmitters, hormones, growth factors, cytokines, vitamin A and D derivatives) , Role of cyclic AMP

Module VII. Biology of Cancer **5 Hrs.**

Biology of cancer: characteristics of cancer cells, dedifferentiation of cancer cells, theories of cancer, carcinogenesis, oncogenes and tumor suppressor genes

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SEMESTER I

Life Sciences Lab1

Cell Biology – Practical

(4 Hrs. / Week) **Credits - 2**

1. Study of microscope - parts of a compound microscope; proper use and maintenance of a microscope.
2. Study of prokaryotic cells (use appropriate stain): (a) Lacto bacillus (b) Nitrogen fixing bacteria (*Rhizobium*) from root nodules of legumes.
3. Study of eukaryotic cells - buccal epithelial cells
4. Buccal smear – Identification of Barr Body.
5. Study of Tissues (permanent slides of epithelial tissues, striated muscle, smooth muscle, cartilage, bone).
6. Preparation of human blood smear and identification of Leucocytes.
7. Squash preparation of onion root tip to study mitotic stages.
8. Calculation of mitotic index
9. Study of meiosis – Grasshopper testis squash. (demo)
10. Identification of meiotic stages. (slide/figure)
11. Laboratory Record

SEMESTER II

Life Sciences Paper - 2

Microbiology

(3 Hrs. / Week, Total content 54 Hrs.) **Credits - 3**

Module I. Introduction to microbiology **4 Hrs.**

Scope of microbiology. Microbial diversity: Microbial taxonomy and phylogeny - Major groups and their characteristics (Five kingdom system and three domain system of classification).

Module II. Bacteria **22 Hrs.**

(a) Bacterial morphology. Classification of Bacteria according to Bergey's manual of systematic bacteriology.

(b) Ultra structure of Gram positive and Gram negative bacteria; cell membrane, cell wall, flagella, pili, fimbriae, capsule and slime, ribosome and endospores.

(c) Major groups of Bacteria: Spirochetes, Rickettsias, Chlamydias, Mycoplasmas, Actinomycetes, Myxobacteria, Archaebacteria. Extremophiles - thermophilic, halophilic, acidophilic and alkalophilic bacteria.

(d) Nutritional types - Photolithotrophs, chemolithotrophs, photoorganotrophs, and chemoorganotrophs.

(e) Bacterial Genetics: Organization and replication of genetic material in bacteria – bacterial chromosome, plasmid. Recombination in bacteria - conjugation, transformation and transduction.

Module III. Viruses **22 Hrs.**

(a) Nomenclature and classification, distinctive properties of viruses, morphology (symmetry) and a general account on different kinds of viruses. Capsid and their arrangements, types of envelops and their composition. Viral genome.

(b) Structure of bacteriophages belonging to 'T' series. Ultra structure of TMV and HIV.

(c) Viral replication: Lytic and Lysogenic cycles - Lytic cycle in T even phages, lysogeny in lambda phage.

(d) Sub viral particles - prions, viroids, virusoid.

(e) Pathogenesis of viral infection: Stages of infection, Epidemiology and transmission of HIV, HPV. Viral oncogenesis.

Module IV. Culture of microorganisms **6 Hrs.**

Methods for isolating pure cultures, types of culture media, enrichment culture techniques, maintenance and preservation of pure cultures, Lyophilization, Solid state fermentation, Bioreactors, immobilization .

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SEMESTER II

Life Sciences Lab - 2

Microbiology - Practical

(4 Hrs. / Week) **Credits - 2**

1. Preparation and sterilization of various microbial culture media and inoculation - liquid media – nutrient broth , peptone water, Solid media – Nutrient Agar, Mac Conkey' Agar, Semi solid agar
2. Culturing of microorganism - broth culture, pure culture techniques- streak plate, pour plate culture, lawn culture, stab culture
3. Isolation of colonies and preservation of bacterial culture
4. Identification of microorganisms - Differential staining of bacteria using Gram stain, Oxidase test, Catalase test, Oxidation/fermentation (O/F) test
5. Isolation of *Rhizobium* from root nodules.
6. Isolation of microbes from soil: Serial dilution - pour plate/spread plate method and enumeration of microorganisms.
7. Antibacterial assay - disc diffusion / agar well method.
8. Laboratory Record.

SEMESTER III

Life Sciences Paper - 3

Plant Diversity

(3 Hrs. / Week, Total content 54 Hrs.) **Credits - 3**

Module I. Systematic Botany
4 Hrs.
Aim scope and significance, Uninominal, Binomial, & Trinomial nomenclature,ICN.

Module II. General characters of the following groups of algae **9 Hrs.**
Classification proposed by Fritsch.

1. Cyanophyceae
2. Chlorophyceae
3. Xanthophyceae
4. Bacillariophyceae
5. Phaeophyceae
6. Rhodophyceae

Module III. Mycology and Lichenology **10Hrs.**
Introduction, structure, reproduction, life cycle and evolutionary trends in fungi. Classification based on Ainsworth (1973). Reproductive structures and life history of the following groups;

1. Myxomycotina
2. Mastigomycotina
3. Zygomycotina
4. Ascomycotina
5. Basidiomycotina
6. Deuteromycotina

General account on economic and ecological importance of lichen, Structure and reproduction.

Module IV. Bryophyta **5 Hrs.**

Introduction, General Characters, classification, evolution and alternation of generation in bryophytes.

ModuleV. Pteridophytes **8 Hrs.**

Introduction, General Characters, classification, evolution and alternation of generation in pteridophytes.

Module VI. Gymnosperms **8 Hrs.**

Introduction, General Characters, classification, evolution and development of seed habit in gymnosperms.

Module VII. Angiosperm morphology and systematic botany **10 Hrs.**

Morphology of flower, inflorescence and fruits. Herbarium technique, Herbaria, Botanical gardens and BSI. Bentham and Hookers system of classification.

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Wendy B. Zomlefer 2006. *Guide to Flowering Plant Families*. Overseas Press India Private Ltd.

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SEMESTER III

Life Science Lab - 3

Plant Diversity - Practical

(2 Hrs. / Week) **Credits - 2**

I. Students are expected to identify the following types by making suitable micropreperations and make labelled sketches.
   1. Spirogyra
   2. Rhizopus
   3. Puccinia
   4. Riccia
   5. Pteris
   6. Cycas
   7.

II. Family Studies
   1. Annonaceae
   2. Malvaceae
   3. Leguminosae
   4. Rubiaceae
   5. Compositae
   6. Ascipediaceae
   7. Euphorbiaceae
   8. Poaceae

III. Laboratory Record

SEMESTER IV

Life Sciences Paper - 4

Animal Diversity

(3 Hrs. / Week, Total content 54 Hrs.) **Credits - 3**

Module I.Animal Taxonomy **4 Hrs.**

Brief history, Concepts and definition, Importance of classification, International Code of Zoological Nomenclature (ICZN), Importance principles of ICZN, Five Kingdom Classification.

Module II. Animal Body Organization **3 Hrs.**

Symmetry - Asymmetry, Spherical, Radial, Biradial and Bilateral. Coelom – Acoelomates, Pseudocoelomates and Eucoelomates, Schizocoelom and Enterocoelom., Protostomia and Deuterostomia.

Module III. Kingdom Protista **7 Hrs.**

Introduction, general characters, classification with brief account on examples of each phylum. Study of important human Protist pathogens.

Module IV. Kingdom Animalia – Non Chordata **20 Hrs.**

(Only brief account on examples)

Outline classification of Kingdom Animalia. Three branches – Mesozoa, parazoa, Eumetazoa.

Phylum Porifera – Salient features, Classification upto classes, Class I- Calcarea. Eg. Sycon., Class II – Hexactinellida . Eg. Euplectella., Class III – Demospongia Eg. Cliona.

Phylum Coelenterata (Cnidaria) - Salient features, Classification upto classes., Class I - Hydrozoa Eg. Halistemma., Class II – Scyphozoa Eg. Rhizostoma., Class III- Anthozoa Eg. Fungia. Polymorphism in Coelenterates.

Phylum Ctenophora - Salient features, Eg. Pleurobrachia.

Phylum Platyhelminthes - Salient features, Classification upto classes**.,** Class I - Turbellaria. Eg. Planaria**.,** Class II – Trematoda Eg. Fasciola, Class III- Cestoda Eg. *Taenia saginata.*

Phylum Nematoda - Salient features, Class phasmidia Eg. Enterobius, Ascaris, Class Aphasmidia Eg. Trichinella, Human Pathogenic nematodes.

Phylum Annelida - Salient features, Classification upto classes., Class I- Archiannelida Eg. Polygordius., Class II – Polychaeta Eg. Chaetopterus., ClassIII- Oligochaeta Eg. Megascolex.,Class IV - Hirudinomorpha Eg. Hirudinaria

Phylum Arthropoda - Salient features, Classification upto classes.

1. Sub Phylum - Trilobitomorpha Class - Trilobita

2. Sub Phylum- Mandibulata, Class I – Crustacea Eg. Sacculina**.,** Class II- Chilopoda Eg. Centipede (Scolopendra)**.,** Class III – Symphyla Eg. Scutigerella., Class IV – Diplopoda Eg. Millipede (Spirostreptus)**.,** Class V - Insecta Eg. Dragon fly**.,** Class VI – Pauropoda Eg. Pauropus

3. Sub Phylum - Chelicerata., Class - Merostomata Eg. Limulus**.,** Class II – Arachnida Eg. Scorpion

General Topics - Arthropods as Vectors, Beneficial Insects.

Phylum Mollusca - Salient features, Classification upto classes., Class I- Monoplacophora Eg. Neopilina., Class II- Amphineura Eg. Chiton., Class III- Gastropoda Eg. Aplysia., Class IV- Scaphopoda Eg. Dentalium., Class V- Pelecypoda Eg. Pinctada., Class VI- Cephalopoda Eg. Sepia

Phylum Echinodermata - Salient features, Classification upto classes., Class I- Asteroidea Eg. Astropecten., Class II- Ophiuroidea Eg. Ophiothrix., Class III- Echinoidea Eg. Echinus, Class IV- Holothuroidea Eg. Holothuria., Class V – Crinoidea Eg. Antedon

Minor Phyla - 1. Chaetognatha Eg. Sagitta., 2. Sipunculida Eg. Sipunculus
3. Rotifera Eg. Brachionus

Phylum Hemichordata - Salient features, Eg. Balanoglossus

Module V. Kingdom Animalia – Chordata **20 Hrs.**

Phylum Chordata – Salient features of Chordates.

Sub phylum :Urochordata Class I Larvacea Eg. Oikopleura., Class II Ascidiacea Eg: Ascidia, Class III Thaliacea Eg: Doliolum

Sub phylum: Cephalochordata Eg: Amphioxus

Sub phylum: Vertebrata

Division 1 – Agnatha Class I Ostracodermi Eg: Cephalaspis**.,** Class II Cyclostomata Eg: Petromyzon

Division 2 – Gnathostomata

Super class Pisces - Class: Chondrichthyes., Sub class – Elasmobranchi Eg: Narcine Sub class Holocephali Eg: Chimaera

Class: Osteichthyes., Sub class – Choanichthyes., Order 1 Crossopterigii Eg: Latimeria., Order 2 Dipnoi Eg: Lepidosiren., Sub class: - Actinopterygii., Super order 1. Chondrostei Eg: Acipencer., Super order 2. Holostei Eg: Amia., Super order 3. Teleostei Eg: Sardine.

Super class: Tetrapoda

Class Amphibia., Order I Anura Eg: Frog., Order II Urodela Eg: Amblystoma Order III Apoda Eg: Ichthyophis.

Class Reptilia - Sub class I: Anapsida., Order Chelonia Eg: Chelone., Sub class II: Parapsida Eg: Ichthyosaurus., Sub class III: Diapsida., Order I Rhynchocephalia Eg: Sphenodon., Order II Squamata Eg: Chamaleon., Sub class IV: Synapsida Eg: Cynognathus

Class Aves - **Sub class I: Archeornithes** Eg: Archaeopteryx ., **Sub class II: Neornithes** Super order I: Palaeognathe Eg: Struthio., Super order II: Neognathe Eg; Brahminy kite

Class Mammalia

Sub class I: Prototheria Eg: Echidna

Sub class II: Metatheria Eg: Macropus

Sub class III: Eutheria, Important orders with examples

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SEMESTER IV

Life Science Lab - 4

Animal Diversity - Practicals

(2 Hrs. / Week) **Credits - 2**

1. General identification- (No need of drawings). The students are expected to identify the following animals by their scientific names
    a. 2 Protists, 2 sponges, 2 coelenterates, 2 flat worms (1 free living & 1 parasitic), 2 parasitic nematodes, 2 economically important crustaceans, 2 insect vectors/pests, 2 economically important molluscs, 2

echinoderms, 4 common food fishes of Kerala (2 marine & 2 fresh water), 2 common amphibians of Kerala, 4 snakes of Kerala (2 Non poisonous & 2 Poisonous), 2 rodents.

2. Study the beak and feet modifications in the following birds - duck, parrot, king fisher, owl, kite and wood pecker.

3. Taxonomic identification using keys (five specimens each)**:-**
    a. Identification of insects up to the level of order
    b. Identification of fishes up to the level of order.
    c. Identification of snakes up to family.
4. Scientific Drawing –
    a. Make scientific drawings of 10 locally available specimens (5 invertebrates + 5 vertebrates) belonging to different phyla.

5. Study the following using temporary/permanent slides
    a. Mouth parts –House fly, Honey bee, Mosquito
    b. Neries – Parapodia
    c. Cockroach - Salivary glands
    d. Fish scales – Placoid,cycloid,ctenoid

6. Laboratory Record.

SEMESTER V

Life Sciences Core Paper - 1

Molecules of Living Systems

(4 Hrs. / Week, Total content 72 Hrs.) **Credits - 4**

Module I. Introduction **3 Hrs.**

Atoms, molecules and chemical bonds. Water: biological importance, pH and acid - base balance. Buffers - biological importance.

Module II. Carbohydrates **12 Hrs.**

Monosaccharides: Classification and nomenclature

Isomerism – structural isomerism and stereoisomerism, optical isomerism, epimerism and anomerism. Mutarotation and inversion of sugars.

Disaccharides: Sucrose, Lactose, Maltose, Isomaltose, Cellobiose and Trehalose.

Polysaccharides**:** Homopolysaccharides- Starch, Glycogen, Cellulose, Chitin, Dextrans, Inulin, Pectin.

Heteropolysaccharides- Hyaluronic acid, Heparin, Chondroitin sulphate, Keratan sulphate, Dermatan sulphate and Agar-agar. Glycoproteins and Mucoproteins.

Biological importance of carbohydrates.

Module III. Proteins **15 Hrs.**

Structure, classification and properties of amino acids. Amphoteric properties of amino acids, p*K* value and iso-electric point of amino acids. Peptide bond formation and peptides. Reactions (due to carboxyl group, amino group and side chains). Colour reactions of amino acids and proteins.

Protein structure: Primary structure of protein (*e.g.* insulin). Secondary structure - Conformation of proteins- chemical bonds involved, Alpha helix, Collagen helix, Beta pleated sheet, Ramachandran angles and Ramachandran map.

Tertiary structure- *e.g.* Myoglobin. Quaternary structure – *e.g.* Haemoglobin.

Chaperons and folding of polypeptides

Classification of proteins: a) based on structure (simple, conjugated, derived) b) based on molecular organisation and solubility (fibrous and globular proteins)

Fibrous proteins- examples (Keratin, Collagen, Elastin, Resilin, Fibrous muscle proteins).

Globular proteins – examples (albumin, globulin, myoglobin,lysozyme)

Biological importance of proteins

Module IV. Lipids **12 Hrs.**

Classification of lipids: simple, compound and derived lipids.

Fatty acids: classification, nomenclature.

Simple fats: Triacylglycerol (Triglycerides) - Physical properties.

Reactions-Hydrolysis, Saponification,Rancidity.

Acid number, Saponification number, Iodine number, Polenske number and Reichert-Meissl number of lipids.

Waxes, Compound lipids: Phospholipids- Lecithin, Phosphatidyl inositol, Cephalins, Plasmologens, Glycolipids, Sphingolipids.

Prostaglandins- structure, types and functions.

Derived Lipids: Steroids: Structure, Biologically important steroids- cholesterol (types), Bile acids, Ergosterol, Terpenes, Lipoproteins. Biological importance of lipids.

Module V. Nucleic Acids **10 Hrs.**

Structure of nucleic acids and nucleotides: Structural organization of DNA (Watson –Crick model) Characteristic features of A, B, C and Z DNA. Structural organization of tRNA, rRNA and mRNA; Protein-nucleic acid interaction. DNA regulatory proteins, folding motifs, conformation flexibilities, denaturation, renaturation,

DNA polymerases, Restriction endonucleases. Biological roles of nucleotides and nucleic acids.

Module VI. Enzymes **10 Hrs.**

Chemical nature of enzymes, Specificity, Classification and nomenclature, mechanism of enzyme action, factors influencing enzyme action (temperature, pH, enzyme concentration, substrate concentration), enzyme activation, enzyme inhibition, allosteric enzymes, isoenzymes, co-enzymes.

Module VII. Vitamins and Minerals **4 Hrs.**

Fat-soluble and water-soluble vitamins, Minerals important in living system, Biological significance of vitamins and minerals.

Module VIII. Hormones **6 Hrs.**

Classification and types of hormones, Chemical nature of important hormones, Role of main hormones.

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SEMESTER V

Life Sciences Core Paper - 2

Plant Physiology

(4 Hrs. / Week, Total content 72 Hrs.) **Credits - 4**

Module I. Water relations **8 Hrs.**

Physical aspects of absorption - Diffusion, imbibition, osmosis, OP, DPD, TP, WP, Concept of Water potential, matrix potential, pressure potential. Absorption of water- active & passive, Ascent of sap - cohesion adhesion theory, Transpiration - types- mechanism – theories - (starch - sugar, proton - K^+ion exchange) – significance, leaf anatomy for regulating transpiration Control of stomatal mechanism , antitranspirants, Guttation.

Module II. Mineral Nutrition and mechanism of absorbtion. **6 Hrs.**

Essential and non essential elements- macro& micro- role- deficiency symptoms. Absorption of minerals– active & passive-ion exchange, carrier concept. Entry of minerals into roots.

Module III. Nitrogen metabolism **6 Hrs.**

N - cycle . N fixation processes. Biological N fixation – structure of nitrogenase complex, reduction of N, Symbiotic N fixation – nodule formation, leghaemoglobin, Nitrate and ammonium assimilation. Transport of amides and ureides.

Module IV. Photosynthesis **10 Hrs.**

Photosynthetic pigments, photo exitation- Fluorescence, Phosphorescence - Absorbtion and action spectra, Red drop and Emerson enhancement effect, Concept of photo systems, Cyclic & Non Cyclic photophosphorylation, Carbon assimilation pathways-C_3, C4, CAM- Photorespiration –factors affecting photosynthesis.

Module V. Translocation of solutes **6 Hrs.**

Pathway-phloem transport-mechanism-pressure flow-phloem loading and unloading.

Module VI. Respiration **8 Hrs.**

Aerobic and Anaerobic, Glycolysis, Krebs cycle, Electron transport system & Oxidative phosphorylations, ATPases - chemi osmotic hypothesis-RQ –significance- factors affecting respiration, β oxidation.

Module VII. Plant responses to environment **10 Hrs.**

Allelochemicals- herbivory, Abiotic-concept of plant responses to water, salt and temperature stresses – Biotic factors (pathogens & insects), Mechanisms of resistance to biotic stress and tolerance to abiotic stress.

Module VIII. Sensory photobiology **8 Hrs.**

Structure, function and mechanisms of action of phytochromes, cryptochromes, phytochrome mediated plant responses, Photoperiodism and biological clocks – circadian rhythms, Floral induction and development

Module VIII. Physiology of growth and development **10 Hrs.**

Physiological effects and practical application of hormones-Auxins, Gibberillins, Cytokinins, ABA, ethylene. Physiology of flowering – phytochrome – photoperiodism – vernalisation. Biosynthesis, storage, breakdown, transport, physiological effects, and mechanism of action of plant growth hormones.

REFERENCES

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SEMESTER V

Life Sciences Core Paper - 3

Animal Physiology

(4 Hrs. / Week, Total content 72 Hrs.) **Credits - 4**

Module I. Metabolism **12 Hrs.**

Basal metabolism- calculation BMR by Harris-Benedict formula; Energy metabolism- (a)Carbohydrate metabolism – glycolysis, glycogenolysis, glycogenesis, glucogenesis, gluconeogenesis, Pentose Phosphate pathway), Kreb's cycle; Electron Transport System (ETS) and oxidative phosphorylation.

(b)Protein metabolism- deamination, transamination, decarboxylation, transmethylation.

(c) Lipid metabolism – oxidation of glycerol and fatty acids (β oxidation); Biosynthesis of fatty acids

Module II. Respiration **8 Hrs.**

Anatomical considerations, Gas exchange, respiratory pigments- structure of haemoglobin**,**transport of Oxygen, Oxyhaemoglobin curve, Bohr effect, transport of CO2 - carbonic acid, carbamino haemoglobin, bicarbonate and chloride shift, regulation of respiration – neural and chemical.

Module III. Cardio-vascular system **12 Hrs.**

Heart - structure, myogenic, neurogenic heart, cardiac cycles, cardiac output, blood pressure, regulation of heart heartbeat, conducting system and pace maker, pulse, ECG - basis, principles of recording, significance

Blood - Composition and functions of blood plasma and formed elements,blood volume regulation, blood groups, mechanism of blood, disorders of blood clotting, anticoagulants

Lymph and lymphatic system (brief account)

Module IV. Muscle Physiology **10 Hrs.**

Brief account of types of muscles, fast and slow twitch muscles, red and white muscles. Ultra structure of striated muscle fibre, muscle proteins, simple muscle twitch,summation, tetanus, tonus, All or None law, fatigue, oxygen debt, rigor mortis. Physiological and biochemical events in muscle contraction.

Module V. Excretion **10 Hrs.**

Nephron – Structure, Urine formation, Role of hormone in urine formation and concentration, Counter-current multiplier system,Role of kidney in osmoregulation, composition of urine, abnormal constituents of urine, regulation of kidney functions, renal disorders – nephritis, haematurea, renal calculi, acidosis and alkalosis, Dialysis.

Module VI. Nerve Physiology **5 Hrs.**

Neurons – structure, types of neuron, Synapse and types of synapse, nerve impulse propagation, synaptic transmission. Reflex action, refractory period, neuro transmitters, electro encephalo gram. Nerve disorders – epilepsy, Alzheimer's disease, Parkinson's disease.

Module VII. Sensory Physiology **5 Hrs.**

Structure of eye, Physiology of vision, visual elements and pigments, photo chemistry of vision. Eye defects – myopia, hyperopia, presbyopia, astigmatism, cataract. Structure of ear and mechanism of hearing, hearing impairments, deafness. Olfactory, gustatory and tactile sense organs

Module VIII. Reproductive physiology **5 Hrs.**

Male and female reproductive organs, Reproductive Cycles(role of hormones), puberty, adolescence, pregnancy, parturition, lactation.

Module IX. Endocrinology **5 Hrs.**

Endocrine glands in man, Hormones as messengers, hormones and disorders, feed-back mechanism.

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SEMESTER V

Life Sciences Core Lab - I

Molecules of Living Systems, Plant Physiology Animal Physiology - Practicals

(4 Hrs. / Week) **Credits - 4**

Molecules of Living Systems

1. Qualitative Analysis.

A) Reactions of carbohydrates:

(i) General test for carbohydrates- Molisch's test.

(ii) Tests for monosaccharides (Glucose/fructose) – Benedict's test, Fehling's test, Moore's test, Rapid furfural test, Seliwanoff's test, Barfoed's test– (Any 3 tests).

(iii) Test for non-reducing disaccharides (Lactose/Sucrose)– Hydrolysis test.

(iv) Test for polysaccharide (Dextrin/Starch) – Lugol's iodine test.

B) Tests for proteins–Ninhydrin test, Biuret test, Nitric acid test, Millon's test, Sodium nitroprusside test – (Any 3 tests).

C) Tests for lipids – Solubility test, Spot test, Acrolein test, Emulsification test, Saponification test, Sudan test – (Any 3 tests).

(Testing of a mixture with 3 unknown samples to be a major experiment for practical examination)

2. Effect of temperature / pH on salivary amylase activity

Plant Physiology

1.Determination of osmotic pressure of plant cell sap by plasmolytic method.

2.Compare the stomatal indices of hydrophytes, xerophytes and mesophytes.

3. Measurement of photosynthesis by Willmott's bubbler/any suitable method.

4. Estimation of plant pigments by colorimeter.

5. Measurement of Photosynthesis - Hill Reaction.

Animal Physiology

1.Study of tonicity of blood cells

2.Estimation of haemoglobin of blood using Haemoglobinometer

3.Total RBC count using Haemocytometer

4.Total WBC count using Haemocytometer

5.Estimation of microhaematocrit

6.Effect of adrenalin on heart beat of Cockroach (Demonstration)

Laboratory Record based on these practicals.

SEMESTER VI

Life Sciences Core Paper - 4

Biophysical Techniques

(4 Hrs. / Week, Total content 72 Hrs.) **Credits - 4**

Module I. Microscopy **10 Hrs.**

Light microscope (use of oil immersion objective), dark field microscope, Phase contrast microscope, Differential Interference contrast (Nomarsky) microscopy, Polarizing microscope, Fluorescent microscope, Electron microscope (TEM & SEM), Camera lucida and micrometry

Module II. Chromatography **15 Hrs.**

Partition and adsorption Chromatography - paper, TLC, GLC, GCMS, Gel filtration-theory, materials, advantages, molecular weight determination and other applications. Ion exchange chromatography – properties of ion exchangers, choice, technique and applications. Amino acid analyzer - HPLC, HPTLC, affinity chromatography, Methods of ligand immobilization, Immuno-adsorption – Hydrophobic interaction chromatography, Metal chelate chromatography, covalent chromatography. Special chromatographic techniques for nucleic acids.

Module III. Electrophoresis **15 Hrs.**

Theory, types, moving boundary electrophoresis, zone electrophoresis, paper, cellulose acetate, gel Electrophoresis, Native PAGE, disc PAGE, Gradient PAGE, SDS PAGE, DNA agarose gel electrophoresis Southern, Northern, Western transfers, Isoelectric focusing finger printing, DNA sequencing Pulsed – field Electrophoresis, Capillary Electrophoresis, Biological applications of electrophoresis.

Module IV. Centrifugation **10 Hrs.**

Theory, Preparatory and analytical ultracentrifuges, factors affecting sedimentation velocity, sedimentation coefficient, measurement of S, Zonal centrifugation, DNA analysis, Determination of molecular weight by sedimentation, diffusion and sedimentation equilibrium methods. Specific example of application.

Module V. Spectrophotometric tecchniques **10 Hrs.**

UV and visible Spectophotometry, IR and NMR Spectrophotometry. Principles of turbidimetry and nephelometry. Principle, instrumentation and application of

luminometry. Atomic spectroscopy - Principle and applications of atomic flame and flameless spectrophotometry, Mass spectroscopy

Module VI. Isotope Tracer Technique **8 Hrs.**

Types of radiations, measurement scintillation and gamma counters. Background noise quenching, Applications. Interaction of radiation with matter, passage of neutrons through, matter, interaction of gamma rays with matter, units of measuring radiation absorption, Radiation dosimetry, Radiolysis of water, free radicals in water. Autoradiography

Module VII. Immunological techniques **2 Hrs.**

Radio Immuno Assay, Immunodiffusion – immunoelectrophoresis – ELISA, RIA (Basic principle and uses only)

Module VIII. Nanotechnology **2 Hrs.**

Introduction to Nanobiology. Nanosensors and Nanomedicines.

REFERENCES

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SEMESTER VI

Life Sciences Core Paper - 5

Research Methodology & Biostatistics

(4 Hrs. / Week, Total content 72 Hrs.) **Credits - 4**

Module I. Basic concepts of research **15 Hrs.**

Meaning, Objectives, Approaches, Types of research, Scientific method in research (eight steps), Defining and formulating the research problem. Selecting the problem and necessity of defining the problem, Importance of literature reviewing in defining a problem, Identifying gap areas from literature review, Research Design: Basic principles, meaning, need and features of good design, Important concepts and types of research designs. Development of a research plan: Determining experimental and sample designs.

Module II. Research Communication and scientific documentation **15 Hrs.**

Project proposal writing, Research report writing, (Structure of a scientific paper), Thesis, dissertation, research article, Presentation techniques: Oral presentation techniques, Assignment, Seminar, Debate, Workshop, Colloquium, Conference, Sources of Information: Primary and secondary sources. Library- Books, Journals, Periodicals, Reference sources, Abstracting and indexing sources, Reviews, Internet, Search engines and software: Online libraries, e-Books, e-Encyclopedia, Institutional Websites.

Module III. Bioethics **12 Hrs.**

Introduction, Animal rights and animal laws in India, Prevention of cruelty to animals Act 1960,Wildlife protection act 1972 and Amendments, Biodiversity Act 2003.

Concept of 3 R – conservation (**R**efined- to minimize suffering, **R**educed – to minimize animals, **R**eplaced – modern tools and alternate means),

Animal use in research and education: Laboratory animal use, care and welfare, Animal protection initiatives, Animal Welfare, Animal Welfare Board, India CPCSEA, Working with human: Consent, harm, risk and benefits.

Module IV. Animal Collection techniques **10Hrs.**

Brief account on Collection methods, techniques and equipments for Plankton, Insects, Fish, Bird, **Preservation techniques:** Different techniques for preservation of animals including taxidermy, **Rearing techniques:** Techniques in laboratory and on field.

BIOSTATISTICS

Module V. Sample and Sampling techniques **8Hrs.**

Collection of data, Classification of data, Frequency distribution tables, **Graphical representation of data:** Bar diagrams, Histogram, Pie diagram and Frequency curves.

Module VI. Analysis of data **12Hrs.**

Measures of Central Tendency: Mean, Median, Mode (Problem - Direct method only) **Measures of dispersion:** Range, Quartile Deviation, Mean Deviation, Standard Deviation, Standard error. (Merits & demerits and problems on SD). **Correlation:** Definition, Types of correlation. (Brief account only). **Test of Hypothesis and Test of Significance:** Basic concept, Levels of significance, test of significance, Procedure for testing hypothesis, types of hypothesis- Null hypothesis and Alternate hypothesis. **Statistical packages - SPSS, BIOSTAT, PRIMER.** (Brief account only)

REFERENCES

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SEMESTER VI

Life Sciences Core Lab - II

Biophysical Techniques, Research Methodology & Biostatistics - Practicals

(4 Hrs. / Week) **Credits – 2**

1. Working of various types of microscopes - Dark field microscope, Phase contrast microscope, Polarizing microscope, Fluorescent microscope
2. Micrometry - Measurement of microscopic objects.
3. Drawings using camera lucida
4. Chromatography – Determination of Rf value and identification of amino acid using paper chromatography
5. Separation of plant pigments by Thin Layer Chromatography (TLC)
6. Centrifugation- cell fractionation and separation of nuclei.
7. Preparation of standard curve and estimation of solute concentration in a sample using a colourimeter / spectrophotometer
8. Searching and data collection of online databases and online libraries.
9. Simple statistical problems - mean, median, mode, mean deviation & standard deviation for grouped and ungrouped data.
10. Construction of Line graph, Bar diagram, Pie diagram, Histogram, & Frequency Polygon
11. Introduction to a statistical software
12. Laboratory Record

SEMESTER VI

Life Sciences Core Paper - 6

Genetics & Biotechnology

(4 Hrs. / Week, Total content 72 Hrs.) **Credits - 4**

Genetics

Module I. Mendelian Genetics **12 Hrs.**

Mendel's experiments- Monohybrid Cross, Dihybrid Cross, Test Cross, Back Cross and Reciprocal Cross. Principles of Inheritance. Chromosome Theory of Inheritance; Interaction of genes: Allelic: Incomplete Dominance (Four O Clock Plant), Co-Dominance (Skin colour in Cattle) Lethal Alleles (Yellow Fur colour in Mice); Non Allelic: Complementary (Flower colour in Sweet Pea), Supplementary (Coat colour in mice), Epistasis - dominant (Plumage in poultry) and recessive (Coat colour in mice), Polygenes (Skin colour inheritance in man), Pleiotropism (Drosophila), Multiple alleles – ABO Blood group system, Rh group and its inheritance, Extra nuclear inheritance: General characteristics, organelle DNA (mitochondrial and plastid DNA), Inheritance of Kappa particles in *Paramecium*.

Module II. Recombination and Linkage: **15 Hrs.**

Linkage and recombination of genes based on Morgan's work on Drosophila, Linked genes, Linkage groups, Chromosome theory of Linkage, Types of linkage- complete and incomplete, Two point & Three point cross, Factors affecting Crossing over and its significance, Interference & Coincidence, Linkage and Chromosome mapping

(brief account only). Sex determination: Chromosome theory of sex determination (Autosome and Sex chromosomes), male heterogamy and female heterogamy, (xx-xo, xx-xy, zz), Genic Balance theory of Bridges. Barr bodies, Lyon's hypothesis, evidence for sex chromosome inactivation. Gynandromorphism, sex mosaics, intersex (Drosophila), Hormonal and Environmental influence on Sex determination (Bonelia). Sex Linkage: Characteristics of Sex Linked inheritance, Sex Linked inheritance of man (Colour blindness and Hemophilia), Incompletely Sex Linked genes (Bobbed bristles in Drosophila), Pseudo autosomal genes, Holandric genes, Sex limited genes (Beard in man) and Sex influenced genes (inheritance of baldness in man).

Module III. Mutation 6Hrs.

Types of mutations - Somatic, germinal, spontaneous, induced, autosomal and allosomal, chromosomal mutations, structural and numerical changes. Gene mutations, molecular basis of mutations, induced mutations, physical and chemical mutagens, factors causing mutation.

Module IV. Bacterial genetics 6Hrs.

Bacterial Genome, Recombination in Bacteria- Transformation. Transduction, Conjugation, F mediated sexduction. Resistance Transfer Factor (RTF), Mechanism of drug resistance in Bacteria. Transposable genetic elements in Bacteria, Basic components and transposition in Bacteria.

Module V. Human Genetics 15Hrs.

Karyotyping - Characterisation of chromosomes using various banding techniques such as Q banding, G banding, R banding, C banding and N banding. Normal Human chromosome Complement, Pedigree analysis, Aneuploidy and Non- disjunction. Autosomal abnormalities (Trisomy 21, Trisomy 18, Trisomy 13) Sex chromosomal abnormalities (Klinefelters syndrome, Turner's and Cri du chat syndrome) Single gene disorder (Brief mention) Autosomal single gene disorder (Achondroplasia, Huntington's Disease, Brachydactly), Inborn errors of metabolism such as phenylketonuria, alkaptonuria, sicke cell anaemia, Albinism. Multifactorial traits – polygenic disorder- cleft lip and cleft palate. Sex-linked Diseases – Colour blindness, Haemophilia, Holandric traits.

Biotechnology

Module VI. Tools and Techniques in Biotechnology 10Hrs.

Genetic engineering and recombinant DNA technology - Brief History, Scope and Importance, Enzymes in biotechnology (restriction endonucleases, ligases, modifying enzymes), Vectors- Plasmids, Phage vectors, Cosmids, Phagemids, Phasmids, Artificial Chromosomes, Probes, Linkers, Host cells. Basic steps & techniques in rDNA technology- Gene Libraries, Construction of genomic library and cDNA Library ,PCR technique and DNA amplification, Brief description of screening methods –Nucleic Acid hydridization, *In situ* Hybridization, Fluorescence *in situ* Hybridization (FISH), Colony hybridization. Methods of transfer of desired gene into target cell. Blotting Techniques- Southern, Northern, Western, Dot Blotting. DNA Finger printing (DNA Profiling) and its application. Molecular Markers-RFLP

Module VII. Animal Cell Culture **2Hrs.**

Brief account on methods, substrates, media and procedure of animal cell culture, Stem Cell Technology, types of stem cells and potential use, Organismal Cloning-reproductive & therapeutic- brief account only.

Module VIII. Plant Tissue Culture **6Hrs.**

Basic components in tissue culture medium – Solid and liquid medium – suspension culture. Murashige and Skoog medium – composition and preparation. Aseptic techniques in tissue culture – sterilization – different methods – sterilization of instruments and glass wares, medium, explants; working principle of laminar air flow and autoclave; preparation of explants – surface sterilization. Inoculation, incubation, subculturing, Micropropagation - Different methods – axillary bud proliferation, direct and indirect organogenesis and somatic embryogenesis. Different phases of micropropagation – hardening, transplantation and field evaluation Advantages and disadvantages of micropropogation. Somaclonal variation.

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Zoological Society of Kerala Study material 2002. *Cell Biology Genetics and Biotechnology*.

SEMESTER VI

Life Sciences Core Paper - 7

Environmental Science

(4 Hrs. / Week, Total content 72 Hrs.) **Credits - 4**

ModuleI. Environmental science and its multidisciplinary nature **1 Hr.**
Introduction, relevance and scope, public awareness

Module II. Natural Resources **12 Hrs.**
Types of resources-renewable and non renewable

- Forest resources: Timber extraction, mining, dams, over exploitation, deforestation, MFP (minor Forest products) , Joint Forest Management (JFM)

- Water resources: surface and ground water, drinking water, dams-benefits and problems, conflict over water, Rain water harvesting, Water shed conversation
- Food resources: major food crops in India. Causes of food shortage. Food security, world food problems.
- Energy resources: Renewable and non – renewable energy resources, Energy plantation, - *Jatropha*
- Land resources: Land use, land degradation, desertification, EFL(Ecologically Fragile Land)
- Ecological footprints

Module III. Ecosystems 10 Hrs.

- Structure and function of ecosystem: Ecosystem components- abiotic and biotic, Productivity – primary and secondary - gross and net productivity. Decomposition in nature, homeostasis in ecosystem
- Ecological energetics: energy flow, trophic levels, food chain and food web, ecological pyramids
- Nutrient cycles: Biogeochemical cycles of C, N and S.

Module IV. Community ecology 10 Hrs.

- Population: size, density, natality, mortality.
- Community characteristics: Species diversity and species richness, dominance, growth forms and structure, trophic structure.
- Association of communities: plant association, ecotypes, ecotone, edge effect, ecological indicators.
- Ecological succession: types of succession, process – migration, ecesis, colonization, stabilization and climax community; hydrosere, xerosere, lithosere.

Module V. Environmental pollution and Management 15 Hrs.

- Definition and general introduction
- Air pollution: Causes and sources, types of pollutants-particulates-aerosol, mist, dust, smoke, fume, plume, fog, smog. Effect of air pollution on plants and animals, Bhopal Gas Tragedy.
- Water pollution: Sources and types of pollutants. Water quality standards, water quality assessment. Ground water pollution-blue baby syndrome. Cycling of heavy metals, biomagnification, hydrocarbons. Eutrophication, BOD, Minamata disease.
- Soil pollution: Causes and sources-waste dumps, municipal wastes, agrochemicals, mining, solid waste management-vermi composting.
- Noise pollution: Sources, standards and measurements, effect on health, control techniques.
- Thermal pollution: Sources and effects
- Nuclear hazards: Sources and impacts.

- EIA: Environmental Impact Assessment in polluted areas

Module VI. Social issues and the environment 6 Hrs.
Climate change, global warming and green house gases, IPCC, Acid rain, Ozone layer depletion, nuclear accidents and nuclear holocaust.

Module VIII. Environmental legislation and laws 4 Hrs.
(1) Environment (protection) Act, 1986, (2) Air (Prevention and control of pollution) Act, 1981, (3) Water (Prevention and control of pollution) Act, 1974, (4) Wildlife (protection) Act, 1972, (5) Forest (Conservation) Act, 1980 (briefly)**.**

Module IX. Biodiversity and Conservation biology 10 Hrs.
Biodiversity – Definition, types, Values of biodiversity, Endemism: Definition-types-factors. Hotspot of endemism-hotspots in India. IUCN-threat categories. Red data book., Western Ghats as the hottest spot and its conservations.

- Biodiversity loss: Causes and rate of biodiversity loss, extinction-causes. Alien species, negative and positive impacts
- Conservation efforts: Rio Earth Summit, Agenda 21, Kyoto protocol, COP 15(15^{th} Conference of the Parties under the U N Framework Convention on Climate Change), IPCC (Inter Governmental Panel for Climate Change) and its contribution. Paris summit 2015, Conservation strategies and efforts in India and Kerala, In situ and ex situ conservation methods. Role of NGOs in biological conservation

Module X. Organizations and contributors of Ecological studies 4 Hrs.

- *Organizations*: BNHS, WWF, CSE, NEERI, , MoEF, Green Peace, Chipko
- *Famous contributors of Ecology in India:* Salim Ali, M.S. Swaminathan, Madhav Gadgil, M.C. Mehta, Anil Agarwal, Medha patkar, John C. Jacob, Sunderlal Bahuguna

REFERENCES

Ahuwalie V.K., SunitaMalhotra, 2009. *Environmental science*, Ane Books Pvt. Ltd.
Alan Beeby, 2006. *Ecological principles and Environmental issues* . International students edition Sec. edition Oxford University Press.
Andrew S. Pullin 2002 *Conservation Biology*. Cambridge University Press, Cambridge, UK
Bharucha, E. 2005.*Textbook of Environmental Studies for Undergraduate Courses*. University Grants commission
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Miller, Tyler. G. (Jr) 2005. *Essentials of Ecology*.Thomson Brooks/cole.
Misra S.P., Pandy S.N. 2009. *Essential Environmental Students*, Ane books Pvt. Ltd.
Nambiar, K.R. 2008.*Textbook of Environmental Studies (For Undergraduate Courses as per the UGC Model Syllabus*. Scitech Publications (India) Pvt. Ltd. Chennai, India.
Odum, E.P. (1983), *Basic Ecology*, Sanders, Philadelphia.

Robert May & Angela Mc Lean 2007. *Theoretical Ecology. Principles and Application*, Oxford University Press (India Ed.)
Santra, S.C. 1994. *Ecology Basic and Applied.* M.D. Publications Pvt. Ltd. New Delhi.
Sharma, P.D. 2007. Ecology and Environment. Rastogi Publishers

SEMESTER V

Life Sciences Core Lab - III

Genetics & Biotechnology, Environmental Science - Practicals

(4 Hrs. / Week) **Credits - 2**

1. Study of normal male and female human karyotype (use photographs or Xerox copies) and abnormal human karyotypes - Down's Syndrome, Klinefeller's Syndrome,Turner's Syndrome & Edward's Syndrome.
2. Genetics Problems - Di hybrid cross, test cross and sex linked inheritance
3. Preparation of nutrient medium for plant tissue culture – Murashige and Skoog medium, sterilization, preparation of explants, inoculation.
4. Immobilization of whole cells or tissues in sodium alginate.
5. Determination of appropriate flower bud containing uninucleate pollen for anther culture using cytological techniques
6. Isolation of plant genomic DNA and quantification
7. Estimation of CO_2, Cl, and salinity of water samples (Titremetry)
8. Determination of pH of soil and water
9. Assessment of diversity, abundance, and frequency of plant species by quadrate method (Grasslands, forests)
10. Visit to a forest/aquatic ecosystem to make an assessment of biodiversity and plant – animal interactions. (no collection of specimens)
11. Laboratory Record

SYLLABI FOR IN STREAM ELECTIVES

for
Semester III, IV & V

(Students have to choose any **Two** in – stream electives in Semester III, IV & V)

In Stream Elective – 1
Biosafety, Bioethics and IPR Issues

(3 Hrs. / Week, Total content 54 Hrs.) **Credits - 2**

Module I. Biosafety Guidelines and Regulations. **12 Hrs.**
Introduction and Development of Biosafety Practices, Definitions and Biosafety levels: 1,2,3,4., General lab requirements, Good Laboratory Practice (GLP) and Good Manufacturing Practice (GMP). Biological safety cabinets: centrifuges, Shipment of biological specimens, Biological waste management, Decontamination, Biosafety manuals, Medical surveillance, Emergency response, Biosafety protocol 2000. Bio safety regulation: handling of recombinant DNA products and process in industry and in institutions (Indian context). Role of Public and Non-Governmental Organizations (NGOs).

Module II. Bioethics – Principles and Pracice **18 Hrs.**
What is Bioethics. History and Introduction. Ethical conflicts in biotechnology - interference with nature, unequal distribution of risk and benefits of biotechnology, bioethics vs business ethics. Legal and Socio-economic Impacts of Biotechnology. Ethical Issues in Genetically Modified Organisms: Foods and Crops. Use of Genetically Modified Organisms and their Release in the Environment, their Handling and Disposal. General guidelines for recombinant DNA research activity. Prenatal Diagnosis, Molecular Detection of Pre-Symptomatic Genetic Diseases and ethical issues. Stem Cell Research and ethical issues involved in Stem Cell research and use. Animal Cloning, Human Cloning and their Ethical Aspects. Organ Transplantation and Ethical Issues. Bioethics in Biodiversity and Resource Management. Ethical, Legal and Social Implications of Human Genome Project. Genetics Studies on Ethnic Races.

Module III. Bioethics in Research **12 Hrs.**
Use of Animals in Research and Testing, and Alternatives for Animals in Research. Animal rights and animal laws in India. Prevention of cruelty to animals Act 1960 Wildlife protection act 1972 and Amendments, Biodiversity Act 2003. Animal protection initiatives - Animal Welfare, Animal Welfare Board, India CPCSEA, Working with Humans, harm, risk, and benefits, Consent. Testing of Drugs on Human Volunteers. Children and Vulnerable people, Equality, Anonymity, Confidentiality. Right to information- 2005.

Module III. Intellectual Property Rights **12 Hrs.**

Introduction to Intellectual Property Rights, Types of IP: Patents, Trademarks, Copyrights. Basics of Patents, Types of patents; Indian Patent Act 1970; Recent Amendments. Process Involved in Patenting. Patenting of Living Organisms, Traditional Knowledge, their commercial exploitation and protection. Introduction to the History of GATT, WTO, WIPO and TRIPS. Intellectual Property Rights and Agricultural Technology, and their Implications for India and other Developing Countries. International Organizations and Intellectual Property Rights.

REFERENCES

Beier, F.K., Crespi, R.S. and Straus, T. *Biotechnology and Patent protection*. Oxford and IBH Publishing Co. New Delhi

Encyclopedia of Bioethics 5 vol set, 2003. ISBN - 10: 0028657748

Fleming, D.A., Hunt, D.L., (2000). *Biotechnology and Safety Assessment* (3rd Ed) Academic press.ISBN -1555811804

Ganguli. 2001. *Intellectual property rights* –Tata McGrawhill. ISBN - 10:0074638602

Goel D. and Parasar S. 2013. *IPR, Bioethics and Biosafty*, Pearson Publications

Marie, M. 2005. *Animal Bioethics: Principles and Teaching Methods***.** Wageningen Academic Publishers

Wattal.1997. *Intellectual Property Right*. Oxford Publicatiopn House ISBN: 0195905024

In Stream Elective – 2
Wildlife Biology

(3 Hrs. / Week, Total content 54 Hrs.) **Credits – 2**

Module I. Evaluation of Wildlife habitat **10 Hrs.**
Define habitat – Forest habitat types (mangroves, moist deciduous, dry deciduous, semi evergreen, evergreen, shola forests)

Module II. Wildlife Resources of India with special reference to Kerala **10 Hrs.**
Definition of wildlife, Brief account of mammals, birds, herpetofauna, fishes, invertebrates of Kerala, IUCN status.

Module III. Human-Wildlife Conflicts **10 Hrs.**
Basic concepts, reason for conflicts, Identification of damages caused by wild animals and control measures. Case studies – Elephant, gaur, wild boar, monkey, tiger and leopard, Translocation of Wild animals – Principles, Methods and application. Human wildlife co existence, traditional knowledge in wildlife conservation.

Module IV. Wildlife management **12 Hrs.**
Threats and conservation issues (poaching, habitat loss, habitat fragmentation and habitat degradation, roadside kills, alien species, pollution, other anthropogenic activities, endemism etc.). Population estimation of wildlife - Basic concepts and applications - Direct count (block count, transect methods, Point counts, visual encounter survey, waterhole survey). Indirect count (Call count, track and signs, pellet count, pugmark, camera trap, DNA finger printing and aerial photography).

Module V. Wildlife Conservation **12 Hrs.**
Definition, In-situ and ex-situ conservation, formation, management and administration. Case studies (Silent Valley National Park, Chinnar Wildlife sanctuary, Salim Ali Bird sanctuary, Thattekkad,). Project Tiger – Project Elephant – Project Crocodile. Wildlife (Protection) Act.

REFERENCES

Daniel, J.C. 2002. *The Book of Indian Reptiles and Amphibians*, Oxford University Press, Mumbai

Daniels, R.J. R. 2002. *Freshwater Fishes of peninsular India*. Universities press (India) Private Ltd. Hyderabad

Dasmann, RF. 1964. *Wildlife Biology*. John and Wiley and sons Newyork. Pp231.

Giles, R.H. Jr. (Ed) 1984. *Wildlife Management Techniques* 3rd edition. The wildlife

Menon, V. 2003. *A Field Guide to Indian Mammals*. Dorling Kindersley (India) Pvt. Limited
Saharia, V.B. 1982. *Wildlife in India*, Nataraj Publishers, Dehra Dun
Seshadri, B.1986. *India's Wildlife reserves* , Sterling Pub'rs Pvt. Ltd., New Delhi
Thomas, A.P. (Ed) 2013. *Biodiversity Scope and Challenges*. Green leaf Publications, Kottayam
Tripheron, C.A. and Johnson, N.F. 2005. *Borror and Delong's Introduction to the Study of Insects*. Brooks/Cole Ceanage Learning Ltd.

In Stream Elective – 3
Plant Cell Culture

(3 Hrs. / Week, Total content 54 Hrs.) **Credits – 2**

Module I. **10 Hrs.**
Reflections on aseptic culture, Embryogenesis, organogenesis and plant regeneration Clonal multiplication: meristem, shoot-tip maintenance and manipulation of development in embryogenic suspension cultures

Module II. **12 Hrs.**
In vitro pollination and fertilization, Embryo culture, Endosperm culture, Triploid production, Haploid production - androgenic, gynogenic, uses of haploids, Suspension culture, Cellular totipotency, Somatic embryogenesis: Synthetic seeds: Somaclonal and gameticclonal variation, Haploid production, Anther and Pollen culture, Triploid production

Module III. **8 Hrs.**
Protoplast isolation and culture, Somatic hybridization: fatty protoplasts, fusogens, mechanisms of protoplast fusion.

Module IV. **12 Hrs.**
Selection of somatic hybrids, cytoplasmic hybridization (cybridization), genetic and breeding applications Manipulation with cells and protoplast in culture: Somaclonal variation, induction and selection of mutants, disease- and herbicide-resistant mutants, stress-tolerant mutants

Module V. **12 Hrs.**
Genetic transformation of plants, direct DNA uptake, liposome-mediated DNA delivery, Tiplasmids, particle gun-mediated transformation, Production of Secondary plant products, Cryopreservation

REFERENCES
Chawla H.S. (2004) *Biotechnology in crop improvement*. International book Distribution Co.
Chrispeels M.J & Sadava D.E. (2002). *Plants, genes and agriculture*.The American Scientific publishers.

Donal Grierson & Convey S.V. (1984). *Plant Molecular Biology*. Blackie & Son Ltd, Newyork.
Ignacimuthu S. (1998).*Plant biotechnology*. Oxford & IBH Pub.
Moncia, A. Hughes. (1999). *Plant Molecular genetics*. Pearson education limited, England.
Purohit, Kothari and Mathur. (1993). *Basic Agricultural Biotechnology*. Agrobotanical Pub,
Razdan M.K. (2003). *Introduction to plant tissue culture*. Oxford. IBH publishing Co. Pvt.Ltd.

In Stream Elective – 4
Animal Cell Culture

(3 Hrs. / Week, Total content 54 Hrs.) **Credits – 2**

Module I. Introduction **12 Hrs.**
History of animal cell culture, Laboratory requirements for animal cell culture, Sterilization techniques. Types of cell culture (Primary and Secondary), In vitro cultures—primary, diploid and established cell lines, Characterization and growth of the cultured cells, Stem cells, stem cell culture and their applications. Organ culture.

Module II.Media for Cell culture **12 Hrs.**
Cell culture Media –Physical properties, balance salt solutions, complete media, Role of serum and supplements. Serum and protein free media and their application. Chemical, physical and metabolic functions of different constituents of culture medium. Role of carbon dioxide.

Module III.Techniques of Cell culture **18 Hrs.**
Basic techniques of mammalian cell culture *in vitro*. Gene transfer methods in Animals – Microinjection, Embryonic Stem cell gene transfer, Retrovirus & Gene transfer. Transgenic Animals, Animal propagation – Artificial insemination, Animal Clones, Embryo transfer techniques. Culture of Specialized cells: Epithelia; Mesenchymal and connective tissues; Muscles; Neuroectoderm; Endocrine; Hematopoietic cells; Tumor cells. Cell cloning and cell separation; Cell differentiation; Cell synchronization and transformation; Measurement of cell death and apoptosis.

Module IV.Cell culture – Applications **12 Hrs.**
Cryopreservation of cell cultures, application of animal cell cultures in production of therapeutics proteins. Hybridoma technology. Cell characterization—karyotyping, growth rates. Large scale production—suspension cultures, microcarriers, hollow fiber reactors.

REFERENCES
Basega, R. (ed): *Cell Growth and Division: A Practical Approach*. IRL Press.

Butler, M and Dawson, M. (eds.). *Cell Culture Lab* Fax, Eds., Bios Scientific Publications Ltd., Oxford.
Clynes, M. (ed).: *Animal Cell Culture Techniques*. Springer.
Freshney R. I., 2000. *Culture of Animal cell: A manual of Basic Techniques* (4th ed.), Wiley-Liss.
Masters, J. R. W. (ed): *Animal Cell Culture – Practical Approach*, Oxford Univ. Press.
Mather, J.P and Barnes, D. (eds). : *Methods in Cell Biology*, Vol. 57, Animal Cell Culture Methods. Academic Press.

In Stream Elective – 5
Virology

(3 Hrs. / Week, Total content 54 Hrs.) **Credits – 2**

Module I. Basic Virology **6 Hrs.**

History and principles of virology, virus taxonomy, introduction to replication strategies, Virus structure and morphology, viruses of veterinary importance and plant viruses.

Module II. Virological methods **6 Hrs.**

Cultivation and purification of viruses In vivo, in vitro and in ovo systems for virus growth, estimation of yields, methods for purification of viruses with special emphasis on ultracentrifugation methods

Module III. Virus - Diagnostic methods **15 Hrs.**

Immunological - Immnuodiagnosis, haemagglutination and haemagglutination-inhibition tests, imunohistochemistry. Nucleic acid based diagnosis - Nucleic acid hybridization, polymerase chain reaction, microarray and nucleotide sequencing. Microscopic techniques - Fluorescence, confocal and electron microscopic techniques principles and applications. Analytical techniques - Electrophoresis, chromatography, membrane filtration, NMR, Xray crystallography.

Module IV. Virus Replication **12 Hrs.**

RNA viruses - General strategies, replication of plus stranded RNA virus (polio), negative strand RNA viruses (VSV and influenza). Replication of double stranded RNA virus (rota), ambisense RNA (LCM) and retroviruses (HIV and HTLV). DNA viruses - Replication of double stranded DNA viruses (SV40, pox), ssDNA virus (AAV), Prion proteins, replication of plant virus (Poty).

Module V. Viral Vaccines and Antivirals **15 Hrs.**

Viral Vaccines - Conventional vaccines killed and attenuated, modern vaccines—recombinant proteins, subunits, DNA vaccines, peptides, immunomodulators

(cytokines), vaccine delivery and adjuvants, large scale manufacturing—QA/QC issues. Antivirals - Interferons, designing and screening for antivirals, mechanisms of action, antiviral libraries, antiretrovirals —mechanism of action and drug resistance. Antisense RNA, siRNA, ribozyme

REFERENCES

Alan Cann J. Cann. 2005. *Principles of Molecular Virology*. Elsevier Science & Technology Books.

Alan J. Cann. 2000. *DNA Virus Replication*. Oxford University Press.

B.N. Fields, D.M. Knipe, P.M. Howley, R.M. Chanock, J.L. Melnick, T.P. Monath, B. Roizman, and S.E. Straus. *Fields Virology Vol 1 and 2. eds.),* 3rd Edition. LippincottRaven, Philadelphia, PA.

Flint S. J., Racaniello V. R., Enquist L. W. Rancaniello V. R. & A. M. Skalka. 2003. *Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses*. AmericanSociety Microbiology.

John R. Stephenson (Editor), Alan Warnes 1998 . *Diagnostic Virology Protocols: Methods in Molecular Medicine*. Humana Press.

Paul F. Torrence (Editor). 2005. *Antiviral Drug Discovery for Emerging Diseases and Bioterrorism Threats*. Wiley, John & Sons, Incorporated.

Pierre Payment, Trudel (Editor). 1993. *Methods and Techniques in Virology*. Publ. Marcel Dekker

Wolfram H. Gerlich (Editor), Detlev H. Krueger (Editor), Rainer Ulrich (Editor). 1996. *Chimeric Virus like Particles as Vaccines*. Karger, S. Inc.

In Stream Elective – 6
Gandhian Ecology

(3 Hrs. / Week, Total content 54 Hrs.) **Credits - 2**

Module I.Truth and Ecology **10 Hrs.**

Gandhi an ecologist, Nonviolence and Truth, Indian ecological heritage, Indian Home Rule or Hind Swaraj, Gandhi and Human Ecology, Gandhi on conservation of Natural Resources' Gandhi's Village: An ldeal Ecological Unit, Life as message

Module II. Modernity and Ecology **16 Hrs.**

History of Modern Ecology, Deep Ecology: Respect and veneration for Nature, Anthropocentrism and its impacts on nature, Biocentrism, Stewardship approach, Modernity and sustainability, Need and greed, World economic order, Why Indian farmers commit suicide, Swadeshi the solution, Gandhian Approach to Development, Gandhi as a Critique of contemporary Development.

Module III. Energy and Ethics **8 Hrs.**

Energy and Ecosystems, Energy and war, Gandhi on machines, Energy and rural poverty, Energy and Ecological Crisis.

Module IV. Sustainability **8 Hrs.**

Natural Ecosystems, Manmade Ecosystems, Gramswaraj and Concept of Ecosystem, Cultural Diversity for Biodiversity, Limits to growth

Module V. Organism and Community **12 Hrs.**

Systems approach - Levels of Organization, Human Population Ecology, Healthy community and healthy individual, Frugal (Eco-friendly) lifestyle and health, Fasting for purification

REFERENCES

Anthony J. Patel 1997. *Hind Swarajand Other Writings* Foundation Books, New Delhi-2

Fisher Louis 1953. *The Life of Mahatma Gandhi* Bharatiya Vidyabhavan Mumbai 7

Gandhi M.K.1927. *An Autobiography*, Navajivan Publishing House Ahmedabad 14

Gandhi M.K.1938. *Hind Swaraj or Indian Home Rule*, Navajivan Publishing House Ahmedabad 14

Gandhi M.K.1941. *Consructive Programme It's Meaning and Place*, Navajivan Publishing House Ahmedabad 14

Gandhi M.K.1959. *The Moral Basis of Vegeterianism*, Navajivan Publishing House Ahmedabad 14

Narayan S. Hriman 1968. *The Selected Works of Mahatma Gandhi Vol. 1-6*, Navajivan Publishing House Ahmedabad 14

Odum, E.P. 1983. *Basic Ecology*, Sanders, Philadelphia.

Radhakrishnan N. 2006. *Gandhi's Constructive Programme An Antidote to Global Economic Planning,* The Gandhigram Rural Institute –Deemed University Gandhigram 624 303 Tamil Nadu.

Five Year Integrated Interdisciplinary Master of Science Programme (IIRBS)

Scheme & Syllabus-2016

Chemistry

	Semester I-VI (Undergraduate level courses)						**Total credits**
	Course	***Paper***	**L**	**T**	**P**	**C**	
Semester I	Chem 1	General Chemistry-1	3	0	0	3	5
	Chem lab 1	Chemistry Lab -1	0	0	4	2	

Semester II	Chem 2	General Chemistry-2	3	0	0	3	5
	Chem lab 2	Chemistry Lab -2	0	0	4	2	
Semester III	Chem 3	General Chemistry-3	3	0	0	3	9
	Elective	Elective-1	3	0	0	2	
	Elective	Elective-2	3	0	0	2	
	Chem lab 3	Chemistry lab-3	0	0	4	2	
Semester IV	CHT 4	General Chemistry-4	3	0	0	3	9
	Elective	Elective-3	3	0	0	2	
	Elective	Elective-4	3	0	0	2	
	Chem lab 4	Chemistry lab-4	0	0	4	2	
Semester V	Core I	Physical Chemistry-1	4	0	0	4	22
	Core II	Organic Chemistry-1	4	0	0	4	
	Core III	Inorganic Chemistry-1	4	0	0	4	
	Elective	Elective-5	3	0	0	3	
	Elective	Elective-6	3	0	0	3	
	Core lab I	Chemistry lab-5	0	0	4	4	
Semester VI	Core IV	Physical Chemistry-2	4	0	0	4	24
	Core V	Organic Chemistry-2	4	0	0	4	
	Core VI	Organic Chemistry-3	4	0	0	4	
	Core VII	Inorganic Chemistry-2	4	0	0	4	
	Core lab II	Chemistry lab-6	0	0	4	2	
	Core lab III	Chemistry lab-7	0	0	4	2	
	Project I	Minor Project	0	0	6	4	
	Total						**74**
	Semester VII-X (Postgraduate level courses)						**Total Credits**
	Course	***Paper***	**L**	**T**	**P**	**C**	
Semester VII	Core I	Theoretical Chemistry	4	0	0	4	24
	Core II	Organometallics	4	0	0	4	
	Core III	Co-ordination compounds	4	0	0	4	
	Core IV	Stereochemistry & asymmetric synthesis	4	0	0	4	
	Core V	Advanced Physical Chemistry	4	0	0	4	
	Core lab I	Organic Chemistry Practical	0	0	8	4	
Semester VIII	Core VI	Molecular Spectroscopy	4	0	0	4	24
	Core VII	Structural Inorganic chemistry	4	0	0	4	
	Core VIII	Organic reactions and mechanism	4	0	0	4	
	Core IX	Chemical kinetics	4	0	0	4	
	Core X	Inorganic Chemistry Practical	0	0	4	4	
	Core Lab II	Physical Chemistry Practical	0	0	8	4	
Semester IX	Core XI	Organic synthesis	4	0	0	4	12
	Elective	Elective I	4	0	0	4	
	Elective	Elective II	4	0	0	4	
	Project II	Major Project	0	0	0	0	

Semester X	Project II	Major Project & Viva -Voce	0	0	0	20	20
	Total						**80**

L=Lecture**,** **T=** Tutorial, **P=**Practical**,** **C=**Credit

In stream elective courses	
Semester III, IV and V (Undergraduate level)	**Semester IX** (Postgraduate level)
1 Environmental chemistry 2 Polymer chemistry 3 Biochemistry 4 Computational chemistry 5 Green Chemistry 6 Nanomaterials 7 Medicinal chemistry 8 Atmospheric chemistry	1 Bio-inorganic chemistry 2 Instrumental analysis 3 Supra molecular chemistry 4 Heterocyclic chemistry

Semester I General Chemistry-1

Credit: 3 (3-0-0)

Module I: Atomic Structure & Periodic Properties

Atomic Structure, Electronic Configuration, Atomic and ionic radii, ionization energy, electron affinity and electronegativity, trends in periodic table and applications in predicting and explaining the chemical behaviour.

Module II: Chemical Bonding

Covalent Bond – Valence bond theory and its limitations, various types of hybridization and shapes of simple inorganic molecules and ions. Valence shell electron pair repulsion (VSEPR) theory to NH_3 H_3O^+, SF_4, ClF_3, ICl_2 and H_2O. MO theory, homonuclear diatomic molecules, multicenter bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference. Weak Interactions – Hydrogen bonding, Van der Waals forces.

Module III Gaseous & Liquid States of Matter

Postulates of kinetic theory of gases, deviation from ideal behavior, van der waals equation of state. Law of corresponding states. Molecular velocities: Root mean square, average and most probable velocities. Qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter. Liquification of gases (based on Joule Thomson-effect) Intermolecular forces, structure of liquid. Structural differences between solids, liquids and

gases. Liquid crystals: Difference between liquid crystal, solid and liquid . Classification, structure of nematic and cholestric phases. Thermography and seven segment cell.

Module IV Introductory Organic Chemistry

IUPAC nomenclature: Alkanes, cyclo-alkanes, alkenes, alkynes, halogen compounds, alcohols, ethers, aldehydes, ketones, carboxylic acids, nitro compounds. Hybridization and Geometry of Molecules: methane, ethane, ethylene, acetylene. Electronic Effects: Inductive, resonance, hyper conjugation and steric effect. Cleavage of bonds: homolytic and heterolytic C-C bond fission. Reaction Intermediates and their stability: carbocations, carbanions and free radicals.

Module V: Basic Organic Synthesis and Principles

Alkanes: preparation by reduction of alkyl halides, Wurtz reaction and Kolbe's electrolytic methods with mechanism; Alkenes: preparation by dehydration of alcohols, dehydrohalogenation of alkylhalides, dehalogenation of vicdihalides and by Kolbe's electrolytic method. Alkynes: Preparation by dehydrohalogenation of vic-dihalides and gem-dihalides, dehalogenation of tetrahalides. Reactions:addition reactions with hydrogen, halogens, hydrogen halide (markownikoffs rule, peroxide effect), hydroboration, ozonolysis, hydroxylation with KMnO4, allylic substitution by NBS.

Books Recommended:

1. Inorganic Chemistry by J. E. Huhey, Harpes & Row
2. Organic Chemistry, Morrison and Boyd, Prentice Hall.
3. Advanced Organic Chemistry, Bahl, B S, Bahl A.
4. Physical Chemistry by P. W. Atkins, Elbs
5. Basic Inorganic Chemistry by F. A. Cotton & Wilkinson, John Wiley

Semester I Chemistry Lab-1

Credit: 2(0-0-4)

1. Basic Laboratory Skills: Demonstration & concept of good lab practices including safety, glassware handling, chemical handling, chemical/glassware waste management. Calibration and handling of balances, pipettes and burettes, basic principles & experiments related to sample & reagent preparation: practical concept of Molarity, Molality, Normality, equivalence, weight %, vol.%, Preparation of standard solutions, Dilution 0.1 M to 0.001 M solutions.

2. Calibration of Thermometer using 80-82 C (Naphthalene), 113.5-114 C (Acetanilide) 132.5-133 (Urea), 100 C (Distilled Water)

Determination of Melting Point(any three):Naphthalene 80-82 C, Benzoic Acid 121.5-122 C Urea 132.5-133 C, Succinic Acid 184.5-185 Cinnamic Acid 132.5-133, Salicylic Acid 157.5-158 C Acetanilie 113.5-114 C, m-Dinitrobenzene 90 C p-Dichlorobenzene 52 C, Aspirin 135 C

Determination of Boiling Point (any one)a. Ethanol 78 C, Cyclohexane 81.4 C, Toluene 110.6 C

3. Crystallization of the any three of following compounds
   a. Phthalic acid from hot water (using fluted filter paper and stemless funnel)
   b. Acetanilide from boiling water
   c. Naphthalene from ethanol
   d. Benzoic acid from water
   7. Distillation a. Simple distillation of ethanol-water mixture using water condenser
   b. Distillation of nitrobenzene and aniline using air condenser

4. Macro analysis (qualitative) of cations and anions (known samples)

Books Suggested:

1. Experiments in General chemistry, C. N. R. Rao and U. C. Agarwal
2. Vogel's Textbook of Practical Organic Chemistry (5th Edition)
3. Vogel's Inorganic Practical Chemistry

Semester II General Chemistry-2

Credit: 3 (3-0-0)

Module I Phase Equilibrium

Statement and meaning of the terms – phase, component and degree of freedom, phase equilibria of one component system – water, phase equilibria of two component system – solid equilibria, simple eutectic – Pb-Ag system, desilverisation of lead.

Module-II Chemical kinetics and Catalysis

Introduction to chemical kinetics Theories of chemical kinetics: effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy, Simple collision theory based on hard sphere model transition state theory (equilibrium hypothesis) Expression for the rate constant based on equilibrium constant and thermodynamic aspects. Catalysis, characteristics of catalysed reactions, classification of catalysis, miscellaneous examples.

Module III: s- and p- Block Elements

Comparataive study, diagonal relationships, salient features of hydrides, solvation and complexation tendencies, an introduction to alkyls and aryls. Chemical properties of the noble gases, chemistry of xenon, structure and bonding xenon compounds

Module IV: Acids and Bases

Arrhenius, Bronsted-Lowry, solvent system, Lewis and HSAB concept of acids and bases.

Module V Aromatic Compounds & Aromaticity

Aromatic hydrocarbons and aromaticity, resonance in benzene, Huckel's (4n+2) rule and its simple applications. Acidic character of phenols - explanation on the basis of resonance stabilization. Electrophilic substitution reactions in aromatic compounds. ortho/para/meta directive influence with examples.

Module VI Elimination & Substitutions Reactions

SN1 and, SN2 reaction mechanism: effects of structure, substrate, solvent, nucleophile and leaving groups. Mechanisms of E1 and E2 reactions, Hoffmann and Saytzeffs rules cis and trans eliminations, Elimination Vs substitution. Addition reactions.

Module VII Basics of Stereochemistry

Introduction, Concept of Isomerism, Classification of Stereoisomers, Optical isomerism, Chirality & Elements of symmetry, Wedge formula, Fischer projection, Newmann projection. Relative and absolute configurations, sequence rules, D & L, R & S systems of nomenclature. Understanding with examples for Enantiomers, mesoform, erythro/threo forms, diastereoisomers, inversion, retention, and racemization. Conformational understanding with an example of ethane, n-butane, Cyclohexane and Decalin**.**

Books Recommended:

1 Fundamentals of Organic Chemistry by Solomons, John Wilev
2 Introduction to Organic Chemistry, Streitwiesser, Hathcock and Kosover, Macmillan.
3 Physical Chemistry Vol. 1-5, by K.L Kapoor
4 Physical Chemistry: A Molecular Approach by McQuarrie & Simon Viva
5 Concise Inorganic Chemistry by J D Lee, Amazon.
6 Chemistry of the Elements by N. N. Greenwood & Earnshow, Pergamon

Semester II Chemistry Lab-2

Credit: 2(0-0-4)

1. Volumetric analysis
   (a)Acidimetry and alkalimetry
   Determination of acetic acid in commercial vinegar using NaOH
   (b)Permanganometry.
   Estimation of calcium in calcium chloride solution by Permanganometry.
   (c) Dichrometry.
   Estimation of Ferric ion using internal and external indicators.
   (d) Iodimetry and iodometry.
   Estimation of copper using thiosulphate
2. Gravimetric Experiments.
   Estimation of Barium as Barium Sulphate, Iron as Fe_2O_3., Nickel as Ni-DMG complex.

3. Qualitative inorganic analysis of mixtures containing not more than 4 radicals (two cations and two anions) from the following:

Cation Radicals, NH_4^+, Ca^{+2}, Sr^{+2}, Ba^{+2}, Al^{+3}, Cr^{+3}, Mn^{+2}, Fe^{+3}, Co^{+3}, Ni^{+2}, Cu^{+2}, Zn^{+2} Mg^{+2} Pb^{+2}. Anion Radicals: CO_3^{2-} $C_2O_4^{2-}F^-$, Cl^-, Br-, Br^- , I^-, SCN^-, S^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, NO_3^-, PO_4^{3-}, $B_2O_3^{3-}$, CrO_4^{2-}/ $Cr_2O_7^{2-}$,SO_4^{2-}. Insoluble Materials: Al2O3, Fe2O3, Cr2O3, SnO2, SrSO4, BaSO4, CaF2. Experiment A: Preliminary Tests for acid and basic radicals in given samples. Experiment B: Wet tests for Acid and Basic radicals in given samples.Experiment C: Identification and Confirmatory tests.

Reference practical Books:

1. G. Svehla: Vogel's Qualitative Inorganic Analysis.
2. J. Mendham, R. C. Denny, M. J. K. Thomas: Vogel's Text Book of Quantitative Chemical Analysis.
3. Vogel's Textbook of Quantitative Chemistry.
4. Synthesis & characterization of Inorganic Compounds by W. L. Jolly, Prentice Hall. Lab Skills

Semester III General Chemistry-3

Credit: 3 (3-0-0)

Module-I Thermodynamics

Thermodynamic terms, State and path functions and their differentials. Thermodynamic process. Concept of heat and work. First Law of thermodynamics, 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 condition for reversible process. Introduction to Thermo chemistry, Kirchhoff's equation. Second law of thermodynamics

Module-II Chemical Equilibrium

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

Module IV Chemistry of d and f block Elements

Characteristic properties of d- and f- block elements. Properties of the elements, their binary compounds and complexes illustrating relative stability of their oxidation states, coordination number and geometry. lanthanide contraction, complex formation

Module V Hydroxy and Carbonyl Compounds

Preparation of monohydric alcohols from carbonyl compounds using Grignard reagents, Methods to distinguish between Primary, secondary and tertiary alcohols (Lucas, Victor Meyer's and oxidation method) Preparation of aldehydes and ketones by Rosenmund's reduction, Oppeanauer oxidation. Reactions of aldehydes and ketones (Reduction using $LiA1H_4$, Clemensen and Wolf-Kishner reduction, reaction with alcohols) Mechanism of Aldol condensation, Cannizzaro's reaction, Reimer – Tiemann reaction, Perkin's reaction, Benzoin condensation.

Module VI Organic Compounds of Nitrogen

Preparation of nitroalkanes and nitroarenes, Separation of primary, secondary and tertiary amines using Hinsberg and Hoffmann method, Structural & basicity relation of amines, Amine salts as phase transfer catalyst, Reduction of nitro compounds, Reductive amination of aldehyde and ketones, Gabriel-phthalimide reaction, Synthetic transformation of aryl diazonium salts, azo coupling.

Books Recommended:

1. Chemistry of the Elements by N. N. Greenwood & Earnshow, Pergamon
2. Metalo-organic Chemistry by A. J. Pearson, Wiley
3. Physical Chemistry by Samuel Glasstone
4. Physical Chemistry by IRA. N. Levine TMH
5. Organic Chemistry by Morrison Boyd
6. Organic Chemistry by Finar

Semester III Chemistry Lab-3

Credits 2(0-0-4)

Mixed melting point determination : a. Urea-Cinnamic acid mixture of (1:4, 1:1, 4:1) compositions
Qualitative Analysis a. Element detection and Functional group determination (phenolic, carboxylic, carbonyl, esters, carbohydrates, amines, amides, nitro and aniline) in simple organic compounds.
Decolorisation and Crystallization using Charcoal a. Decolorisation of brown sugar (sucrose) with animal charcoal using gravity filtration.
b. Crystallization and decolorisation of impure naphthalene (100 g of naphthalene mixed with 0.3 g Congo Red using 1 g decolorizing carbone) from ethanol
Sublimation (Simple and Vacuum):Camphor, Naphtalene, Phthalic Acid and Succinic Acid
Thin Layer Chromatography: Determination of Rf values and identification of organic compounds.
a. Separation of green leaf pigments (spinach leaves may be used).
b. Preparation and separation of 2,4-dinotrophenylhydrazones of acetone, 2-butanone, hexan-2- and 3-one using toluene and light petroleum (40:60).
One step organic synthesis: Rf determination, crystallization, melting point determination.

Books Suggested:

1. Vogels Textbook of Practical Organic Chemistry
2. Experiments in General chemistry, C. N. R. Rao and U. C. Agarwal
3. Experimental Organic Chemistry Vol 1 and 2, P R Singh, D S gupta, K S Bajpai, Tata McGraw Hill
4. Laboratory Manual in Organic Chemistry, R. K. Bansal, Wiley.

Semester IV General Chemistry-4

Credits 3 (3-0-0)

Module- I Colloidal State

Definition of colloid, classification of colloids. Solids in liquids (sols): properties – kinetic, optical and electrical: stability of colloids, protective action Hardy-Schulze law, gold number. Liquids in solids (gels): classification, preparation and properties, inhibition, general application of colloids.

Module II Redox Chemistry

Nernst Equation, Electrochemical series, Use of redox potential data – analysis of redox cycle,. Electrical transport, Migration of ions and kohlrausch law, Arrhenius theory of electrolytic dissociation, Application of conductivity measurements, conductometric titrations. Types of reversible electrodes Electrode reactions, Nernst equation, derivation of cell E. M. F. and single electrode potential, standard hydrogen electrode – reference electrodes, electrochemical series and its significance. Electrolytic and Galvanic cells – reversible and irreversible cells. EMF of a cell and its measurement. Potentiometric titrations.

Module III Coordination Compounds

Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes.

Module IV Nuclear chemistry

Radioactivity: Characteristics of radioactive decay, Decay kinetics, types of decay, α, β, γ- emissions, artificial radioactivity. Nuclear fission and fusion; Nuclear Reactors: Classification of reactors, reactor power, and application of radioactivity, nuclear waste Management.

Module V Carboxylic Acids & its derivatives

Acidity of Carboxylic Acids, Effects of Substituent's on Acid Strength. Preparation and reactions of carboxylic acids. Hell-Volhard-Zelinsky reaction. Synthesis of acid chlorides, esters and amides. Mechanisms of esterification and hydrolysis (acidic and basic). Reduction of carboxylic acids, Mechanism of decarboxylation, effect of heat and dehydrating agents, methods of formation and chemical reactions of unsaturated monocarboxylic acids, Dicarboxylic acids, haloacids, hydroxy

acids- Malic, tartaric & citric acid and acid anhydrides. Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution.

Module VI Spectroscopic Characterization of Organic Molecules

Basic principles of UV-VIS and, FTIR, spectroscopy. Brief application of spectroscopic characterization of organic molecules.

Books Recommended:

1. Modern Electrochemistry – Vol – I & II, by J. O. M. Bockris & A. K. N. Reddy, Plenum.
2. Organic Chemistry, F.A. Carey, McGraw-Hill Inc.
3. Organic Chemistry, Morrison and Boyd, Prentice Hall.
4. Concise Inorganic Chemistry by J D Lee, Amazon.
5. Comprehensive Co-ordination Chemistry by G. Wilkinson, R. D. Gillars & J. A. Mccleverty, Pergamon

Semester IV Chemistry Lab 4

Credits 2 (0-0-4)

Physical chemistry experiments:

1. To determine the cell constant of a conductivity cell.
2. To determine the molar conductivity of weak mono basic acid over a given range of concentration
3. To determine Pka value of the given organic acid by $_{pH}$ measurement.
4. Determine λ max for KMn04 by colorimetric measurements
5. Determine the surface tension of a liquid by stalagmometer method
6. Determine the Viscosity of a given liquid by Oswald's Viscometer.
7. To study the distribution of benzoic acid between benzene and water at room temperature
8. Determine the heat of neutralization of HCl by NaOH.
9. Study the hydrolysis of an ester in presence of HCl

References

1. Findley's Practical Physical Chemistry, B. P. Levitt, Longman.

Semester-V Physical Chemistry I

Credit –4(4-0-0)

Module I: Phase Equilibria

Derivation of Gibbs Phase Rule , Phase equilibria of one component system of CO2 & Sulfur,two component system of Bi –Cd. Solid solutions – compound formation with congruent m.pt. Mg- Zn & incongruent m.pt. (Nacl- H2O, Ferric chloride – water & copper sulfate water), Freezing mixtures, acetone-dry ice. Liquid-liquid mixtures: ideal liquid mixtures, Raoult's and Henry's Law, Non Ideal systems, azeotropes, HCl-Water and ethanol-water systems. Partially miscible liquids-Phenol-water.

Module II Electrochemistry

Nernst distribution law-thermodynamic derivation, applications. Concentration cell, with and without transport, liquid junction potential, application of concentration cells, solubility product and activity coefficient, potentiometric titrations, definition of pH and pka, determination of pH using Hydrogen, quin hydrone and glass electrodes by potentiometric methods. Buffers: Mechnism of buffer action, Henderson –hazel equation, hydrolysis of salts, corrosion: types, theories and methods of control.

Module III Thermodyanamics

Third law, Nernst Heat theorem, statement and concept of residual entropy, evaluation absolute entropy from heat capacity data, Gibbs and Helmholtz functions, G & A functions as themodyanamic

quantities, , A& G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change, variation of G & A with P, V & T.

Module IV: Solutions, Dilute Solutions and Colligative Properties

Ideal and non-ideal solutions, methods of expressing concentrations of solutions of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination. Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing point, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties. Abnormal molar mass, degree of dissociation and association and association of solutes.

Books recommended:

1. The Elements of Physical Chemistry, P. W. Atkins, Oxford
2. Physical Chemistry, G. M.. Barrow, McGraw Hill
3. Physical Chemistry through problems: S. K. Dogra & S. Dogra, Wiley Eastern Ltd.

Semester-V Organic Chemistry-I

Credit 4 (4-0-0)

Module I Alkanes and Cyclolkanes

Corey House reactions and decaroxylation of carboxylic acids, Mechanism of free radical halogination of alkanes, Cycloalkanes: Nomenclature, methods of preparations, chemical reactions, Bayer's strain theory and its limitations, Ring strain in cyclopropane and cyclobutanes, Theory of stainless rings. The case of cyclopropane ring: banana bonds.

Module II Alkenes, Cycloalkenes, Dienes and Alkynes

Regio-selectivity: Saytzeff rule, Hoffmann elimination, physical properties and relative stabilities of alkenes. Chemical reactions of alkenes: hydroboration-oxidation, oxymercuration-reduction, Epoxidation, hydration, polymerization of alkenes, Substitution at the allylic and vinylic positions of alkenes. Cycloalkenes: conformation, synthesis, and chemical reactions. Dienes: nomenclature, isolated, conjugated and cumulated dienes: structure, method of formation, polymerization, chemical reaction-1,2 and 1,4 additions, diels-alder reaction. Alkynes: hydroboration-oxidation, metal-ammonia reductions, oxidation and polymerization

Module-III Aryl compounds

The aryl group, Aromatic nucleus and side chain, Side chain reactions of benzene derivatives, Birch reduction, Methods of formation and chemical reactions of alkylbenzenes, alkynylbenzenes and biphenyl.

Module-IV Alkyl and Aryl Halides

Methods of formation alkyl halide, Mechanisms of nucleophilic substitution reactions of alkyl halides, substitution at the allylic and vinylic positions of alkenes, Mechanisms of elimination reactions of alkyl halides. Methods of formation of aryl halides, nuclear and side chain reactions. The addition-elimination and the elimination-addition, mechanisms of nucleophilic aromatic substitution reactions.

Module-V Alcohols and Phenols

Monohydric alcohols: methods of formation (Grignard reagent), reduction of aldehydes, ketones, carboxylic acids and esters. Hydrogen bonding, Acidic nature, Reactions of alcohols. Dihydric alcohols: methods of formation, chemical reactions of vicinal glycols, oxidative cleavage [Pb(OAc)4 and HIO4] and pinacol-pinacolone rearrangement. Trihydric alcohols: methods of formation, chemical reactions of glycerol.

Nomenclature, structure and bonding of phenols, Preparation of phenols, physical properties and acidic character, Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion, Reactions of phenols - electrophillic aromatic substitution, acylation and carboxylation, Mechanisms of Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Hauben-Hoesch, Lederer-Manasse and Reimer-Tiemann reaction.

Suggested Books:

1. Organic Chemistry", I. L. Finar, Vol. I & II, 5th Edition (1975), Longman Ltd., New Delhi.
2. Organic Chemistry, Morrison and Boyd, Prentice Hall.
3. Organic reaction and mechanism-structure and reactivity by Jerry March
4. Introduction to Organic Chemistry, Streitwiesser, Hathcock and Kosover, Macmillan.
5. *A Guide Book to Mechanism in Organic Chemistry",* P. Sykes, Orient Longman Ltd.
6. Fundamentals of Organic Chemistry, Solomons, John Wilev.

Semester-V Inorganic Chemistry-I

Credit 4(4-0-0)

Module I:

Atomic Structure : Idea of de Broglie matter waves. Heisenberg uncertainty principle. Schrödinger wave equation, significance of wave functions, Atomic orbitals. Quantum numbers. Aufbau and Paulis exclusion principles. Hund's multiplicity rule. Hydrogen atom: energy of orbitals, atomic spectra, P-fund, bracket series. Variation of orbital energies with atomic number and energy level diagram, electronic configuration of elements, effective nuclear charge and shielding; radial and angular wave functions and distribution curves, shape of s,p,d orbitals and their characteristics.

Module II:

Multielectron systems: Quantum numbers and vectors, mutual inclination of electron orbits and resultant vectors, Russel-Saunders coupling, J-J coupling, ground states term symbols, microstates and derivation of Russell-Saunders terms: p^2, d^2 and pd configuration,

Module III:

Transition elements: General group trends with special reference to electronic configuration, colour, variable valency, ability to form complexes, magnetic and catalytic properties, Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

Module IV :

Redox Chemistry: Standard reduction potentials, E^o, relatioanship between E^o, ΔG^0 and K, Formal Potential and its application: Effect of pH**,** complexation, solubility; Disproportionation and comproportionation reaction Redox stability in water: Frost-Ebsworth, Latimer and Pourbaix diagrams, applications of redox reactions to the extraction of elements from their ores: Ellingham diagrams.

Module V: Chemistry of Non-aqueous Solvents Reactions in non-aqueous solvents with reference to liquid NH_3, H_2SO_4, liquid HF, HSO_3F, liquid SO_2. N_2O_4, PCl_5, BrF_3 superacids, ionic liquid: molten salts solvent systems, ionic liquid at ambient temperature; supercritical fluids: properties of supercritical fluids and their uses as solvents,

Books Recommended:

1 Basic Inorganic Chemistry by F. A. Cotton & Wilkinson, John Wiley
2 Inorganic Chemistry by J. E. Huhey, Harpes & Row
3 Comprehensive Co-ordination Chemistry by G. Wilkinson, R. D. Gillars & J. A. Mccleverty, Pergamon
4 Concise Inorganic Chemistry by J D Lee.

Semester-V Chemistry Lab 5

Credits: 2 (0-0-4)

Organic Chemistry Experiments

1. Steam Distillation
   - i. Naphthalene from its suspension in water
   - ii. Clove oil from cloves
   - iii. Separation of o- and p-nitrophenols
2. Column chromatography

i. Separation of fluorescein and methylene blue
ii. Separation of leaf pigments from spinach leaves
iii. Resolution of racemic mixture of mandelic acid

3. Qualitative Analysis: Analysis of an organic mixture containing two solid components using water, NaHCO3, NaOH for separation and preparation of suitable derivatives.

4. Synthesis of Organic Compounds

i. Acetylation of salicylic acid, aniline, glucose and hydroquinone.
Benzoylation of aniline and phenol
ii. Aliphatic electrophilic substitution: Preparation of iodoform from ethanol and acetone
iii. Aromatic electrophilic substitution a. Nitration: Preparation of m-dinitrobenzen, Preparation of p-nitroacetanilide

b. Halogenation: Preparation of p-bromoacetanilide, Preparation of 2,4,6-tribromophenol

iv. Diazotization/Coupling: Preparation of methyl organge and methyl red

v. Oxidation: Preparation of benzoic acid from toluene

vi. Reduction: Preparation of aniline from nitrobenzene, Preparation of m-nitroaniline from m-dinitrobenzene.

5. Two-step organic synthesis: i. Rf determination, crystallization, melting point determination.

ii. Characterization understanding through UV, IR and NMR spectroscopic analysis.

Books Suggested:

1. Vogels Textbook of Practical Organic Chemistry
2. Experiments in General chemistry, C. N. R. Rao and U. C. Agarwal
3. Experimental Organic Chemistry Vol 1 and 2, P R Singh, D S gupta, K S Bajpai, Tata McGraw Hill
4. Laboratory Manual in Organic Chemistry, R. K. Bansal, Wiley.

Semester- VI Physical Chemistry 2

Credit-4 (4-0-0)

Elementary Quantum Mechanics:

Planck's quantum theory, wave-particle duality. Uncertainty Principle, Black – body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect. De Broglie hypothesis, the Heisenberg's uncertainty principle, Sinusoidal wave equation, Hamiltonian operator, Schrodinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one dimensional box.Schrodinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial wave functions, angular wave functions. Molecular orbital theory, basic ideas- criteria for forming M .O, from A.O, construction of M.O's by LCAO – H_2^+ ion, calculation of energy levels from wave functions, physical picture of bonding and antibonding wave functions, concept of σ, σ*, π, π* orbitals and their characteristics. Hybrid orbitals – sp, sp^2. sp^3, calculation of coefficients of A.O.'s used in these hybrid orbitals.Introduction to valence bond model of H_2, comparison of M.O. and V.B. models.

Spectroscopy

Introduction: electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born- Oppenheimer approximation, degrees of freedom.

Rotational Spectrum: Diatomic molecules. Energy levels of a rigid rotor (semi- classical principles), selection rules, spectral intensity, distribution using population distribution (Maxell- Boltzmann distribution) determination of bond length, qualitative description of non- rigid rotor, isotope effect.

Vibrational Spectrum: Infrared spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of

vibrational frequencies of different functional groups. Raman Spectrum: concept of polarizability, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.

Books Recommended:

1. The Elements of Physical Chemistry, P. W. Atkins, Oxford
2. Physical Chemistry, G. M.. Barrow, McGraw Hill
3. Physical Chemistry through problems: S. K. Dogra & S. Dogra, Wiley Eastern Ltd.

Semester-VI Organic Chemistry-2

Credit 4 (4-0-0)

Module I Ethers and Epoxides

Nomenclature and methods of formation, physical properties, Chemical reactions: cleavage and autoxidation, Zeisel's method. Synthesis of epoxides. Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.

Module II Aldehydes and Ketones: Synthesis of aldehydes and ketones from acid chlorides, 1,3-dithianes, nitriles and carboxylic acids, Physical properties. Mechanism of nucleophilic additions to carbonyl group: Perkin and Knoevengel condensations, Condensation with ammonia and its derivatives. Wittig reaction. Mannich reaction, Use of acetals as protecting group. Baeyer-Villiger oxidation, Meerwein-Pondorof Verley, Clemmensen, and $NaBH_4$reductions, Halogenation of enolizable ketones, An introduction to α, β unsaturated aldehydes and ketones.

Module III Nitrogen Compounds Mechanisms of nucleophilic Substitution in nitroarenes and their reductions in acidic, neutral and alkaline media. Picric acid. Halonitroarenes: reactivity, structure and nomenclature, physical properties, Stereochemistry of amines. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitriles), reductive amination of aldehydic and ketonic compounds, Gabriel-Phthalamide reaction, Hoffmann bromamide reaction, Reactions of amines, electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid.

Module IV Organometallic Compounds Principle, preparations, properties and applications of the following reagents in organic synthesis with Mechanistics details: Group-I & II metal organic compounds-Li, M, Hg, Cd, Zn & Ce compounds. Transition metals-Cu, Pd, Ni, Fe, Co, Rh, Cr & Ti compounds.

Module V Organosulphur Compounds Nomenclature, structural features, Methods of formation and chemical reactions of thiols, thioethers, sulphonic acids, sulphonamides and sulphaguanidine

Suggested Books:

1. Organic Chemistry", I. L. Finar, Vol. I & II, Longman Ltd., New Delhi.
2. Organic Chemistry, Morrison and Boyd, Prentice Hall.
3. Organic reaction and mechanism-structure and reactivity by Jerry March
4. *A Guide Book to Mechanism in Organic Chemistry",* P. Sykes, Orient Longman Ltd.
5. Fundamentals of Organic Chemistry, Solomons, John Wilev.
6. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, Peter Wothers, Oxford University Press, USA

Semester-VI Organic Chemistry-3

Credit 4(4-0-0)

Module I

NMR Spectroscopy and Structure Determination Nuclear magnetic resonance (NMR) spectroscopy: Proton magnetic resonance (1H NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, interpretation of PMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene and acetophenone, Brief introduction to ^{13}C NMR, Problems pertaining to the structure elucidation of simple organic compounds using UV, IR and NMR spectroscopic techniques.

Module III Heterocyclic Compounds Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine. Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic substitution reactions in pyridine derivatives. Comparison of basicity of pyridine, piperidine and pyrrole. Introduction to condensed five and sixmembered heteroeycies. Preparation and reactions of Indole, quinoline and isoquinolme with special reference to Fischer indole synthesis, Skraup synthesis and Bischler-Napieralski synthesis. Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

Module V - Introductory Photochemistry and Pericyclic Chemistry Principles of photochemistry, photochemical reactions of carbonyl compounds and olefins. Concerted reaction, Molecular orbital theory, LCAO methods, bonding and anti-bonding orbitals, orbital symmetry, correlation diagram for electrocyclic reactions, Diels-Alder reaction.

Suggested Books:

1. Organic Chemistry", I. L. Finar, Vol. I & II, Longman Ltd., New Delhi.
2. Organic Chemistry, Morrison and Boyd, Prentice Hall.
3. Organic reaction and mechanism-structure and reactivity by Jerry March
4. Introduction to Organic Chemistry, Streitwiesser, Hathcock and Kosover, Macmillan.
5. *A Guide Book to Mechanism in Organic Chemistry",* P. Sykes, Orient Longman Ltd.

Semester-VI Inorganic Chemistry -2

Credits 4(4-0-0)

Module I: Inorganic Rings, chains and cages Catenation and Heterocatenation, Heterocyclic Ring System- Borazines, Phosphazines- Monomer and Polymer, S-N ring compounds, Homocyclic rings of S, Se and Te. Silicates minerals, Isopolyanions, Boranes: boron cage compounds-closo, nido, arachno, carboranes; cage compounds of S and P.

Module II : Coordination Chemistry Bonding theories: Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of (10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors effecting the magnitude of 10 Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar coordination. Ligand field and MO Theories (Elementary idea only Chelate effect, polynuclear complexes.

Module III: Isomerism in coordination compounds Stereoisomerism: geometrical and optical, Structural isomerism: coordination, ionization, hydrate, linkage.

Module IV Electronic spectra of coordination complexes Types of electronic transitions, selection rule for d-d transitions, spectroscopic ground states. Spectrochemical series, nepheleuxatic effect,

Module V: Reaction kinetics and mechanism .The trans effect, theories of trans effect, mechanism of trans effect, kinetics of substitution reactions in square planar complexes. Thermodynamic and kinetic stability including factors affecting them. Labile and inert complexes**.** Electron transfer reactions, Inner sphere, outer sphere, without breaking M-L bond.

Books Recommended:

1. Basic Inorganic Chemistry by F. A. Cotton & Wilkinson, John Wiley
2. Inorganic Chemistry by J. E. Huhey, Harpes & Row
3. Comprehensive Co-ordination Chemistry by G. Wilkinson et.al. Pergamon
4. Concise Inorganic Chemistry by J D Lee.

Semester-VI Chemistry lab -6

Credits:2(0-0-4)

Physical chemistry experiments-2

1. To study the saponification of ethyl acetate conductometrically.
2. To determine the Ionisation constant of a weak acid conducto metrically.
3. To Titrate potentiometrically the given ferrous ammonium sulphate solution using KMnO4/$K_2Cr_2O_7$ as titrant and calculate redox potential of $Fe+^2/fe+^3$system on hydrogen scale.

4. To determine the specific rotation of a given optically active compound.
5. Determination of Molecular wt. Of a non-volatile solute by Rast Method/ Beckmann Method.
6. To verify Beer- Lambert Law for KMnO4/$K_2Cr_2O_7$and determine the concentration of the given solution of the substance.
7. To determine the strength of the given acid condutometrically using Std. Alkali solution.
8. Investigate the adsorption of oxalic acid by activated charcoal and test the validity of Freundlich and Langmuir Isotherms.
9. Study the mutual solubility of Phenol and water at various temps and hence determine the CST.

Reference book

1. Findley's Practical Physical Chemistry, B. P. Levitt, Longman.

Semester-VI Chemistry lab -7

Credits:2(0-0-4)

Inorganic Chemistry experiments

1. Synthesis and analysis by UV,IR,NMR methods.

(a) Preparation of tetraammine copper (II) complex, $[Cu(NH_3)_4]SO_4$

(b) Tris thiourea Copper(I) complex

(c) Preparation of cis and trans- bisoxalato diaquachromate(III) ion

(d) Preparation of sodium trioxalato ferrate (III)

(e) Preparation of Schiff's base complexes of Cu(II) and Ni(II) complexes.

4. Ion Exchange Method :Separation and estimation of Mg(II) and Zn(II)
5. Solvent extraction: Separation and estimation of Mg(II) and Fe(II)

Books Recommended:

1. Vogel's Textbook of Quantitative Chemistry.
2. Synthesis & characterization of Inorganic Compounds by W. L. Jolly, Prentice Hall.
3. Vogel's Text book of Macro & Semimicro Qualitative Analysis

In stream electives (UG level) for Semester III & IV

UG Elective-1: Environmental Chemistry

Credits: 2(3-0-0)

Introduction: Role, importance and scope of environmental chemistry, multidisciplinary nature Concept of an ecosystem, structure and function of an ecosystem, energy and nutrient flow, biogeochemical cycles, sources, pathways and fate of environmental pollutants-Environmental transformation & degradation processes

Atmospheric Chemistry: Chemical composition of the earth's atmosphere, units for expressing atmospheric concentration Various segments of atmosphere & their significance, sources and toxic effects of air pollutants, Stratospheric Chemistry- Ozone,formation & turnover of ozone, processes for catalytic decomposition of ozone, chlorofluorocarbons, arctic & Antarctic ozone hole formation. Tropospheric Chemistry- Smog, Phototransformation, types of hydrocarbon in the troposphere, reaction of organic compounds in the atmosphere .Chemistry of photochemical smog, emissions from internal combustion engine and control measures , sulfurous smog & emissions from stationary sources and control measures Tropospheric Chemistry – Precipitation .acid rains, sources & sinks. Atmospheric Aerosols: Sources of aerosols, aerosol concentrations & life times, PM -2.5 & its significance, control of particulate emissions The chemistry of global climate : energy balance & the earth's atmosphere, greenhouse gases & global warming

Aquatic Chemistry The Hydrosphere: physical & chemical properties of water, concentration units used for aqueous solutions , Water resources, Chemistry of natural waters, physico-chemical properties of water, Water pollution: Deoxygenating substances, influence of chemical process on dissolved oxygen, sources of water pollution, various pollutants their detrimental effects. Portability limits as per WHO & PHED specification, treatment of municipal supply water, slow sand filters, rapid

sand filter, disinfections, their advantage & disadvantages, break point chlorination, Commonly used water purification techniques

Soil Chemistry Soil formation: Physical weathering ,chemical weathering,Composition of soil, micro and macro nutrients, Physical & chemical properties of soil. Sources and chemical nature of soil contaminants, Distribution of soil contaminants: Soil –water partition process, soil- organism processes, Ecological and health effects of soil contaminants.

Chemistry of Solid wastes Sources, Classification and composition of MSW, Properties of MSW, MSW management, Waste minimization, Life cycle assessment, benefits, waste reduction techniques, Reuse and recycling, Biological MSW treatment, Thermal treatment, Landfill, Integrated waste management. Radiation hazards: Types of radiation, sources, effects, control and disposal of nuclear waste.

Books recommended

1. Environmental Chemistry : a global perspective,G.W.vanLoon, S.J. Duffy,Oxford publication
2. Practical Environmental Analysis by Miroslav Radojevic and Vladimir N. Bashkin, RSC.
3. An Introduction to Environmental Science & Engineering by Gilbert M. Masters.

UG Elective-2 Polymer Chemistry

Credits: 2(3-0-0)

Polymers: Importance of polymers, Basic concepts: monomers, repeat units, degree of polymerization, linear, branched and network polymers, classification of polymers, polymerization: condensation, addition and free radical chain-ionic and coordination and co-polymerization, polymerization conditions and polymer reactions; Kinetics & mechanism of polymerization in homogenous and heterogeneous systems.

Polymer characterization: Polydispersion and molecular weight concept, number average, weight average and viscosity average molecular weights, polydispersity and molecular weight distribution, The practical significance of molecular weight, measurement of molecular weights, end group, viscosity, light scattering, osmotic and ultracentrifugation methods, analysis and testing of polymers, chemical analysis of polymers, spectroscopic methods, X-ray diffraction study, microscopy, Thermal analysis and physical testing-tensile strength, Fatigue, impact, tear resistance, hardness and adhesion resistances.

Structure and properties: Morphology and order in crystalline polymer configurations of polymer chains, crystal structure of polymers, morphology of crystalline polymers, strain induced morphology, crystallization and melting, crystalline melting temperature Tm, effect of chain flexibility and steric factors, entropy and heat of fusion. The glass transition temperature Tg, relationship between Tm and Tg, effects of molecular weight, diluents, chemical structures, chain topology, branching and cross linking, property requirements and polymer utilization.

Properties of commercial polymers: PE, PVC, Polyamides, Polyesters, Phenolic resins, epoxy resins, silicone polymers, Functional polymers, Fire-retarding polymers and electrically conducting polymers, biomedical polymers: contact lens, dental polymers, artificial hearts and skin materials

References:

1. Text book of polymer sciences, F. W. Billmeyers, Jr., Wiley
2. Polymer Sciences, V.R. Gowariker, N. V. Biswanathan, J. Sreedhar, Wiley-Eastern
3. Contemporary polymer chemistry, H. R. Alcock, F. W. Lambe, Prentice Hall
4. Physics and chemistry of polymers, J. M. G. Cowie, Blackie academic and professional.

UG Elective-3 Biochemistry

Credits:2(3-0-0)

Chemistry of biomolecules and natural products, basic aspects(structure, chemistry and bonding),carbohydrates, amino acids and proteins, nucleic acids, terpenoids, alkaloids, fatty acids,steroids, plant pigments, lipids, and vitamins. Nomenclature of prostaglandins..Methods for primary structure determination of peptides, proteins and nucleic acids.

Reactions and concepts in protein chemistry. Concept of supramolecular assemblies based on structural aspects-example proteins (enzymes) and biomembrane assemblies.
Biocatalysis: with respect to conformations and structure and function relationship, enzyme catalysis, vitamins as co-factors, enzyme kinetics, graphical evaluation of KM and Vmax, enzyme inhibition, mechanisms regulatory aspects.
Metabolism: overview and selected individual and important oxidative pathways. Glycolysis, TCA cycle-pentose phosphate pathway. Citric acid cycle: energetic and amphibolic nature. Regulatory aspects of TCA cycle and glycolysis. Photosynthetic electron transport and phosphorylation and CO2 fixation.
Transfer of genetic information: chemistry of nucleic acids, nucleotide, nucleoside, cyclic AMP, assembly of DNA, types of RNA. Replication of DNA, flow of genetic information, protein biosynthesis, transcription and translation, Genetic code, regulation of gene expression, DNA sequencing. The Human Genome Project. DNA profiling and the Polymerase Chain Reaction (PCR).
Repair of DNA and recombinant DNA concept.

References

1. A. Lehninger, Principles of Biochemistry, CBS Publishers, 1990.
2. R.W. McGilvery, G.W. Goldstein, Biochemistry: a Functional Approach, 3rd Edn.,Saunders, 1983.
3. D.W. Martin, P.A. Mayes, V.M. Rodwell, Harper's Review of Biochemistry, 19th Edn., Lange Medical Publications, 1981.
4. G. Zubay, Biochemistry, 2nd Edn., MacGraw Hill Ryerson, 1999.
5. P.S. Kalsi, Chemistry of Natural Products, Kalyani Publishers, 2001.
6. S.V. Bhat, B.A. Nagasampagi, M. Sivakumar, Chemistry of Natural Products, Springer, 2005
7. D.E. Metzler, Biochemistry: The Chemical Reactions of Living Cells, Academic Press, 2001.

UG Elective-4 Computational chemistry

Credits: 2(3-0-0)

Module 1: Introduction about the computational chemistry and molecular modeling, Coordinate systems, Concept of 2D and 3D structure, molecules, Surfaces, Molecular energetic profile, Brief idea about the computational software's for drawing, visualization and simulation of small and large molecules. Basic concept of Chemoinformatics, 3D-Structure file system and Databases.
Module 2: Brief introduction about Quantum Mechanics & Molecular Mechanics, Molecular Orbital Theory, The Hartree-Fock method, ab-initio calculation, Semi-empirical methods, Huckel theory, Valence bond theories, Force Field, Geometrical Parameters, Non-covalent Parameters: understanding of electrostatic interactions, van der Waals interaction, Hydrogen bonding, hydrophobic interactions,; application of quantum mechanics and molecular mechanics in drug design.
Module 3: Computer simulation methods: Minimization, Molecular dynamics, Monte Carlo Simulations, Simulated Annealing, Conformational Search and Conformational Analysis, Understanding of iterations, convergence, protocols and algorithm such as steepest descents, conjugate gradient etc.,
Module 4: Structure Activity Relationship (QSAR): Mathematical parameters or descriptors: Lipophilicity, Electronic and Steric factor, Mathematical Models based on physicochemical relations: Hammett equations, Taft Equation and Linear Free Energy Relationship (LFER), Hansch Equations and Hansch analysis, mixed approach, Other QSAR Approaches

Reference Books:

1 Computational Chemistry, Introduction to Theory and Application of Molecular and Quantum Mechanics. By Errol Lewars, Springer
2 Molecular Modelling : Principle and Application, 2nd edn By Andrew R. Leach, Addison-Wesley Longman Ltd, (February 2001) ISBN: 0582382106.
3 E. Kreyszig, Advanced Engineering Mathematics, 10th Edn., John Wiley and Sons, 2011.

UG Elective-5 Green chemistry

Credits: 2(3-0-0)

Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products , Atom Economy, alculation of atom economy of the rearrangement, addition, substitution and elimination reactions.

Prevention/ minimization of hazardous/ toxic products reducing toxicity.

risk = (function) hazard × exposure; waste or pollution prevention hierarchy.

Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.

Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy. Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups. Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.

Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Examples of Green Synthesis

1. Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)

2. Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C2S3); Green chemistry in sustainable development.

Reference Books:

1. Ahluwalia, V.K. & Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
2. Anastas, P.T. & Warner, J.K.: *Green Chemistry - Theory and Practical*, Oxford University Press (1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
4. Cann, M.C. & Connely, M.E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington (2000).
5. Ryan, M.A. & Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition,2010.

In stream electives (UG level) for Semester V

UG Elective-6 Nano materials

Credits: 3(3-0-0)

General introduction to nanomaterials and emergence of nanotechnology, defining nanodimensional materials, size effects in nanomaterials , Moore's law, , physical and chemical methods of synthesis of nanomaterials, synthesis and properties of fullerenes and carbon nanotubes, synthesis of nanoparticles of gold, silver, rhodium, palladium and platinum, techniques of synthesis-electroplating and electrophoretic deposition, conversion through chemical reactions and lithography. Thin films-chemical vapor deposition and atomic layer deposition techniques,

Diversity in nanosystems: nanofabrication methods: top-down and bottom-up methods, self assembled monolayers on gold-growth process and phase transitions. Gas phase clusters- formation, detection and analysis. quantum concepts. Quantum dots- preparation, characterization and applications. Nanoshells-types of systems, characterization and application.

Evolving interfaces of nanotechnology-nanobiology, nanosensors, nanomedicines.Types of nanostructured materials: nanocrystals, nanoparticles, oxide nanostructures, nanotubes and nanowires. Characterization of nanoparticles: transmission electron microscopy(TEM), atomic force microscopy(AFM), X-ray spectroscopy.

Shape of nanoparticles-exterior surface and particle shape, interior nanoscale surface area, specific surface area, spherical cluster approximation, packing fractions and density, structural magic numbers. Nanooptics: interaction of light with nanoparticles, surface Plasmon resonance, colour generation from nanoparticles, quantum dots, Determination of nanoparticle size, surface area and porosity-BET method, BJH method, Mercury Porosimeter method.

References

1. H.S. Nalwa, R. Smalley, Encyclopedia of Nanoscience and Technology, American Scientific Pub., 2004.
2. C.N. R. Rao, A. Govindraj, Nanotubes and Nanowires, 2nd Edn., RSC, 2011.
3. C.N.R. Rao, A. Muller, A.K. Cheetham, The Chemistry of Nanomaterials, Vol 1 & 2, John Wiley & Sons, 2005.
4. G. Schmid, Nanoparticles: From Theory to Applications, John Wiley & Sons, 2011.
5. G.L. Hornyak , H.F. Tibbals , J. Dutta, J.J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2009.

UG Elective-7 Medicinal Chemistry

Credits: 3(3-0-0)

General aspects of medicinal chemistry, basic terminology in drug discovery, IC50, LogP, LogD, MIC, efficacy, adsorption, distribution, metabolism and excretion, dose response curves, drug and disease classification, drug targets, pharmacology, pharmacokinetics, Lipinski rule. Stages in drug discovery, SAR and QSAR, natural and synthetic drugs. Introduction to process research.

Introduction to Drug design: modeling techniques, receptor proteins, drugreceptor interaction, drug action, drug selectivity, drug metabolism. Important chemicals used in drug action, anticoagulants and anticoagulant therapy, anti-anginal drugs, antihypertensive agents, antimalarial drugs, aminoquinolines and alkaloids.

Antibiotics: Important penicillins, chloramphenicol, tetracyclins and cephalosporins. Drugs for cancer, aromatase inhibitors for cancer treatment. Drugs for AIDS and diabetes.

Antibiotics: antibacterials(Cipro and Zyvox), β-lactam antibiotics(Penicillins), tetracyclines and quinolones(Fluoroquinolones), basic knowledge of TB and its treatment.

Viral and fungal diseases: antiviral drugs(Tamiflu), antifungal drugs(Fluconazole) Analgesics and anti inflammatory drugs: analgesics(Cimetidine), opioid analgesics(morphine), anti inflammatory drugs(Celebrex), non-steroid antiinflammatory drugs (NSAIDS) like ibuprofen, naproxen.

Proton pump inhibitors: hyperacidity, Peptic Ulcer Disease (PUD), gastroesophageal reflux disease (GERD), ATPase inhibitors-omeprazole and esomeprazole. Cardiovascular diseases: hypertension, cardiovascular drugs-Statin drugs, ACE inhibitors, calcium channel inhibitors, cholesterol absorption inhibitors.

Concept of rational drug design : Structure activity relationship, Drug-receptor understanding, Molecular modeling, Structure based drug design. QSAR. Brief discussion about the rational discovery of anti-influenza compound and anti-HIV compound.

References

1. W. Sneader, Drug Discovery: A History, John Wiley & Sons, 2006.
2. G.L. Patrick, An Introduction to Medicinal Chemistry, 4th Edn., Oxford University Press, 2011.
3. G. Thomas, Fundamentals of Medicinal Chemistry, John Wiley & Sons, 2003
4. X. Liang, W. Fang, Medicinal Chemistry of Bioactive Natural Products, John Wiley & Sons, 2006.
5. A. Kar, Medicinal Chemistry, New Age International, 2005
6. R. Vardanyan, V.J. Hruby, Synthesis of Essential Drugs, Elsevier, 2006.

UG Elective-8 Atmospheric chemistry

Credits: 3(3-0-0)

Module- I Atmospheric chemistry overview Chemical composition of the Earth's Atmosphere, Atmospheric Aerosols and Clouds, Physical properties and structure of the troposphere and the stratosphere, Temperature profile, Different types of inversion, Concentration profiles, Atmospheric radiation and photochemistry

Module-II Chemistry of the Troposphere Sources, Sinks and Transport, Oxidation and Transformation, Air Pollution, Primary and Secondary Pollutants, Tropospheric chemical cycles, Hydroxyl and chlorine radical, chemical cleansing, hydrocarbons in the troposphere

Module-III Chemistry of the Stratosphere Atmospheric Chemistry of the Stratosphere – ozone cycle, depletion, Influence of trace constituents, Effect of ozone depletion on surface UV radiation, Polar ozone holes, Man's impact on stratosphere

Module-IV Atmospheric Pollution Chemistry of oxides of Carbon, Nitrogen, Sulphur, Hydrocarbons and Particulate Matter, Photochemical Smog, Acid rain, Volatile organic compounds, Stationary and Mobile emission sources, Pollution Standard Index, Criterion Pollutants, Ambient Air Quality Standards

Module-V Global Atmospheric Change Atmospheric stability, Adiabatic lapse rate, Radiation inversion, subsidence inversion, Global temperature, Energy balance, Radiative forcing, Carbon cycle and emissions from fossil fuels, Green House effect and Global warming Potential

Module-VI Global initiatiatives Montreal, Kyoto Protocol and Copenhagen summit, Air pollution regulations: Domestic and International, Environmental disasters, Nuclear accidents, Frontier Areas in Atmospheric Chemistry

Books Recommended:

1. Chemistry of Atmospheres: Richard P. Wayne
2. Introduction to Environmental Engineering: G.M. Masters
3. Environmental Chemistry: S.E Mannahan
4. Environmental Pollution Monitoring and Control: S.M. Khopkar
5. Atmospheric chemistry Fundamentals and Experimetnal Techniques: Finlayson- B.J Pitts and J.N. Pitts

Semester-VII Theoretical Chemistry

Credits: 4(4-0-0)

Quantum Chemistry Review of basics of quantum mechanics, The variation method and perturbation theory: Application to the helium atom, antisymmetry and Exclusion Principle, Terms symbols and spectroscopic states. Born – Oppenheimer approximation, Hydrogen molecule ion. LCAO – MO and VB treatments of the hydrogen molecule; electron density, forces and their role in

chemical binding. Hybridization and valence MOT of H_2O, NH_3 and CH_4. Huckel pi-electron theory and its applications to ethylene, butadiene and benzene. Idea of self-consistent field methods.

Symmetry & Group theory Symmetry elements & symmetry operation, Definition of group, sub-group, relation between order of a finite group and its sub-group, classes, Point symmetry group, representation of groups by matrices, character of the representation, The great orthogonality theorem (without proof), its importance, character tables & their use.

Statistical Thermodynamics Concept of distribution, Thermodynamic probability, Ensemble averaging, Canonical, grand canonical and micro canonical ensembles, Partition functions: Translational, rotational, Vibrational and electronic and calculation of thermodynamic properties, Applications Heat capacity behaviour of solids: Chemical Equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, Distribution law and applications to metals, Bose-Einstein statistics- distribution law and application to helium.

Non-equilibrium thermodynamics Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for irreversible processes, non- equilibrium stationary states, elctrokinetic phenomena, electric conduction, irreversible thermodynamics for biological systems, coupled reactions.

Reference Books:

1. Quantum Chemistry by Ira. N. Levine, Prentice Hall
2. Modern Quantum Chemistry by N. S. Ostlund & A. Szabo, McGraw Hill
3. Methods of Molecular Quantum Mechanics by R. Mcweeny & B. T. Sutcliffe, Academic Press
4. Density functional Theory of Atoms and Molecules by R. G. Parr & W. Yang, Oxford.
5. Theoretical Chemistry, S. Glasstone, ELBS 6. Symmetry and group theory, F. A. Cotton, Wiley.

Semester-VII Orgnaometallics

Credits: 4(4-0-0)

Module I Organometallics

Review of basic concepts, Structure and bonding of organometallics with metal-metal bonds, metal clusters, metalcarbon σ-bond, complexes with chain pi-donor ligands, olefines, acetylenes and pi-allyl complexes, complexes with cyclic pi-donors-cyclopentadiene, benzene. Metal polyenes, metal carbynes, metal allyls, metal carbenes and metal cyclobutadiene complexes. Fragment molecular orbitals (FMO) of various organic and inorganic moieties like CH3, CH2, CH, BH2, BH, NH2, NH, FMO's (π-orbitals) of C3H5, C4H4, C4H6, C5H5, C6H6, C8H8 and MLn, isolobal concept, iso-electronic and isolobal relationships between various organic and inorganic (MLn) fragments, structure and bonding based on MO level diagrams of various organometallics like metal-olefins, MLn-cyclobutadiene, MLn-carbene, MLn-carbyne, sandwich and half-sandwich compounds, low and high nuclearity clusters, compounds with metal-metal multiple bonds, metal-metal σ, π and δ bonds, stereochemically non-rigid molecules, fluxional nature of organometallic compounds, characterization of non-rigidity by NMR spectroscopy.

Activation of small molecules by metal ions, reactions involving various organometallic compounds-oxidative addition reactions and reductive elimination reactions, migratory insertion reactions, 1,1-migratory insertion reaction, 1,2-insertion and b-hydride elimination reactions, cyclometallation reactions, alkene hydrogenation(Wilkinson's catalyst), water-gas shift reaction, hydro-formylation reactions, catalytic addition of molecular oxygen to alkenes(Wacker process), Ziegler-Natta polymerization of alkenes, Fischer-Tropsch process, alkene metathesis, oligomerisation of alkynes, metallacycles, ortho-metallation.

Module II Reaction Mechanism of Transition Metal Complexes

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valency bond and crystal field theory, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, substitution reaction in square complexes, trans effect, redox reactions, electron transfer reactions, mechanism of one electron transfer reaction, outer sphere type reactions, inner sphere type reactions.

References

1. J.E. Huheey, R.A. Keiter, R.L. Keiter, Inorganic Chemistry-Principles of Structure and Reactivity, 4th Edn., Prentice Hall, 1997.
2. F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry,6th Edn., Wiley-Interscience, 1999.
3. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver and Atkins Inorganic Chemistry, 4th Edn., Oxford University Press, 2006.
4. J.D. Atwood, Inorganic and Organometallic Reaction Mechanism, 2nd Edn., Wiley-VCH, 1997.
5. B.E. Douglas, D.H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn., Wiley-India, 2007.
6. M. Bochmann, Orgaonometallics1: Complexes with Transition Metal-Carbon Sigma Bonds, Oxford University Press, 1994.

Semester-VII Co-ordination compounds

Credits: 4(4-0-0)

Module 1 Coordination Chemistry

Introduction to co-ordination chemistry. Theories of bonding in complexes: Valence Bond theory and its limitations. Crystal Field Theory-splitting of d orbitals in different fields, crystal field splitting and crystal field stabilization energy, spectrochemical series, Jahn Teller distortion. Evidence of covalency in metal ligand bond-nephelauxetic effect. Ligand Field Theory. Molecular Orbital theory, MO energy level diagram for octahedral complexes without and with π-bonding, two-dimensional spectrochemical series.

Term symbols and energy states, electronic spectra of complexes: d-d transition and charge transfer transition, selection rules for electronic transition, effect of spin-orbit coupling and vibronic coupling on electronic transition. characteristic spectra of complexes of fast row transition metal ions, typical spectra of second & third row transition metal ions, Octahedral, tetrahedral and planar complexes of first row transition metal ions; spectrochemical & nephelauxetic series, charge transfer spectra. Spectroscopic ground state, Orgel and Tanabe-Sugano diagrams for transition metal complexes, calculations of D_q, B and beta parameters.

Module II Photochemistry of Co-ordination complexes

Photochemical reactions of Cr(III), Ru(II) and Ru(III) complexes. Photo substitution, Photo racemization reactions and energy and electron transfer process in ruthenium complexes.

Metal complex sensitizers-electron relay, semiconductor supported metal oxide systems, water photolysis.Dye sensitized photochemical solar cells – Ruthenium and supramolecular sensitizers. Photo induced electron collection

References

1. F.A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 3rdEdn., Wiley, 1972.
2. J.E. Huheey, R.A. Keiter, R.L. Keiter, Inorganic Chemistry-Principles of Structure and Reactivity, 4th Edn., Prentice Hall, 1997.
3. B. Douglas, D.H. McDaniel, J.J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn., John Wiley & Sons, 2006.
4. J.D. Lee, Concise Inorganic Chemistry, 5th Edn., Chapman& Hall, 1996.
5. A. Earnshaw, Introduction to Magnetochemistry, Academic Press, 1968.

Semester-VII Stereochemistry and asymmetric synthesis

Credits: 4(4-0-0)

Unit 1: Stereochemistry of Organic Compounds

Introduction to molecular symmetry and chirality: examples from common objects to molecules. Axis, plane, center, alternating axis of symmetry. Center of chirality: molecules with C, N, S based chiral centers, absolute configuration, enantiomers, racemic modifications, R and S nomenclature using Cahn-Ingold-Prelog rules, molecules with a chiral center and Cn, molecules with more than one center of chirality, definition of diastereoisomers, constitutionally symmetrical and unsymmetrical chiral molecules, erythro, threo nomenclature.

Axial, planar and helical chirality with examples, stereochemistry and absolute configuration of allenes, biphenyls and binaphthyls, ansa and cyclophanic compounds, spiranes, exo-cyclic alkylidenecycloalkanes.

Stereoisomerism: definition based on symmetry and energy criteria, configuration and conformational stereoisomers. Topicity and prostereoisomerism, topicity of ligands and faces as well as their nomenclature.Geometrical isomerism: nomenclature, E-Z notation, methods of determination of geometrical isomers. Interconversion of geometrical isomers.

Unit 2: Conformational Analysis

Conformational descriptors - factors affecting conformational stability of molecules. Conformational analysis of acyclic and cyclic systems: substituted ethanes, cyclohexane and its derivatives, decalins, adamantane, congressane, sucrose and lactose. Fused and bridged bicyclic systems. Conformation and reactivity of elimination (dehalogenation, dehydrohalogenation, semipinacolic deamination and pyrolytic elimination-Saytzeff and Hofmann eliminations), substitution and oxidation of 20 alcohols. Chemical consequence of conformational equilibrium - Curtin Hammett principle.

Unit 3: Asymmetric synthesis

Asymmetry in nature, chiral pool, asymmetric induction, enantiomeric and diastereomeric excess, chiral reagents and chiral catalysts, chiral auxiliaries, Evans chiral oxazolidones, Davis chiral sulfinimines

Dynamic kinetic resolution(DKR)-definition, principles and examples, DKR from asymmetric conjugate reduction.Preg's rule, Cram's rule, Karabatso's rule, Felkin's rule and their application in organic synthesis, enzymatic and catalytic asymmetric synthesis, stereoselectivity in hydride reduction.

Asymmetric hydrogenation with Rh and Ru complexes, Noyori's hydrogenation, hydrogenation of ketones, enantioselective hydrogenation of ketones using borohydride reagents, hydrogenation of imines.

References

1. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanisms, Academic Press, 2002.
2. F.A. Carey, R.A. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, 5th Edn., Springer, 2007.
3. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, 2004.
4. D. Nasipuri, Stereochemistry of Organic Compounds: 3rd Edn., New Age Pub., 2010.
5. E.L. Eliel, S.H. Wilen, Stereochemistry of Organic Compounds, John Wiley & Sons, 1994.

Semester VII Advanced physical chemistry

Credits: 4(3-0-0)

Electro chemistry:-Electrolytic conduction-the significance of conductivity data, conductivity and transport properties of ions, relationships between molar conductivity and concentration, conductivity at high field strengths and high frequency of alternation of the field, electrical migration and transport numbers, applications of conductivity measurements.

Reversible(equilibrium) potentials-comparison of chemical and electrochemical reactions, reversible electrode potentials, reference electrodes, the hydrogen scale, electrochemical concentration cells, concentration cells without and with liquid junctions. Applications of electrode potentials and cell EMF-thermodynamics of cell reactions, determination of standard potentials and mean ion activity coefficients, determinations of transport numbers, equilibrium constants and pH, electrochemical detectors, potentiometry.

Interfacial phenomena-the significance of the interface between conduction phases, the electrode double layer, polarized and non-polarized electrodes, the diffuse double layer, electrocapillarity, electrokinetic phenomena, the behaviour of colloidal systems, membrane equilibria.

Surface Chemistry Adsorption: Langmuir and Freundlich adsorption isotherm, Gibbs Adsorption isotherm, BET equation, Micelles: Surface active agents, Classifications, micellization, hydrophobic

interaction, CMC, Factors affecting the CMC surfaces, Counter ion binding, Thermodynamics of micellization-phase separation, solubilization, Micro-emulsion, Reverse micelles

Thermodynamics First law of thermodynamics, relation between Cp and Cv; enthalpies of physical and chemical changes; temperature-dependence of enthalpies. Second law of thermodynamics, entropy, entropy of mixing, Maxwell's Relations and its applications and thermodynamic equations of state. Free energy, free energy mixing of gases and variation of free energy with temperature, pressure and volume (Gibbs-Helmholtz equations with its applications). Third law of thermodynamics and calculation of entropy, partial molar quantities, Gibbs-Duhem equation, equilibrium constant, temperature dependence of equilibrium constant, Fugacity.

References:

1. Physical Chemistry by P. W. Atkins, Elbs
2. Micelles Theoretical and Applied Aspects by V. Moroi, Plenum
3. Modern Electrochemistry – Vol – I & II, by J. O. M. Bockris & A. K. N. Reddy, Plenum.
4. Physical Chemistry Vol. 1-5, by K.L Kapoor
5. Physical Chemistry: A Molecular Approach by McQuarrie & Simon Viva Books

Semester VII Organic chemistry Practical

Credits: 4(0-0-8)

PART I

General methods of separation and purification of organic compounds such as:

Solvent extraction, Soxhlet extraction, Fractional crystallization, TLC and Paper Chromatography, Column Chromatography

PART II Qualitative Analysis

Identification of organic compounds (solid and liquid) using chemical analysis and preparation of their suitable derivatives Separation, Purification and identification of compounds of binary / tertiary mixtures (one liquid and one solid) using TLC, Paper and Column chromatography, chemical tests, IR spectra.

PART III

a. Multistep organic Synthesis (any two) i) Photochemical reaction-Benzophenone to Benzpinacol to Benzpinacolone ii) Beckmann Rearrangement-Benzanilidine from Benzene iii) Synthesis of heterocyclic compounds-Skraup Synthesis iv) Biosynthesis of ethanol from sucrose v) Synthesis of Binol from β-napthol.

b. Extraction of Organic compounds from natural sources (any two) i) Isolation of caffeine from Tea leaves. ii) Isolation Casein from Milk iii) Isolation of Nicotine as dipicrate from tobacco. iv) Isolation of β-carotenes from carrots.

c. Microwave assisted Organic Synthesis

PART IV

Prediction of FTIR, UV-Visible, 1H and 13C NMR spectra of the substrates and products at each stage of the products synthesized by the above methods.

References

1. A.I. Vogel, B.S. Furniss, Vogel's Text Book of Practical Organic Chemistry, 5th Edn.,1989.
2. B.B. Dey, M.V. Sitaraman, T.R. Govindachari, Laboratory Mole of Organic Chemistry, Allied Publishers, 1992.
3. M.P. Doyle, W.S. Mungall, Experimental Organic Chemistry, John Wiley & Sons, 1980.
4. F.G. Mann, B.C Saunders, Practical Organic Chemistry, 4th Edn., Pearson Education India, 2009.
5. Hand book of Organic Chemistry, Qualitative & Quantitative by H. Clark, Adward-Arnold
6. Systematic Qualitative Organic Analysis by H. Middleton, Adward-Arnold

Semester VIII Molecular spectroscopy

Credits: 4(4-0-0)

Introduction: Origin of different spectra, intensity of absorption, influencing factors-signal to noise ratio, natural line width, contributing factors-Doppler broadening, Lamb dip

spectrum, Born Oppenheimer approximation, energy dissipation from excited states, relaxation time.

Microwave spectroscopy: principal moments of inertia and classification (linear, symmetric tops, spherical tops and asymmetric tops), selection rules, intensity of rotational lines, relative population of energy levels, derivation of Jmax , effect of isotopic substitution, calculation of intermolecular distance, Stark effect and its application, nuclear and electron spin interaction.

Ultraviolet-Visible and Chirooptical Spectroscopy: energy levels and selection rules, Woodward-Fieser and Fieser-Kuhn rules. Influence of substituent, ring size and strain on spectral characteristics. Solvent effect, stereochemical effect, non-conjugated interactions. Chirooptical properties-ORD, CD, octant rule, axial haloketone rule, Cotton effect.

Infrared Spectroscopy: fundamental vibrations, characteristic regions of the spectrum (fingerprint and functional group regions), influence of substituent, ring size, hydrogen bonding, vibrational coupling and field effect on frequency, determination of stereochemistry by IR technique. IR spectra of C=C bonds (olefins and arenes) and C=O bonds.

Nuclear Magnetic Resonance Spectroscopy: magnetic nuclei with special reference to 1H and 13C nuclei. Chemical shift and shielding/deshielding, factors affecting chemical shift, relaxation processes, chemical and magnetic non-equivalence, local diamagnetic shielding and magnetic anisotropy. 1H and 13C NMR scales. Spin-spin splitting: AX, AX2, AX3, A2X3, AB, ABC, AMX type coupling, first order and non-first order spectra, Pascal's triangle, coupling constant, mechanism of coupling, Karplus curve, quadrupole broadening and decoupling, diastereomeric protons, virtual coupling, long range coupling-epi, peri and bay effects. NOE and cross polarization. Simplification non-first order spectra to first order spectra: shift reagents, spindecoupling and double resonance, off resonance decoupling. Chemical shifts and homonuclear/heteronuclear couplings. Basis of heteronuclear decoupling. 2D NMR and COSY, HOMOCOSY and HETEROCOSY. Polarization transfer. Selective Population Inversion. DEPT, INEPT and RINEPT.

Mass Spectrometry: ion production methods (EI). Soft ionization methods: SIMS, FAB, CA, MALDI, PD, Field Desorption Electrospray Ionization. Fragmentation patterns-nitrogen and ring rules. McLafferty rearrangement and its applications. HRMS, MS-MS, LC-MS, GC-MS.

EPR spectroscopy: electron spin interaction with magnetic field, g factor, fine and hyperfine structures, Kramers' degeneracy, McConnell equation.

Mossbauer spectroscopy: principle, Doppler effect, chemical shift, application to metal complexes, MB spectra of Fe(II) and Fe(III) cyanides.

References

1. G. Aruldhas, Molecular Structure and Spectroscopy, Prentice Hall of India, 2001.
2. C.N. Banwell, E.M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edn., Tata McGraw Hill, 1994.
3. H. Kaur, Spectroscopy, 6th Edn., Pragati Prakashan, 2011.
4. R.M. Silverstein, G.C. Bassler, T.C. Morril, Spectroscopic Identification of Organic Compounds, 5th Edn., Wiley, 1991.
5. D.F. Taber, Organic Spectroscopic Structure Determination: A Problem Based Learning Approach, Oxford University Press, 2007.
6. D.L. Pavia, G.M. Lampman, G.S. Kriz, Introduction to Spectroscopy, 3rd Edn., Brooks Cole, 2000.

Semester VIII Structural Inorganic chemistry

Credits: 4(4-0-0)

Module I solid state chemistry:

Crystal defects and Non-stoichiometry in solids: Perfect and Imperfect Crystals, intrinsic and extrinsic defects- Point defects, line and plane defects, Vacancies- Schottky and Frenkel defects. Thermodynamics of Schottky and Frenkel defects formation, Colour centres. Structure of compounds of AX (Zinc blende, Wurtzite), AX2 (Rutile, fluorite, antifluorite), AmX2 (Nickel Arsenide), ABX3 (Perosvskite, Ilmenite). Spinels. Inverse spinel structures.

Solid state reactions-diffusion coefficient, mechanisms, vacancy diffusion, thermal decomposition of solid-Type I reactions, Type II reactions. Phase transition in solids: classification of phase transitions-first and second order phase transitions, Martensitic transformations, order-disorder transitions and spinodal decomposition. Kinetics of phase transitions, sintering. Growing single crystals-crystal growth from solution, growth from melts and vapor deposition technique.

Module II Inorganic Chains and Rings :

Chains - catenation, heterocatenation. Silicate minerals. Structure of silicatescommon silicates, silicates containing discrete anions, silicates containing infinite chains, silicates containing sheets, framework silicates. Silicones. Zeolitessynthesis, structure and applications. Isopoly acids of vanadium, molybdenum and tungsten. Heteropoly acids of Mo and W. Condensed phosphates-preparation, structure and applications. Phosphate esters in biological systems. Polythiazil-one dimensional conductors.

Rings-topological approach to boron hydrides, Styx numbers. Structure and bonding in borazines, ring silicates and silicones, phosphorous-nitrogen compounds, phosphazenes. Heterocyclic inorganic ring systems-structure and bonding in phosphorous-sulphur and sulphur-nitrogen compounds. Homocyclic inorganic ring systems-structure and bonding in sulphur, selenium and phosphorous compounds.

Module III Inorganic Cages and Metal Clusters

Cages: synthesis, structure and bonding of cage like structures of phosphorous. Boron cage compounds-Wade Mingos Lauher rules, MNO rule, boranes, carboranes, metallacarboranes.

Metal clusters**:** dinuclear compounds of Re, Cu and Cr, metal-metal multiple bonding in (Re2X8)2-, trinuclear clusters, tetranuclear clusters, hexanuclear clusters. Polyatomic zintl anion and cations. Infinite metal chains.

Reference Books

1. L.V. Azaroff, Introduction to Solids, Mc Graw Hill, 1984.
2. A.R. West, Solid State Chemistry and its Applications, Wiley-India, 2007.
3. D.K. Chakrabarty, Solid State Chemistry, New Age Pub., 2010.
4. C.N.R. Rao, K.J. Rao, Phase Transitions in Solids, McGraw Hill, 2010.
5. A. Earnshaw, Introduction to Magnetochemistry, Academic Press, 1968.
6. J.E. Huheey, E.A. Keiter, R.L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4th Edn., Harper Collins College Pub.,1993.
7. F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6th Edn., Wiley-Interscience,1999.

Semester VIII Organic reactions and mechanism

Credits: 4(4-0-0)

Structure and reactivity: Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, Hammond's postulate, potential energy diagrams, transition states and intermediates. Organic reactive intermediates. Generation, structure and reactivity of carbenes and nitrenes. Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes, The Hammett equation and linear free energy relationship, substituent and reaction constants. Taft-equation.

Photochemistry: Singlet and triplet excited state, radiative and non-radiative proesses, Jablonski diagram, intersystem crossing, quantum yield, photosensitisation, fluorescence and phosphorescence, quenching.

Reactions involving the olefin bond-*cis-trans* isomerisation, velence bond tautomerisations, reactions proceeding through bond dissociation-Norrish type I and type II reactions, Fries, Dienone-phenol, Favorski and di-pi-methane rearrangements, Barton's Reaction. photofragmentation, photoaddition, photosubstitution, cycloaddition, Paterno-Buchi reaction, photoreduction and photooxidation, singlet oxygen and chemeluminescence, photoinduced electron transfer(PET) reactions, photochemistry of vision.

Pericyclic reactions Molecular Orital symmetry, Frontier orbitals of ethylene, 1, 3 - butadiene, 1, 3, 5 -hexatriene and allyl system. energy considerations of thermal and photochemical reactions, concept of ionic, concerted, synchoronous and non synchronous pathways. Classification of pericyclic reactions-electrocyclic, cycloadition and sigmatropic reactions (cheletropic and group transfer reactions). Theory of Pericyclic reactions- symmetry properties of molecular orbital, con and dis rotator modes, correlation diagrams, Woodward Hoffman rules. Analysis of pericyclic reactions using Frontier Molecular Orbital (FMO) and related methods. Stereochemistry and regiochemistry of pericyclic reactions, Exo-endo selectivity in Diels-Alder reactions. Cope and Claisen rearrangements.-Ene reaction. Aromaticity, Huckel and Moebius Systems, valence isomerism. Baldwin rules for ring closure.

Oxidation Reactions: oxidation of C-C and C=C to oxiranes, 1,2-diols and carbonyl compounds, oxidative cleavage, ozonolysis-singlet oxygen, asymmetric epoxidation, Sharpless epoxidation, allylic oxidation, oxidation of alcohols to ketones, oxidative rearrangements to ketones, considerations of the selectivity of common reagents for oxidation, B2H6/H2O2 peracids, SeO2, Quinones, Tl3+, CrO3, KMnO4, MnO2, OsO4, AgOAc/I2, Cu(OAc)2, NaIO4, DMSO.

Reduction reactions: catalytic hydrogenation, hydrogenation of C-C multiple bonds, Birch reduction, reduction by diborane and alkyl boranes, reduction of aldehydes, ketones and carboxylic acid derivatives with hydrides, reduction with N2H4 and N2H2, Wolff-Kishner type reduction, Barton olefin synthesis, McMurry coupling, pinacol coupling, general consideration on the selectivity of common reagents for reduction.

References

1. K.K.R. Mukherjee, Fundamentals of Photochemistry, John Wiley and Sons, 1978.
2. J.M. Coxon, B. Halton, Organic Photochemistry, Cambridge University Press, 1974.
3. G.B. Willis, M.R. Gill, Pericyclic Reactions, Chapman and Hall, 1974.
4. F.A. Carey, R.J. Sundberg, Advanced Organic Chemistry-A & B, Springer, 2007.
5. J. March, Advanced Organic Chemistry, 4th Ed., Wiley India, 1992.
6. R.O.C. Norman, J.M. Coxon, Principles of Organic Synthesis, 3rd Edn., CRC Press, 1993.
7. M. Hudlicky, Oxidations in Organic Chemistry, American Chem. Society, 1990.
8. M. Hudlicky, Reductions in Organic Chemistry, Ellis Horwood, 1984.

Semester VIII Chemical kinetics

Credits: 4(4-0-0)

The analysis of kinetic results: the method of integration, graphical methods, half life methods, Guggenhiem's method, the differential method. Opposing reactions. Flow methods..Relaxation theory.Theories of reaction rates: Collision theory-steric factor, potential energy surfaces. Conventional transition state theory-Eyring equation. Comparison of the two theories. Thermodynamic formulation of the two theories. Thermodynamic formulation of the reaction rates. Significance of $\Delta G^{\neq}$, $\Delta H^{\neq}$ and $\Delta S^{\neq}$. Volume of activation. Effect of pressure and volume on velocity of gas reactions.

Lindemann-Hinshelwood mechanism, qualitative idea of RRKM theory, chain reactions: free radical and chain reactions, steady state treatment, kinetics of H2-Cl2 and H2-Br2 reactions, Rice-Herzfeld mechanism, branching chains H2-O2, Semonov-Hinshelwood mechanism of explosive reactions, mechanisms of stepgrowth, ionic and addition polymerization, kinetics of anionic and cationic polymerization.

Fast reactions: relaxation, flow and shock methods, flash photolysis, NMR and ESR methods of studying fast reactions.

Reactions in solution: factors determining reaction rates in solutions, effect of dielectric constant and ionic strength, cage effect, Bronsted-Bjerrum equation, primary and secondary kinetic salt effect, influence of solvent on reaction rates, significance of volume of activation, linear free energy relationship, kinetic isotope effect.

Acid-base catalysis: specific and general catalysis, Skrabal diagram, Bronsted catalysis law, prototropic and protolytic mechanism with examples, acidity function.
Enzyme catalysis and its mechanism, Michelis-Menten equation, effect of pH and temperature on enzyme catalysis.
Mechanisms of heterogeneous catalysis: unimolecular and bimolecular surface reactions, mechanisms of catalyzed reactions like ammonia synthesis, Fischer-Tropsch reactions, hydrogenation of ethylene and catalytic cracking of hydrocarbons and related reactions.
Chemical Equilibrium: explanation in terms of statistical mechanics.
Reaction Mechanisms. Activation co-ordintates. Quantum mechanical explanation of the activation reaction. The Hydrogen exchange reaction. Frequency factor. Explanation of frequency factor using kinetic theory of gases. Explanation of frequency factor using statistical mechanics (translation and vibration partition functions).

References

1. J. Rajaram, J.C. Kuriakose, Kinetics and Mechanisms of Chemical Transformations, Macmillan India, 2000.
2. K.J. Laidler, Chemical kinetics, 3rd Edn., Harper & Row, 1987.
3. C. Kalidas , Chemical Kinetic Methods: Principles of Fast Reaction Techniques and Applications, New Age International, 2005.
4. J.W. Moore, R.G. Pearson, Kinetics and Mechanisms, John Wiley & Sons, 1981.
5. P.W. Atkins, Physical Chemistry, ELBS, 1994.
6. K.J. Laidler, Chemical kinetics, 3rd Edn., Harper & Row, 1987.

Semester VIII Inorganic chemistry Practical

Credits: 4(0-0-4)

1. Colorimetric estimation of Fe, Cu, Ni, Mn, Cr, NH_4^+, nitrate and phosphate ions.
2. Complexometric titrations.
   Estimation of Zinc and Magnesium
   Estimation of hardness of water.
3. Determination of Mn/Cr/V in steel sample by spectrophotometic method.

References

1. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn., Longman,1996.
2. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman, 1966.
3. I.M. Koltoff, E.B. Sandell, Text Book of Quantitative Inorganic analysis, 3rd Edn., McMillian, 1968.
4. V.V. Ramanujam, Inorganic Semimicro Qualitative Analysis, The National Pub.Co.,1974.

Semester VIII Physical chemistry practical

Credits: 4(0-0-8)

I. Adsorption (**any two)**

1 Verification of Freundlich and Langmuir adsorption isotherm: charcoal-acetic acid or charcoal-oxalic acid system.
2 Determination of the concentration of the given acid using the isotherms.
3 To study the adsorption of iodine from alcoholic solution of charcoal.

II. Chemical equilibrium : (**any one**)

1 Determination of congruent composition & temperature of a binary system – Phenol-water
2 Determination of glass transition temperature of a given salt conductometrically
3 To construct the phase diagram for a three component systems.
4 to determine the equilibrium constant for the reaction $KI + I_2 = KI_3$.

III. Distribution law (**any one**)

1. Distribution coefficient of iodine between an organic solvent and water.
2. Distribution coefficient of benzoic acid between benzene and water.
3. Determination of the equilibrium constant of the reaction KI + I2 ↔ KI3

IV. Chemical Kinetics: (**any two**)

1 Determination of rate constant of saponification ethyl acetate by NaOH
2 Determination of the effect of change of temperature, concentration of reactant and catalyst and ionic strength of the media on the velocity constant of hydrolysis of an ester
3 Determination of the velocity constant of hydrolysis of an ester in micellar media.
4 Determination of the rate constant for the oxidation of iodide ion by hydrogen peroxide, studying the kinetics as an iodine clock reaction

V. Electrochemistry: (**any two)**

1 Determination of velocity constant, order of reaction and energy of activation for saponification of ethyl acetate by NaOH conductometrically.
2 Determination of solubility and solubility product of sparingly soluble salt conductometrically.
3 Determination of the strength of strong and weak acids in a given mixture conductometrically.
4 Determination activity co-efficient of zinc ions in the solution of 0.002 M $ZnSO_4$ using Debye-Huckel's limiting law.

VI Potentiometry-pH metry: (**any one**)

1 Determination of strengths of halides in a mixture potentiometrically.
2 Determination of valancy of mercurous ions potenti$_o$metrically.Determination of the strength of strong and weak acids in a given mixture using a potentiometer-pH meter.
3 Determination of temperature dependence of e.m.f ^{o}f a cell.

VII Polarimetry **(any one)**

1. Kinetics of inversion of sucrose in presence of HCl.
2. Determination of the concentration of sugar solution.

References

1. J.B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House,2001.
2. G.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Phy. Chem., 8th Edn., McGraw Hill, 2009
3. B. Viswanathan, Practical Physical chemistry, Viva Pub., 2005
4. V.D. Athawala, P. Mathur. Experimental Physical Chemistry, New Age International, 2007.
5. B. Viswanathan, P.S. Raghavan, Experimental Physical Chemistry, Narosa, 1998.
6. A. Halpern, G. McBane, Experimental Physical Chemistry: A Laboratory Text Book, 3rd Edn., W.H. Freeman, 2006..

Semester IX Organic synthesis

Credits: 4(4-0-0)

Retrosynthetic analyses: comparison, design and selection of appropriate organic reactions, retrosynthetic analysis, disconnection approach-one group, two group and illogical disconnections, functional group interconversion, protection of functional groups, synthetic equivalent groups, multistep synthesis, convergent synthesis, formation of C-C bonds, carbonheteroatom bonds, ring closure and ring opening reactions

Protecting Groups Principle of protection, activation and deprotection process in organic synthesis, protection and deprotection of hydroxy, carboxyl, carbonyl, and amino groups.

Transition metals in organic synthesis: Application of organotransition metal complexes in organic synthesis with special reference to organopalladium catalyst, Heck reaction, Stille coupling, Kumada coupling, Suzuki-Miyaura coupling, Negishi coupling and Sonogashira reactions.

macrolactonization, Mitsunobu reaction, metathesis reactions, reactions by metallocarbenes as well as Grubb and Schrock catalysts.

Name reactions in organic synthesis: Baylis Hillman reaction, Bergmann cyclisation, Buchwald Hartwig reaction, Click reaction, Demjanov reaction, Neber reaction, Nef reaction, Noyori reaction,

Nozaki Hiyama Kishi coupling, Pauson Khand cyclisation, Pechmann condensation, Ritter reaction, Sakurai reaction, Shapiro reaction, Tebbe olefination, Vilsmeier formylation.
Sharpless asymmetric epoxidation and dihydroxylation, hydroxylations, Peterson's olefications, Robinson annelation, Barton reaction, Mukayama-aldol reaction, Evan's aldol reaction, Swern oxidation, Moffatt oxidation, Williamson ether synthesis, Prevost reaction, Oppenauer oxidation, Rosenmund reduction, Metathesis reactions, Wittig reaction, Click Reaction, McMurry olefination, Suzuki, Heck and Sonogashira coupling, Mitsonobu reaction, Nef reaction, Multicomponent reactions(MCR): Passerini reaction, Ugi reaction and Biginelli reaction. Introduction to combinatorial chemistry.

References:

1. F.A. Carey, R.J. Sundberg, Advanced Organic Chemistry, 5th Edn., Springer,2007.
2. S. Warren, Organic Synthesis: The Disconnection Approach, John Wiley, 1984.
3. R.H. Crabtree, The Org. met. Chemistry of the Transition Metals, 4th Edn., John Wiley & Sons, 2005.
4. L. Kurti, B. Czako, Strategic Applications of Named Reactions in Organic Synthesis, Academic Press, 2005.
5. J. Zhu, H. Bienaym, Multicomponent Reactions, John Wiley & Sons, 2006.
6. T. Laue, A. Plagens, Named Organic Reactions, 2nd Edn., John Wiley and Sons, 2005
7. Advanced Organic Chemistry: Reactions, Mechanisms and Structure by J. March, Wiley.
8. Principles of Organic Synthesis by R. Norman and J. M. Coxon, Blackie Academia & Professional

In stream electives (PG level) for semester IX

PG Elective-1 Bio-inorganic Chemistry

Credits: 4 (4-0-0)

Elements of life, the natural selection of elements, metallo-biomolecules– enzymes and proteins, their differences, Metal ion storage and transport : Ferritin, metallothioneins, cerruloplasmin; Siderophores – enterobactin, transferin; Natural Oxygen carriers : Hemoglobin, Hemocyanin, Hemerythrin– model compounds. electron transfer processes, generation and function of organic free radicals, reactive oxygen species (ROS), action of ROS in biological systems.Hydrolytic enzyme : Carboxypeptidase A, Redox enzyme : Blue Copper protein.
Chemistry of Vitamin B_{12} , Iron – Sulphur proteins, Cytochrome, Nitrogenase- biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidences, other nitrogenase model systems, metal complexes in transmission of energy, chlorophylls, Photosystem I and II in cleavage of water- Model systems; Na^+ , K^+ pump, Ca^{2+} transport, Hydrogenase.
Cytochromes and its role in biology, cytochrome P-450 and oxygen transfer from O2 to non-activated substrates, catalases and peroxidases, superoxide dismutase. Copper enzymesstructure and function, azurin, plastocyanin, superoxide dismutase, Type I, II and III copper enzyme models, nitrogenase enzyme, N2 fixation, Fe-S clusters, Fe-protein structure, Mo-Fe protein structure, P-cluster and M-centre, their model compounds, photosynthesis, PS-I and PS–II, uptake, transport and storage of iron, Fe-S and other non-heme iron proteins, ferredoxins, transferrin, ferritin.
Role of Mn, Ni, Mo and Cr in biology, metal toxicity and homeostasis, therapeutic complexes-superoxide dismutase mimics, Zn-containing enzymes, Zn-finger proteins, metal ion based (Pt, V, Au) drugs, anticancer agents, chelation therapy, macrocyclic antibiotics, diseases caused by both excess and deficiency of metal ions-thalassaemia, Wilson disease, sickle-cell anemia. DNA intercalators, diagnostic agents, MRI imaging and contrast agents, the role of Gd3+ and other metal ions as contrast agents.

References

1. J.E. Huheey, R.A. Keiter, R.L. Keiter, Inorganic Chemistry-Principles of Structure and Reactivity, 4th Edn., Prentice Hall, 1997.

2. F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6th Edn., Wiley-Interscience, 1999.
3. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver and Atkins Inorganic Chemistry, 4th Edn., Oxford University Press, 2006.
4. B.E. Douglas, D.H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn., Wiley-India, 2007.
5. W. Kaim, B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, John Wiley & Sons, 1994.
6. Bioinorganic Chemistry *Wolfgang KaimBrigitte Schwederski* : Inorganic Elements in the Chemistry of Life: An Introduction and Guide:

PG Elective-2 Instrumental analysis

Credits: 4 (4-0-0)

Principles of Instrumentation: Characteristics of measurement system: Introduction- Functional units -Classification (automatic/manual type, self operated/power operated, analogue/digital)- Performance characteristics (Static/dynamic characteristics) –Zero order instrument and first order instrument. Signal and noise- types of noises- chemical noise- instrumental noise -thermal-shot – flicker and environmental noise-S/N ratio and its significance- techniques for S/N enhancement – hardware and software methods.

Spectrophotometry **:** Interaction of electromagnetic radiation with matter- classification of methods- Beer Lambert law- Deviation from Beer Lambert law.

UV- Visible spectrometry**:** Origin of absorption spectra, components of typical instrument – Source- Tungsten filament lamp, Hydrogen and Deuterium discharge lamps. Wavelength selectors- filters, prisms and grating -Sample cell - Detectors Single and double beam spectrophotometers

I.R spectrophotometry: classification of the types-Sources – Nernst glower, globar, Nichrome wire- Wavelength selectors-Sample cell – characteristics- sample preparation- solvent selection-Detectors – thermal, pneumatic and pyroelectric-NDIR instruments

Potentiometry, polarography, amperometry, bi-amperometry, spectrophotometry, flame photometry, atomic absorption spectroscopy.

Atomic spectroscopy: (1) AAS – Principle- typical instrumentation (2) AES: Excitation techniques- arc, spark and ICP

Principles of ion-exchange, solvent extraction and chromatographic techniques.

Thermal method of analysis-principles and applications of thermogravimetry (TG), differential thermal analysis (DTA), differential scanning calorimetry (DSC) and dynamic mechanical analysis (DMA).

Applications of X-ray diffraction, small angle X-ray scattering (SAXS), scanning electron microscopy (SEM), transmission electron Microscopy (TEM) and scanning probe microscopy (SPM).

References

1. Vogel's Texbook of Quantitative Inorganic Analysis, 6th Edn.,Prentice Hall, 2000.
2. D.A. Skoog, D.M. West, F.J. Holler, Fundamentals of Analytical Chemistry, 7th Edn., Sauders College, 1996.
3. W.W. Wendlandt, Thermal Analysis, 3rd Edn., Wiley, 1986.
4. G. Cao, Y.Wang, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, World Scientific, 2010.
5. D.Patranabis, Principles of Industrial Instrumentation, 2nd Edition , Tata McGraw-Hill Company Delhi.

PG Elective-3 Supramolecular Chemistry

Credits: 4 (4-0-0)

Supramolecular Chemistry and X-ray Crystallography Definition and development of supramolecular chemistry, classifications of supramoleciular host-guest compounds, receptors, coordination and the lock and key analogy, the chelate and macrocyclic effects, preorganization and complementarity, thermodynamic and kinetic stability, nature of supramolecular interactions,

supramolecular host design. Methods for the understanding of supramolecular systems such as NMR and X-ray Crystallography, X-ray Crystallography, Single Crystal, Bragg condition, Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structure analysis of crystals, Index reflection, Identification of unit cells, Space Group, Structure of simple lattices and X-ray intensities, Structure factor and its relation to intensity and electron density.

Supramolecular Chemistry to understand Non-covalent interaction

Supramoleculer assembly by Noncovalent interactions, Definition and examples of supramolecular system to understand noncovalent interaction such as weaker noncovalent interactions, hydrogen bonding, metal coordination, hydrophobic interactions, hydrophilic interaction, electrostatic interactions, van der Waals interactions, arene interactions, π… π interactions, C-H... π interaction, halogen interactions, cation… π interaction, and charge transfer interactions.

Supramolecular Chemistry in Crystal engineering

Concept of the crystal packing, Building block of supramolecular chemistry, Self assembly of organic and inorganic system, Molecular network, Construction of the crystalline materials or new solids, Molecular folding, Interlocked molecular-architecture, Host-guest chemistry, Cavitands, Calixarenes, Cylcodextrin complex with fullerene, Metal-organic materials (benzo-15-crown-5 complex with calcuium picrate and water), Gelators fibres and adhesives, Dendrimers, Catenanes, Rotaxanes, Nanomaterials, Novel liquid crystals.

Supramolecular Chemistry in Drug Design

Molecular Recognition, Lock and key theory, Drug Receptor Interaction, Receptor ligand co-crystal study, Nanoparticles in the Drug Delivery System.

Books Required:

1. J. -M. Lehn, Supramolecular Chemistry: Concepts and Perspectives, VCH, Weinheim, 1995.
2. *The Weak Hydrogen Bond in Structural Chemistry and Biology* by G. R. Desiraju and T. Steiner, Oxford UniversityPress, Oxford, 1999: 528 pages.
3. *Crystal Design. Structure and Function* edited by G. R. Desiraju, Perspectives in Supramolecular Chemistry, 7, Wiley, Chichester, 2003: multi-author work with 9 chapters, 408 pages.
4. J. W. Steed and J. L. Atwood, Supramolecular Chemistry, John Wiley and Sons, New York, 2000
5. H. Dodziuk, Introduction to Supramolecular Chemistry, Springer, 2001.
6. P.D. Beer, P.A. Gale, D.K. Smith, Supramolecular Chemistry, Oxford University Press, 1999.

PG Elective-4 Heterocyclic Chemistry

Credits: 4 (4-0-0)

Heterocyclic Chemistry

Heterocycles-aromatic and non aromatic, synthesis of pyridines, quinolines, isoquinolines, pyrroles, furans, thiophenes, indoles, pyrimidines, imidazoles, pyrazoles, aziridines, fused heterocycles, basicity of heterocycles. Principles of heterocyclic synthesis involving cyclization reactions and cycloaddition reactions. Saturated heterocycles, synthesis of 3-, 4-, 5- and 6 membered rings, aromatic heterocycles in organic synthesis. Benzo-Fused Five - Membered Heterocycles: Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes. Six Membered Heterocycles: Synthesis and reactions of pyrylium salts, pyrones, quinolizium and benzopyrylium salts, coumarins and chromones, diazines, triazines, tetrazenes and thiazines.

Different approaches towards the synthesis of three, four, five and six-membered rings. Photochemical approaches for the synthesis of four membered ringsoxetanes and cyclobutanes, ketene cycloaddition (inter and intra molecular), Pauson-Khand reaction, Volhardt reaction, Bergman cyclization, Nazarov cyclization, Mitsunobu reaction, cation-olefin cyclization and radical-olefin cyclization

Inter-conversion of ring systems (contraction and expansion)-Demjenov reaction, Reformatsky reaction. Construction of macrocyclic rings-ring closing metathesis.

Name reactions in heterocyclic chemistry: Bartoli reaction, Corey Chykovsky reaction, Darzen condensation, Jacobsen Katzuki reaction, Paterno Buchi reaction, Paal Knorr pyrrole synthesis, Paal Knorr furan synthesis, Fischer indole synthesis, Bischler Napieralski reaction, Pictet Spengler Synthesis.

References

1. T.L. Gilchrist, Heterocyclic Chemistry, 3rd Edn., Longman, 2007
2. T. Laue, A. Plagens, Named Organic Reactions, 2nd Edn., John Wiley and Sons, 2005
3. M.B. Smith, Organic Synthesis, 3rd Edn., Wavefunction Inc., 2010.
4. F.A. Carey, R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 5th Edn., Springer, 2007.
5. S. Warren, P. Wyatt, Organic Synthesis: The Disconnection Approach, 2nd Edn.,Wiley, 2008.
6. . W. Carruthers, I. Coldham, Modern Methods of Organic Synthesis, 4th Edn., Cambridge University Press, 2004.
7. J. Clayden, N. Greeves, S. Warren,P. Wothers, Organic Chemistry, Oxford University Press, 2001.

SEMESTER I
COMMUNICATIVE ENGLISH PAPER I
2 hrs/week Total Contents 36 hrs Credits 2

Module I

Speech Sounds (18 hrs)

Phonemic symbols –Vowels – Consonants – Syllables-Word stress- Stress in polysyllabic words- Stress in words used as different parts of speech - Sentence stress - Weak forms and strong forms – Intonation - Awareness of different accents: American, British and Indian – Influence of the mother tongue.

Module II

Listening (18 hrs)

Active listening – Barriers to listening – Listening and note taking – Listening to announcements – Listening to news on the radio and television.

References

1. V.Sasikumar, P Kiranmai and GeethaRajeevan, *Communication Skills in English*, Cambridge University Press and Mahatma Gandhi University.
2. Sasikumar.V, KiranmaiDutt and GeethaRajeevan, *A Course in Listening and Speaking I & II,* New Delhi: CUP, 2007.
3. Tony Lynch, Study Listening: *A course in Listening to Lectures and Note- taking, New Delhi*: CUP, 2008.
4. Sky Massan, *Communication studies*,Palgrave Macmillan.

SEMESTER II
COMMUNICATIVE ENGLISH PAPER II

2 hrs/week Total Contents 36 hrs Credits 2

Module I

Accuracy in Academic Writing (18 hrs)

Articles – Nouns and prepositions – Subject-verb agreement – Phrasal verbs – Modals – Tenses – Conditionals – Prefixes and suffixes – Prepositions – Adverbs – Relative pronouns – Passives – Conjunctions – Embedded questions – Punctuation – Abbreviations.

Module II

Writing Models (18 hrs)

Letters – Letters to the editor – Resume and covering letters – e-mail - Seminar papers – Project reports – Notices – Filling application forms – Minutes, agenda – Essays.

References

1. Marilyn Anderson, Pramod K Nayar and MadhuchandraSen, *Critical Thinking, Academic Writing and Presentation Skills*, Pearson Education and Mahatma Gandhi University.
2. Michal Swan, *Oxford Practical English Usage*, *Third edition*, Oxford University Press.

3. Martin Hewings, *Advanced English Grammar*, Cambridge University Press.
4. Gupta S, *Communication Skills and Functional Grammar*, Laxmi Publications.

5. Five Year Integrated Interdisciplinary Master of Science Programme (IIRBS)

6.

7. Scheme & Syllabus-2016

8.

9. **MATHEMATICS**

	Semester I-IV (Undergraduate level courses)						**Total credits**
	Course	***Paper***	**L**	**T**	**P**	**C**	
Semester I	Maths 1	Abstract Algebra	3	0	0	3	5
	Maths lab 1	Mathematics Lab -1	0	0	4	2	
Semester II	Maths 2	Single variable Calculus	3	0	0	3	5
	Maths lab 2	Mathematics Lab -2	0	0	4	2	
Semester III	Maths 3	Multivariable Calculus	3	0	0	3	3
Semester IV	Maths 4	Probabilityand Statistics	3	0	0	3	3
	Total						**16**

10.**L=**Lecture**,** **T=** Tutorial, **P=**Practical**,** **C=**Credit

11.

12.

13.

14.

15.

SEMESTER I

MATHEMATICS PAPER – I
ABSTRACT ALGEBRA

3 hrs/week. Total Contents 54 hrs. Credits – 3

Module I Groups (15 hrs)

Binary operation, Groups, elementary properties, finite and abelian groups, subgroups, Cyclic groups, properties, Cosets, Lagrange's theorem. Isomorphism, properties.

Module II More on Groups (15 hrs)

Homomorphism, Normal subgroups, Quotient Groups, Isomorphism theorems, Permutation groups, cycles, Cayley's theorem, Conjugate classes, Cauchy's theorem.

Module III Rings (12 hrs)

Rings, definition, basic properties, examples, Fields, definition, Integral domain, Isomorphism, homomorphism, Ideals and Quotient rings.

Module IV Vector Spaces (12 hrs)

Vector Spaces, Subspaces, properties, Linear dependence and independence, Basis and dimension, Linear Transformations.

References

1. University Algebra : N.S. Gopalakrishnan, 2nd edition, New Age International Ltd 1986.
2. Topics in Algebra : I.N. Herstein, 2nd edition, Wiley 1975.
3. A First Course in Abstract Algebra, J.B. Fraleigh, 7th edition, Addison Wesley 2002.
4. Algebra, M. Artin, Phi Learning Pvt Ltd, New Delhi 2011.

SEMESTER II
MATHEMATICS PAPER – II
SINGLE VARIABLE CALCULUS

3 hrs/week. Total Contents 54 hrs. Credits – 3

Module I Limits and Continuity (12 hrs)

Functions, Limits, Continuity, basic properties of limits and continuous functions , Intermediate value theorem.

Module IIDifferentiation (15 hrs)

Derivative of a function, examples, differentiation rules, rate of change, chain rule, implicit differentiation and rational exponents,extreme values of functions,Rolle's theorem.

Module III Integration (15 hrs)

Indefinite Integrals, integration by substitution, integration by parts, integration of rational functions using partial fractions, definite integrals, properties, Mean value theorem, Fundamental theorem, area between curves, volumes of solid of revolution (disk only), lengths of plane curves.

Module IV Infinite series (12 hrs)

Series, Convergent and divergent series, Integral Test, Comparison test, Ratio and Root tests, Taylor series.

References

1. Calculus and Analytic Geometry: G.B.Thomas, R Finney, 1995, Addison Wesley.
2. Calculus, Vol.I : Tom M. Apostol, Wiley.
3. Calculus: J. Stewart, 2012, Cengage Learning.

SEMESTER III
MATHEMATICS PAPER – III
MULTIVARIABLE CALCULUS

3 hrs/week. Total Contents 54 hrs. Credits – 3

Module I Vectors andCurves (12 hrs)

Vectors in the plane, Cartesian coordinates and vectors in space, dot and cross products, lines and planes in space, curves, arc length and curvature.

Module II Partial derivatives (15 hrs)

Functions of several variables, limits and continuity, partial derivatives, chain rule, implicit differentiation, directional derivatives, gradient vectors and tangent planes, extreme valuesand Lagrange multipliers.

Module III Multiple Integrals (15hrs)

Double and Triple integrals, applications to area and volume, triple integral in spherical coordinates, substitutions in multiple integrals.

Module IV Vector Calculus (12hrs)

Vector fields, line integrals, fundamental theorem of line integrals, Divergence and Curl, Statements of Green's theorem, Stokes' theorem and Divergence theorem.

References

1. Calculus and Analytic Geometry: G.B.Thomas, R Finney, 1995, Addison Wesley.
2. Calculus, Vol.I : Tom M. Apostol, Wiley.
3. Calculus: J. Stewart, 2012, Cengage Learning.

SEMESTER IV
MATHEMATICS PAPER – 4
PROBABILITY AND STATISTICS

3 hrs/week. Total Contents 54 hrs. Credits – 3

Module I Probability, Random variables and Expectation (12 hrs)

Definition of probability, Theorems on probability, Conditional probability and independence, Baye's theorem (Statement only), Discrete and Continuous random variables, Mathematical expectation, Variance, Moments, Moment generating function.

Module II Distributions and Law of large numbers (12 hrs)

Binomial, Poisson and Normal distributions, Bernoulli's law and weak law of large numbers. Central limit theorem (Proof not required)

Module III Sampling distributions and theory of estimation (15 hrs)

Sampling distributions, standard error, Sampling distribution of mean and variance of a normal population. Chi-square, t and F distributions.

Estimation of parameters, methods of estimation, properties of best estimates.

Module IV Testing of Hypotheses (15 hrs)

Concept of statistical hypothesis, Null and alternate hypothesis, test criterion, critical region, Type I and Type II errors, Level of significance, Power of a test, Neyman – Pearson theorem (Statement only).

Large sample tests: Testing the AM, Testing the equality of AMs of two populations, Testing proportion, Testing equality of proportions, Chi-square test of goodness of fit.

Small sample tests: Testing mean and equality of means of a normal population, Testing whether there is correlation based on student's t distribution, Testing variance of a population based on Chi-square distribution, testing equality of variances based on F distribution.

References

1. A first course in Probability: Sheldon Ross, 6th edition, Prentice –Hall.
2. Introduction to Probability models: Sheldon Ross, 8th edition, Academic Press, Inc.
3. An Introduction to Probability and Statistics, Vijay K. Rohatgi, A.K.Md. E. Saleh, 2nd edition, Wiley-Interscience .
4. Probability and Statistics in Engineering: William W Hines, Douglas C Montegomery, David M .Goldman, Connie M.Borror, 4th edition Wiley.

SEMESTER I
MATHEMATICS LAB - I

4 hrs/week. **Total Contents 72 hrs.** **Credits – 2**

Matrices:
Revision of Matrices, Matrix operations, adjoint and inverse of a matrix; Hermitian, orthogonal and unitary matrices; Eigenvalue and eigenvector; Similarity transformation; diagonalisation of real symmetric matrices.
Matlab/Octave/Python Hands – ON Exercises:
Introduction to Matlab/Octave/Python. Data handling. Basic plotting 2D and 3D. 2D Matrix operations and manipulation; Addition, subtraction, inverse, transpose, multiplication, element by element operations. Check whether a given matrix is symmetric, hermitian, unitary, orthogonal, antisymmetric, singular. Diagonalisation and Eigenvalue problem. Regression analysis.
Ordinary Differential Equations:
First order differential equations: Basic concepts and ideas; separable differential equations, Integrating factors, linear differential equations; Second order linear differential equations, homogeneous equations with constant coefficients, Linear independence of solutions- Wronskian, Non-homogeneous equations, general solution. System of Linear ODEs.
Matlab/Octave/Python Hands – ON Exercises:
Numerical Differentiation. Euler's method to solve ODEs. First ODE examples: Free particle under gravity, Evolution of chemical concentrationin a reaction, Motion in viscous media/magnetic field. Second ODE examples: Harmonic oscillator with / without damping. First order coupledODE: Predictor-Prey problem. Solution of a system of linear ODEs.

References

1. E.Kreyszig, Advanced Engineering Mathematics, 8th edition, Wiley India, 2006
2. Richard Bronson, Gabriel Costa, Schaum's Outlines Differential Equations, 3rd edition Mc Graw Hill, 2009.
3. C. Edwards and D. Penny, Elementary Differential Equations with Boundary Value Problems, 5th edition, Prentice Hall, 2007.

SEMESTER II
MATHEMATICS LAB - II

4 hrs/week. **Total Contents 72 hrs.** **Credits – 2**

Preliminary Topics:

Functions of several variables-partial differentiation. Cartesian, Spherical and Cylindrical coordinate systems: introduction and equivalence. Parametric representation of an equation. Introduction to Taylor's series with practical examples.

Mathematica Exercises:

Introduction to MATHEMATICA. Importing/exporting formatted datasets. Plotting of functions and data in 2D, 3D; Plotting parametrically defined functions. Basic mathematical operations; symbolic differentiation of single and multi variable functions. Simple data fitting (e.g. polynomial, exponential function etc.), error estimation. Examples for Taylor series expansion, demonstration of convergence. Programming in MATHEMATICA, debugging and execution.

Vector Analysis:

Review of vector algebra: addition, subtraction and product of two vectors-polar and axial vectors with examples; triple and quadruple product. Concept of scalar and vector fields. Differentiation of a vector w.r.t. a scalar unit tangent vector and unit normal vector. Directional derivatives-gradient, divergence, curl and Laplacian operations and their meaning. Concept of line, surface and volume integrals. Statements of Gauss' and Stokes' theorems. Gradient, divergence and curl in spherical, polar and cylindrical coordinate systems.

Mathematica Exercises:

Plotting vectors in 3D; algebraic operations, span and linear independence. Visualizing the plane determined by two vectors; determining the unit normal from vector product. Obtaining equation of the plane and parametric representation of the same. Plotting a system of simple contours and surfaces as a visual representation of scalar fields. Determining the gradient of a scalar field and graphical representation of the gradient as vectors. Determination of divergence and curl of vector fields and their graphical representation. Real life scalar (temperature) and vector fields (static and rotating garden sprinkler, liquid vortex) and practical applications of gradient, divergence and curl.

Complex numbers and functions:

Arithmetic operation, conjugates, modulus, polar form, powers and roots; derivative.

Mathematica Exercises:

Algebraic manipulation of complex functions.

References

1. E.Kreyszig, Advanced Engineering Mathematics, 8th edition, Wiley India, 2006.
2. Murray R. Spiegel, Schaum's Outlines Vector Analysis, Tata Mc Graw Hill, 2009.
3. Murray R. Spiegel, Seymour Lipschutz, John Schiller, Dennis Spellman, Schaum Outlines Complex Variables.
4. Stephen Wolfram, The MATHEMATICA Book, 5th edition.

SEMESTER I

Physics Paper - 1

ELECTRICITY, ELECTRONICS, OPTOELECTRONICS& ELECTRODYNAMICS

(3 Hrs. / Week, Total content 54 Hrs.) Credits - 3

Module I. Alternating Current and Transient Current 12 Hrs.

EMF induced in a coil rotating in a magnetic field- Analysis of LCR series circuits- LCR parallel resonant circuit- comparison- Power in ac circuits- Wattless current- choke coil- transformer- skin effect.

Growth and decay of current in an LR circuit- Charging and discharging of a capacitor through a resistor- Measurement of high resistance by leakage- BG- Growth and decay of charge in an LCR circuit.

Text Book: *Electricity and Magnetism, R. Murugeshan*

Module II. Semiconducting diodes and Transistors 14 Hrs.

PN Junction, Depletion layer, Barrier potential, Biasing- forward and reverse, Reverse breakdown, PN Juction diode – V-I characteristics–Diode parameters, Diode current Equation. Rectification - Half wave, Full wave, Centre tapped, Bridge rectifier circuits - Nature of rectified output, Efficiency & Ripple factor.

Bipolar junction transistors, Transistor biasing, CB, CC, CE configurations and their characteristics-Active, saturation and cut-off regions. Current gain α, β, γ and theirrelationships. Need for biasing-Stabilization- Voltage divider bias. Basic principles of feedback, positive & negative feedback, Advantages of negative feedback.

Text Books: *1. Basic Electronics-B.L.Theraja.*

2. A Text Book of Applied Electronics-R.S.Sedha.

Module III. Laser, Optical Fibers & Light emitting diodes 12 Hrs.

Attenuation of light in an optical medium. Thermal equilibrium- Interaction of light with matter – Einstein relations – Light amplification- Population inversion- Active medium-Pumping – Metastable state- principal pumping schemes -Optical resonant cavity – He - Ne laser -Laser beam Characteristics.

Propagation of light in a fiber -acceptance angle numerical aperture –number of modes in a fiber -single step index fibre –graded index fiber.

Semiconductor energy bands - direct and indirect band gap semiconductors, Light emitting diodes – principles - LED characteristics. Principle of diode laser

Text Books: *1. A text book of Optics (25th edition) by N.Subramanayam, Brijlal, M.N Avadhanulu.*

2. Semiconductor physics and optoelectronics- V Rajendran, J Hemaletha and M S M Gibson, Vikas publications (2003).

3. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson, 2013

Module IV. Electrostatics, Magnetostatics & Maxwell's equations 16 Hrs.

Coulomb's law and electric field- Field due to continuous charge- electric flux density-Gauss Law - Electric potential- Relationship between E and V- Energy density in electrostatic field, Boundary conditions of E.

Biot-Savart's law- Ampere's circuital law - Magnetic flux density- Maxwells's equation for static fields- Magnetic scalar and vector potential. Boundary conditions of B.

Faraday's law- Transformer and motional emf, Displacement current- Maxwell's equations in final forms.

Text Books: *1. Principles of Electromagnetics, Mathew N.O Sadiku-4th Edition 2009, Oxford*

2. Introduction to Electrodynamics, David J Griffiths –3rd Edition 2007, Pearson.

REFERENCES

1. *Fundamentals of Magnetism and Electricity, D.N Vasudeva - S Chand*
2. *Electricity and Magnetism, KK Tewari- S Chand*
3. *Electricity and Electronics, Saxena, Arora and Prakash- Pragati Prakashan*
4. *Classical Electromagnetism, Jerrold Franklin- Pearson*
5. *Principles of electronics, VK Mehta, S Chand*
6. *Basic Electronics(7th Edition), Malvino and Bates, TMH*
7. *Electronics Fundamentals and Applications- D. Chattopadhyay and P.G.Rakshit, New Age International Publishers.*
8. *Semiconductor optoelectronic devices: Pallab Bhattacharya, PHI 2009.*

9. *Lasers and Non linear Optics, BB Laud, New Age Int Pub. 2013*
10. *Laser Fundamentals, William T Silfvast, Cambridge Univ Press. 2012.*
11. *Optoelectronics an Introduction, J Wilson & JFB Hawkes, PHI 1999.*
12. *Fiber Optics and Optoelectronics, R P Khare, Oxford 2012.*

SEMESTER II
Physics Paper - 2
OPTICS, THERMAL, NUCLEAR & ASTROPHYSICS
(3 Hrs. / Week, Total content 54 Hrs.) Credits – 3

Module I. Interference, Diffraction & Polarization 14 Hrs.

Theories about the nature of light- Corpuscular theory, Wave theory, Electromagnetic theory, Quantum theory.

Review of basic ideas of interference, Coherent waves-Optical path and phase change-superposition of waves-theory of interference-intensity distribution. Young's double slit experiment, Coherence-Conditions for interference.

Fresnel Diffraction – Huygens- Fresnel theory –zone plate. Comparison between interference and diffraction –diffraction pattern due to a single silt. Fraunhoffer diffraction at a single slit. Dispersive power and resolving power of grating.

Concept of polarization – plane of polarization- Types of polarized light-production of plane polarized light by reflection-refraction.

Text book: *Optics by N.Subramanayam, Brijlal, M.N Avadhanulu, S.Chand (25th edition)*

Module II. Thermodynamics, Heat engines & Entropy 14 Hrs.

Thermodynamic system, surroundings, variables, thermal equilibrium: zeroth law, thermodynamic equilibrium, thermodynamic processes, reversible and irreversible processes.

Internal energy, heat, work, cyclic processes, first law, work done in reversible isothermal expansion of ideal gas, work done in reversible adiabatic expansion of ideal gas.

Second law statements, heat engine, efficiency, Carnot's ideal heat engine, reversibility, Carnot refrigerator, Carnot theorem,

Definition of entropy, principle of increase of entropy, entropy and unavailable energy, change in entropy in heat conduction, change in entropy of a system in reversible process, increase in entropy in irreversible process,

Text Book: *Thermal and Statistical Physics, R.B. Singh, New Age Pub. (2010)*

Module III. Nucleus, Radioactivity , Fission & Fusion, Cosmic rays and Particle Physics 12 Hrs.

Classification of nuclei-General properties of nucleus-Binding Energy, Binding Energy curve.

Natural radioactivity–Alpha, Beta and Gamma Rays- properties- Law of radioactive disintegration- Mean life- measurement of decay constant- units of radioactivity- Geiger Nuttal law.

Basic idea of Nuclear fission and Nuclear fusion,Cosmic rays- primary and secondary cosmic rays.

Elementary particles –classifications- fundamental interactions.

Text Book: *Modern Physics , R Murugeshan,7th Edition(Revised)(2014), S.Chand*

Module IV. Astrophysics 14 Hrs.

Gravitational contraction - Virial theorem, Jeans mass. Energy production inside stars. Thermonuclear fusion. Hydrogen burning. p-p chain. CNO cycle. Evolution of stars – birth – protostar, hydrostatic equilibrium, red giant, late stages of evolution - white dwarfs & Chandrasekhar limit, Neutron stars & Tolman-Volkof limit, Supernovae, Pulsars, Black holes.

Text Book: Astrophysics: Stars and Galaxies- AD Abhyankar, University Press.

REFERENCES

1. *Optics, E Hecht and AR Ganesan, Pearson*
2. *Optics, 3rd edition, Ajoy Ghatak, TMH*
3. *Optical Electronics, Ajoy Ghatak and K Thyagarajan, Cambridge*
4. *An introduction to thermodynamics by Y.V.C. Rao (New Age Pub.)*
5. *An introduction to Thermal Physics by D.V. Schroeder (Pearson Pub.)*
6. *Heat and thermodynamics by Mark W Zemansky, Richard H Dittman & Amit K Chattopadhyay. MCH New Delhi.*
7. *Thermodynamics and Statistical physics Brij Lal, N.Subrahmanyam and P S Hemne (S. Chand &Co, Multi colour edition 2007).*
8. *Atomic and Nuclear Physics, S N Ghoshal, S.Chand.*
9. *Nuclear Physics, D C Tayal, Himalaya Publishing House*
10. *Nuclear and Particle Physics S L Kakani and Subhra Kakani -Viva Books 2008*
11. *Elements of Nuclear Physics, M L Pandya and R P S Yadav.*
12. *An Introduction to Astrophysics- Baidyanath Basu, PHI.*

SEMESTER III

Physics Paper - 3

MECHANICS and RELATIVITY, CLASSICAL, QUANTUM & STATISTICAL MECHANICS

(3 Hrs. / Week, Total content 54 Hrs.) Credits - 3

Module I. Mechanics and Relativity 16 Hrs.

Inertial and Non inertial frames of reference- Conservation laws, kinetic energy, work-energy theorem, conservative forces, potential energy, Non conservative forces-Conservation of linear momentum, centre of mass, motion of the centre of mass, angular momentum and torque, conservation of angular momentum with examples. Central force, inverse square law force, potential energy of a system of masses, gravitational field and potential.

Galilean transformation, Michelson Morley experiment, Ether hypothesis- Postulates of Special Theory of Relativity, Time dilation, Length contraction, Lorentz transformation equations, Introductory concepts of general theory of relativity.

Text Books:

1. *Mechanics by J.C. Upadhayaya, Ramprasad Pub.*
2. *Modern Physics, Kenneth S Krane (2nd Edition)- Wiley .*
3. *Concepts of modern Physics, Arthur Beiser(6th Edition)- SIE.*

Module II. Lagrangian formulations of Classical Mechanics 10 Hrs.

Constraints, generalized co-ordinates, principle of virtual work, D'Alembert's principle, Lagrange's equations, kinetic energy in generalized co-ordinates, generalized momentum, cyclic co-ordinates, Conservation laws and symmetry properties, Hamiltonian.

Text book: *Classical Mechanics by J.C. Upadhyaya, Himalaya Pub.*

Module III. Historical development & General Formalism of Quantum Mechanics 14 Hrs.

Failure of classical physics- Black Body radiation-Planck's radiation law. Wave particle Dualism-Dual nature of light-Compton effect, Dual nature of matter- De Broglie hypothesis, De Broglie waves-Group and phase velocities

Linear vector space- Hilbert space- Orthogonality- Linear operator-Eigen functions and eigen values- Hermitian operator- Postulates of Quantum Mechanics- wave function, Operators, Expectation value, Eigen value.

Text book: *A Textbook of Quantum Mechanics- G Aruldhas- (2nd Edition)- PHI*

Module IV. Statistical mechanics & distributions 14 Hrs.

Phase space, density of states in phase space, ensemble, density of distribution in phase space, principle of equal a priori probability, ergodic hypothesis, statistical equilibrium, ensemble formulation of statistical mechanics, microcanonical, canonical and grand canonical ensemble, partition function, average energy of particle, equipartition theorem.

Maxwell Boltzmann, Fermi-Dirac and Bose-Einstein statistics, microstate and macrostate, distribution laws, Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein distribution.

Text book: *Thermal and Statistical Physics, R.B. Singh, New Age Pub. (2010)*

REFERENCES

1. *Mechanics- Hans and Puri, TMH*
2. *Mechanics-D.S.Mathur, S.Chand.*
3. *Classical Mechanics-Takwale and Puranik, TMH.*
4. *Classical mechanics- K.SankaraRao, PHI.*
5. *Concepts of Modern Physics- Arthur Beiser, TMH*
6. *Introductory Quantum Mechanics- RI Liboff, Pearson*

7. *Quantum Physics- Gasiorowicz,John Wiely*
8. *Quantum Mechanics- Griffith, Pearson*
9. *Thermodynamics and Statistical physics Brij Lal, N.Subrahmanyam and P S Hemne (S. Chand &Co, Multi colour edition 2007).*
10. *Berkeley Physics Course Volume 5; Statistical Physics; Frederick Reif. McGraw Hill.*
11. *Statistical Mechanics, R.K. Pathria, Pergamon press, Oxford*

SEMESTER IV

Physics Paper - 4

SOLID STATE, SPECTROSCOPY, NANO & MATERIALS SCIENCE

(3 Hrs. / Week, Total content 54 Hrs.) Credits - 3

Module I. Crystal structure 14 Hrs.

Solid state, crystalline, polycrystalline and amorphous materials, crystal lattice, periodicity, translation vectors, unit cell, basis, symmetry operations, point groups and space groups, bravais lattice in two and three dimensions, miller indices, interplanar spacing, simple crystal structures-hcp,fcc,bcc and simple cubic, Structure of NaCl. X-ray diffraction from crystals-Bragg's law, powder method.

Text book : *Solid State Physics by Puri and Babbar (S.Chand)*

Module II. Spectroscopy 14 Hrs.

Early atomic spectra- Hydrogen spectrum- angular momentum – Larmor precession-energy of magnetic moment in a magnetic field- Vector atom model- spin orbit interaction- Normal Zeeman effect- anomalous Zeeman effect- Paschen Bach effect- Stark effect. Interaction of radiation with rotating molecules- Rotation al spectra of rigid diatomic molecule. vibrational energy of a diatomic molecules. Basic principles of Raman, NMR and ESR Spectroscopy

Text book : *Molecular structure and spectroscopy, Aruldas 2nd ed. EEE.*

Module III. Nano Science and Synthesis of Nanomaterials 12Hrs.

Materials at nanoscale- Quantum confinement - Size effect on shape- Magic numbers- Different types of nanostructures- Quantum dots- Fullerenes- Graphene- Carbon nanotubes- Structure, properties and applications

Text books:

1. *Nanotechnology-The science of small, MA Shah and KA Shah, Wiley.*
2. *Nanoscience and Nanotechnology- Fundamentals to frontiers- MS Ramachandra rao and Shubra Singh, Wiley.*

Module IV. Structure and Properties of Materials 14 Hrs.

Classification of engineering materials, Microstructure and Macrostructure, Structure-Property relationships, Physical properties of materials, Mechanical Properties-Stress strain relationship, creep, impact strength- Thermal properties, Thermal cracking- Electrical properties- Dielectric strength and dielectric constant- Chemical and Optical properties.

Text Book: *Material Science-GBS Narang, Khanna Publishers.*

REFERENCES

1. *Solid State Physics, M.A. Wahab, (2nd Edition), Narosa*
2. *Introduction to Solid State Physics, Charles Kittel, (7th Edition), Wiley*
3. *Crystallography applied to solid state Physics, AR Verma, ON Srivastava, New age*
4. *Solid State Physics, AJ Dekker- Macmillian.*
5. *Spectroscopy: Straughan and Walker –(Vol.1) John Wiley*
6. *Fundamentals of Molecular Spectroscopy: CN Banwell –(4th edition) TMH .*
7. *Introduction to Atomic Spectra, HE White, TMH*
8. *Elements of spectroscopy, Guptha, Kumar and Sharma (Pragathi Prakash)*
9. *TextBook of Nanroscience and Nanotechnology- BS Murthy, P Shankar, Baldev Raj, BB Rath and J Murday- University Press.*
10. *Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley,2003*
11. *Nano: the essentials, T. PRADEEP,TMH ,2007.*
12. *Nanotechnology, L.E Foster, Pearson.*
13. *Nanotechnology: Principles and Practices,2nd edition, Sulabha K Kulkarni, Springer.*
14. *Crystallography applied to solid state Physics, A.R Verma, O.N Srivastava, New age*

SEMESTER I

Physics Lab1

Electricity, Electronics and Opto-electronics – Practicals

(4 Hrs. / Week) Credits - 2

1. Forward characteristics of a pn junction diode
2. Zener characteristics - forward and reverse
3. Full wave rectifier- (center tap) Ripple factor and efficiency
4. Full wave rectifier- (bridge) Ripple factor and efficiency
5. Full wave rectifier with L &Π section filters Bridge/Center tap
6. Voltage regulator using zener diode
7. CE characteristics of a transistor
8. RC coupled common emitter amplifier- frequency response and bandwidth.
9. Potentiometer- Resistivity
10. Field along the axis of a coil- B_H
11. CF Bridge- resistivity

12. LCR series resonant circuit analysis
13. LCR parallel resonant circuit analysis
14. Characteristics of LED (Optical and electrical)
15. Laser- Grating- Determination of wavelength
16. Laser- Spot size and divergence
17. Numerical Aperture of an optical fiber.
18. Bending losses of an optical fiber.

SEMESTER II
Physics Lab2
Optics and Thermal – Practicals

(4 Hrs. / Week) **Credits - 2**

1. Characteristics of Thermistor
2. Newton's law of cooling- Specific heat
3. Newton's law of cooling- Emissive Power
4. Thermal conductivity of bad conductor- Lee's disc
5. CF Bridge- Temperature co-efficient of resistance.
6. CF bridge determination of unknown temperature.
7. Measurement of Stefan's constant.
8. To study the variation of thermo emf (Seebeck effect) across two junctions of a thermocouple with temperature.
9. To study the variation of junction temperature (Peltier effect) across two junctions of a thermocouple with current.
10. Specific heat capacity of a solid by method of mixtures
11. Diode as a temperature sensor.
12. Liquid lens- Optical Constants- Boy's method
13. Liquid Lens- Refractive index of a liquid- Boy's method
14. Newton's Rings- Wavelength
15. Spectrometer- Prism- Refractive index of glass
16. Spectrometer- Hollow Prism- Refractive index of liquid
17. Spectrometer- Small angled prism- refractive index- Normal incidence
18. Resolving power of a prism.

SEMESTER III
Physics Lab3
Mechanics and Properties of Matter– Practicals

(2 Hrs. / Week) **Credits - 2**

1. Asymmetric compound pendulum
2. Kater's pendulum
3. Torsion Pendulum- Rigidity modulus
4. Young's Modulus- non uniform bending- pin and microscope
5. Young's modulus- uniform bending- Pin and Microscope

6. Young's modulus- Cantilever- Scale and telescope
7. Static Torsion- Rigidity Modulus.
8. Flywheel – moment of inertia
9. Symmetric Compound pendulum
10. Torsion Pendulum- Rigidity modulus- Equal mass
11. Young's modulus- uniform bending-Optic lever- Scale and Telescope
12. Fly wheel- Moment of Inertia- oscillation method.
13. One dimensional elastic collision- law of conservation of energy and momentum-Hanging sphere method.
14. Viscosity of a liquid- Constant Pressure head
15. Young's Modulus- Koenig's Method- uniform bending
16. Surface Tension of a liquid- Capillary rise method
17. Viscosity- Stoke's method.
18. Viscosity of a liquid- variable Pressure head

SEMESTER IV

Physics Lab4

Solid state & Spectroscopy– Practicals

(2 Hrs. / Week) **Credits – 2**

1. Spectrometer- Stoke's formula
2. Spectrometer - wavelength of Sodium D1 and D2 lines
3. Spectrometer - wavelength of Mercury light using plane diffraction Grating.
4. Dispersive power - Grating-Spectrometer
5. Absorption Co-efficient of $KMnO_4$/ Iodine
6. Spectrometer- Cauchy's constants
7. Thickness of a thin film - air wedge
8. Diffraction patterns of single slit using laser source and measurement of its intensity variation using photodiode.
9. Photosensor and comparison with incoherent source – Sodium light.
10. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
11. Magneto optic modulation.
12. Electro optic modulation
13. Determination of Band gap of a semi conductor using four probe method
14. Determination of Band gap using thermistor.
15. Determination of Dielectric constant of a thin sheet
16. Resistivity of Semiconductor -Four probe
17. X-ray diffraction – lattice constant-Analysis of data.
18. Band gap determination –absorption spectrum analysis- direct band gap material.

References for Practicals Sem I to Sem IV:

1. *Advanced course in Practical Physics by D Chattopadhyay*
2. *Practical Physics - Joseph Ittiavirah, Premnath and Abraham(2005)*
3. *Practical Physics, CL Arora, S.Chand*
4. *Practical Physics Harnam Singh , S Chand*

5. *Electronics lab manual Vol 1 & 2, K A Navas.*
6. *A course of Experiments with He-Ne Laser- R.S Sirohi (2nd Edition) Wiley Eastern Ltd.*
7. *Electronics lab manual Vol 1 & 2, Kuryachan T D and Shyam Mohan S, Ayodhya pub.*

Mahatma Gandhi University
Priyadarshini Hills P. O.
Kottayam
Kerala-686560

Institute for Intensive Research in Basic Sciences (IIRBS)

Integrated Interdisciplinary Programme

(5 – years Integrated)

SYLLABUS
For
(M.Sc. - BOTANY Degree
Part of Integrated Interdisciplinary M.Sc. Programme)
(for Semesters VII, VIII, IX, X)

Abstract of the IIRBS - M.Sc. Degree (Zoology)
Part of Integrated Interdisciplinary M.Sc. ProgrammeProgramme

Semester	Course code	Course	Hours/ week	Credits	Total Credits
VII		Core Paper – 1: Microbiology and Phycology	4	4	24
		Core Paper – 2: Mycology and Crop Pathology	4	4	
		Core Paper – 3: Bryology and Pteridology	4	4	
		Core Paper – 4: Gymnosperms, Evolution and Developmental Biology	4	4	
		Core Paper – 5: Environmental Biology	4	4	
		Core Lab Course – 1	8	4	
VIII		Core Paper – 6: Plant Anatomy and Principles of Angiosperm Systematics	4	4	24
		Core Paper – 7: Taxonomy of Angiosperms	4	4	
		Core Paper – 8:Genetics and Biochemistry	4	4	
		Core Paper – 9: Research Methodology, Biophysical Instrumentation, Biostatistics and Microtechnique	4	4	
		Core Paper – 10:Plant Physiology and Plant Breeding	4	4	
		Core Lab Course – 2	8	4	
IX		Core Paper – 11: Cell and Molecular Biology	4	4	12
		Elective Paper - I	4	4	
		Elective Paper - II	4	4	
		Elective Papers offered			
		1.Tssue Culture and Genetic Engineering			
		2. Genomics, Proteomics and Bioinformatics			
		3. Natural Resources and their Management			
		4. Environmental Monitoring and Management			
		5. Food, Agricultural and Environmental Microbiology			
		6. Industrial Microbiology			
		Major Project - Starts			
X		Major Project & Viva Voce			20

		Grand Total			**80**

SEMESTER VII

CORE I: MICROBIOLOGY AND PHYCOLOGY
(Theory- 72 hrs; Credits: 4)

Microbiology (27 hrs)

Module 1: The Diversity of the Microbial World (4 hrs)

Microbial Evolution, Introduction to Microbial Classification and Taxonomy, Taxonomic Ranks, Techniques for Determining Microbial Taxonomy and Phylogeny, Assessing Microbial Phylogeny, The Major Divisions of Life, Bergey's Manual of Systematic Bacteriology, Survey of Procaryotic Phylogeny and Diversity.

Module 2: The Viruses (8)

(a)Virus- Introduction and General Characteristics: Early Development of Virology, General Properties of Viruses, The Structure of Viruses , Virus Reproduction , The Cultivation of Viruses , Virus Purification and Assays
Principles of Virus Taxonomy

(b) Viruses of Bacteria and Archaea: Classification of Bacterial and Archaeal Viruses, Virulent Double-Stranded DNA Phages, Single-Stranded DNA Phages RNA Phages, Temperate Bacteriophages and Lysogeny, Bacteriophage Genomes

(c) Eucaryotic Viruses and Other Acellular Infectious Agents: Taxonomy of Eucaryotic Viruses , Reproduction of Vertebrate Viruses, Cytocidal Infections and Cell Damage, Persistent, Latent, and Slow Virus Infections, Viruses and Cancer, Plant Viruses , Viruses of Fungi and Protists, Insect Viruses, Viroids and Virusoids, Prions

Module 3:Clinical Microbial (10hrs)

(a)Pathogenicity of Microorganisms: Host-Parasite Relationships, Pathogenesis of Viral Diseases, Overview of Bacterial Pathogenesis, Toxigenicity, Host Defense Against Microbial Invasion, Microbial Mechanisms for Escaping Host Defenses

(b)Antimicrobial Chemotherapy: The Development of Chemotherapy, General Characteristics of Antimicrobial Drugs, Determining the Level of Antimicrobial Activity, Antibacterial Drugs, Factors Influencing Antimicrobial Drug**,** Effectiveness, Drug Resistance, Antifungal Drugs, Antiviral Drugs, Antiprotozoan Drugs.

(c)Human Diseases Caused by Fungi, Protists, Bacteri, Viruses and Prions: Airborne Diseases, Arthropod-Borne Diseases, Direct Contact Diseases, Food-Borne and Waterborne Diseases, Zoonotic Diseases, Prion Diseases, Dental Infections.

Module 4: Microbial Bioechnology (5 hrs)

(a) Screening of microbes for metabolite production. Selection of media, sterilization of media.

(b) Bioreactors – airlift, stirred tank, bubble column, rotary drum. Fermentation process - batch, fed batch, continuous fermentation. Submerged and solid state fermentation Process control during fermentation- pH, aeration, agitation, temperature, foam control.

(c) Downstream processing.

(d) Large scale production of antibiotics - penicillin, streptomycin, industrial chemicals - ethanol, acetone, butanol, lysine. Microbial insecticides. Commercial production of enzymes and their uses - amylase, cellulase, polygalacturonase.

References

1. Bilgrami, Sinha. *Essentials of Microbiology*.
2. Carpenter P L (1967). *Microbiology*. W B Saunder & Co. Philadelphia.
3. Dube H C (2008). *Fungi, Bacteria and Viruses*. Agrobios.
4. Kanika Sharma (2005). *Manual of Microbiology: Tools and Techniques*. Ane Books.
5. Kumar H D (1990). *Modern concepts of Microbiology*. Vikas public. Delhi.
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8. Pelczar (1990). *Microbiology*. T M H.
9. Purohit S S (1997). *Microbiology: Fundamentals and application*. Agrobotanical.
10. Powar C B, Daginawala H F (1991). *General Microbiology* Vol II. Himalaya Publishing House.
11. Salle A J (1978). *Fundamentals of Bacteriology*. Asia TMH
12. Dubey R C, Maheswari D K (2004). *Microbiology*. S Chand.
13. Sharma P D (2003). *Microbiology*. Restogi pub.
14. F H Kayser, K A Bienz, J Eckert, R M Zinkernagel. *Medical Microbiology.*
15. L R Haahelm, J R Pattison, R J Whitley. *Clinical virology.*

Phycology (45 hrs)

Module 1: Introduction (3 hrs)

(a) History of algal classification. Detailed study of the classification by F. E. Fritsch and G. M. Smith.Modern trends and criteria for algal classification.
(b) Centers of algal research in India. Contributions of Indian phycologists – M O P Iyengar, V Krishnamurthy, T V Desikachary.

Module 2: General features of Algae (30 hrs)

(a) Details of habit, habitat and distribution of Algae.
(b) Algal components: Cell wall, flagella, eye-spot, pigments, pyrenoid, photosynthetic products.
(c) Range of thallus structure and their evolution.
(d) Reproduction in algae: Different methods of reproduction, evolution of sex organs.
(e) Major patterns of life cycle and post fertilization stages in Chlorophyta, Xanthophyta, Phaeophyta and Rhodophyta.
(f) Fossil algae.

Module 3: Algal ecology (3 hrs)

Ecological importance of Algae. Productivity of fresh water and marine environment. Algae in symbiotic association, Algae in polluted habitat, Algal indicators, Algal blooms.

Module 4: Economic importance of Algae (3 hrs)

(a) Algae as food, fodder, biofertilizer, medicine, industrial uses, and other useful products. Harmful effects of algae.
(b) Use of Algae in experimental studies.

Module 5: Algal biotechnology (6 hrs)

(a) Methods and techniques of collection, preservation and staining of Algae.
(b) Algal culture: Importance, methods; Algal culture media.

References

1. Chapman V J (1962). *The Algae*. Macmillan & Co. Ltd.
2. Gilbert M Smith (1971). *Cryptogamic Botany (Vol. 1): Algae and Fungi*. Tata McGraw Hill Edition.
3. F E Fritsch (Vol. I, II) (1977). *The structure and reproduction of Algae*. Cambridge University Press.
4. Gilbert M Smith (1951). *Manual of Phycology*.
5. Harnold C Bold, Michael J Wynne (1978). *Introduction to Algae: Structure and reproduction*. Prentice Hall.

CORE II: MYCOLOGY AND CROP PATHOLOGY
(Theory -72 hrs; Credits: 4)

Mycology (36 hrs)

Module 1: General introduction (3 hrs)

General characters of Fungi and their significance. Principles of classification of fungi, Classifications by G C Ainsworth (1973) and C. J. Alexopoulos.

Module 2: Thallus structure and reproduction in Fungi (24 hrs)

Mycelial structure and reproduction of;

(a) Myxomycota – Acrasiomycetes, Hydromyxomycetes, Myxomycetes, Plasmodiophoromycetes.

(b) Mastigomycotina - Chytridiomycetes, Hyphochytridiomycetes, Oomycetes.

(c) Zygomycotina - Zygomycetes, Trichomycetes.

(d) Ascomycotina - Hemiascomycetes, Pyrenomycetes, Plectomycetes, Discomycetes, Laboulbeniomycetes, Loculoascomycetes.

(e) Basidiomycotina - Teliomycetes, Hyphomycetes, Gastromycetes.

(f) Deuteromycotina - Blastomycetes, Hyphomycetes, Coelomycetes.

(g) Types of fruiting bodies in fungi.

Module 3: Fungal associations and their significance (9 hrs)

(a) Symbionts - Lichens, Mycorrhiza, Fungus-insect mutualism.

(b) Parasites - Common fungal parasites of plants, humans, insects and nematodes.

(c) Saprophytes - Fungal decomposition of organic matter, coprophilous fungi, cellulolytic fungi, lignolytic fungi.

(d) Agricultural significance of Fungi - Mycoparasite, mycoherbicide.

References

1. C J Alexopoulos, M Blackwell, C W Mims. *Introductory Mycology* (IV Edn).
2. Jim Deacon (2006). *Fungal Biology* (IV Edn). Blackwell Publishing.
3. L N Nair (2010). *Methods of microbial and plant biotechnology.* New Central Book agency (P) Ltd.
4. Kanika Sharma. *Manual of microbiology: Tools and techniques*.
5. G C Ainsworth, K F Sparrow, A S Sussman. *The fungi: An advanced treatise*.
6. H C Dube (1983). *An introduction to fungi.* Vikas Publ. New Delhi.
7. M E Hale. *The biology of lichens.*
8. A Misra, P R Agarwal. *Lichens.*
9. M C Nair, S Balakrishnan (1986). *Beneficial fungi and their utilization*. Sci. publ. Jodhpur.
10. V Ahamjian, M E Hale. *The Lichens*.
11. R Dayal. *Predaceous Fungi*. Commonwealth Publishers.

Crop Pathology (36 hrs)

Module 1: Introduction to crop pathology (2 hrs)

Classification of plant diseases based on; (a) Major causal agents - biotic and abiotic, (b) General symptoms.

Module 2: Process of infection and pathogenesis (4 hrs)

(a) Penetration and entry of pathogen into host tissue – mechanical, physiological and enzymatic.

(b) Host-parasite interaction, enzymes and toxins in pathogenesis.

Module 3: Defense mechanism in plants (4 hrs)

Pre-existing structural and biochemical defense mechanisms, lack of essential nutrients. Induced structural and biochemical defense mechanisms, inactivation of pathogen enzymes and toxins, altered biosynthetic pathways.

Module 4: Transmission of plant disease (3 hrs)

Spread and transmission of plant diseases by wind, water, seeds and vectors.

Module 5: Plant disease management (8 hrs)

Exclusion, eradication and protection. Chemical means of disease control – common fungicides, antibiotics and nematicides. Biological means of disease control. Biotechnological approaches to diseaseresistance: Fungi in agricultural biotechnology, control of fungal plant pathogens by mycofungicides.

Transgenic approaches to disease resistance.

Module 6: Major diseases in plants (15 hrs)

(a) Cereals: Rice - blast disease, bacterial blight; Wheat - black rust disease.
(b) Vegetables: Chilly - leaf spot; Ladies finger - vein clearing disease.
(c) Fruits: Banana - bacterial leaf blight, leaf spot; Mango - Anthracnose; Citrus - bacterial canker; Papaya – mosaic.
(d) Spices: Ginger - rhizome rot; Pepper - quick wilt; Cardamom - marble mosaic disease.
(e) Oil seeds: Coconut - grey leaf spot, bud rot disease.
(f) Rubber yielding: *Hevea braziliensis* - abnormal leaf fall, powdery mildew.
(g) Sugar yielding: Sugarcane - red rot; root knot nematode.
(h) Cash crops: Arecanut - nut fall disease.
(i) Beverages: Tea - blister blight; Coffee - rust.

References

1. K S Bilgrami, H C Dube. *A text book of modern plant pathology*.
2. Gareth Johnes. *Plant pathology: principles and practice.*
3. R S Mehrotra. *Plant Pathology*.
4. M N Kamat. *Practical plant pathology*.
5. V K Gupta, T S Paul. *Fungi and Plant disease.*
6. Malhotra, Aggarwal Ashok. *Plant Pathology*.
7. Rangaswamy, A Mahadevan. *Diseases of crop plants in India*.
8. B P Pandey. *Plant Pathology*.
9. George N Agrios (2006). *Plant pathology* (V Edn). Elsevier Academic Press.

CORE III: BRYOLOGY AND PTERIDOLOGY
(Theory -72 hrs; Credits: 4)

Bryology (36 hrs)

Module 1: General introduction (4 hrs)

Introduction to Bryophytes, their fossil history and evolution. Concept of algal and pteridophytic originof Bryophytes. General characters of Bryophytes. History of classification of Bryophytes.

Module 2: Ecology and Economic importance of bryophytes (6 hrs)

(a) Bryophyte habitats. Water relations - absorption and conduction, xerophytic adaptations, drought tolerance, dessication and rehydration, ectohydric, endohydric and myxohydric Bryophytes.
(b) Ecological significance of Bryophytes - role as pollution indicators.
(c) Economic importance of Bryophytes.

Module 3: Thallus structure (26 hrs)

Comparative structural organization of gametophytes and sporophytes in an evolutionary perspective. Asexual and sexual reproductive structures, spore dispersal mechanisms and germination of the following groups with reference to the types mentioned in the practical (development of sex organs notnecessary).
(a) Hepaticopsida (Sphaerocarpales, Marchantiales, Jungermanniales and Calobryales).
(b) Anthocerotopsida (Anthocerotales).
(c) Bryopsida (Sphagnales, Polytrichales and Bryales).

References

1. Kashyap S R (1932). *Liverworts of Western Himalayas and the Punjab plains* (Vol. I & II). ResearchCo. Publications.
2. Chopra R N, P K Kumar (1988). *Biology of Bryophytes.* Wiley Eastern Ltd.
3. Chopra R S, S S Kumar (1981). *Mosses of Western Himalayas and adjacent plains*. Chronica Botanica.
4. Kumar S S (1984). *An approach towards phylogenetic classification of Mosses*. Jour. Hattori Bot. Lab. Nichinan, Japan.
5. Rashid A (1981). *An Introduction to Bryophyta*. Vikas publishing house Pvt. Ltd.
6. Richardson D H S (1981). *Biology of Mosses*. Blackwell Scientific publications, Oxford.
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13. Bonver F O (1935). *Primitive land plants*. MacMillan & Co. Ltd.
14. Campbell, Ditt (1940). *The evolution of land plants*. Stanford University Press.
15. Srivastava S N (1992). *Bryophyta*. Pradeep Publications.

Pteridophytes (36 hrs)

Module 1: General introduction and classification (3 hrs)

Introduction, origin, general characteristics and an outline of the classification of Pteridophytes.

Module 2: Structure of the plant body (27 hrs)

Distribution, habitat, range, external and internal morphology of sporophytes, spores, mechanism of spore dispersal, gametophytic generation, sexuality, embryogeny of the following classes of Pteridophytes with reference to the genera mentioned (development of sex organs is not necessary):
(I) Psilopsida (a) Rhyniales; *Rhynia*
(II) Psilotopsida (a) Psilotales; *Psilotum*
(III) Lycopsida (a) Protolepidodendrales; *Protolepidodendron* (b) Lycopodiales; *Lycopodium*, (c) Isoetales; *Isoetes* (d) Selaginellales; *Selaginella*.
(IV) Sphenopsida (a) Hyeniales (b) Sphenophyllales; *Sphenophyllum* (c) Calamitales; *Calamites* (d) Equisetales; *Equisetum*.
(V) Pteropsida (i) Primofilices (a) Cladoxylales; *Cladoxylon* (b) Coenopteridales.

(ii) Eusporangiatae (a) Marattiales; *Angiopteris* (b) Ophioglossales; *Ophioglossum*.
(iii) Osmundales; *Osmunda*.
(iv) Leptosporangiatae (a) Marsileales; *Marsilea* (b) Salviniales; *Salvinia, Azolla* (c) Filicales; *Pteris*, *Lygodium, Acrostichum, Gleichenia, Adiantum*.

Module 3: Comparative study of Pteridophytes (4 hrs)

Stelar organization, soral and sporangial characters, gametophytes and sporophytes of Pteridophytes inan evolutionary perspective.

Module 4: Ecology and Economic importance (2 hrs)

Ecological and economic significance of Pteridophytes.

References

1. Agashe S N (1995). *Palaeobotany*. Oxford and IBH publishing House.
2. Arnold C R (1977*). Introduction to Palaeobotany*. McGraw Hill Book Com.
3. Chandra S, Srivastava M (Eds) (2003). *Pteridology in the New Millennium*. Khuwar Acad. Publishers.
4. Beddome C R H (1970). *Ferns of south India*. Today & Tommorrows Publ.
5. Dyer A F (1979). *The experimental biology of ferns*. Academic Press.
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9. Rashid A (1976). *An introduction to Pteridophytes*. Vikas Publishing House.
10. Sporne K R (1982). *Morphology of Pteridophytes*. Hutchinson university Press.
11. Surange K R (1964). *Indian Fossil Pteridophytes*. CSIR.
12. Louis J D (1977). *Evolutionary patterns and processes in ferns: Advances in Botanical Research*.
13. Scott. *Studies in Fossil Botany*. Haffner publications.
14. Smith, Gilbert (1972). *Cryptogamic Botany* (Vol. II). Tata McGraw Hill publications.
15. Nayar B K, S Kaur (1971). *Gametophytes of homosporous ferns*. Bot. Rev.

CORE IV: GYMNOSPERMS, EVOLUTION AND DEVELOPMENTAL BIOLOGY
(Theory -72 hrs; Credits 4)

Gymnosperms: (27 hrs)

Module 1: Introduction (3 hrs)

Origin, general characteristics, distribution and classification of Gymnosperms (K R Sporne andC J Chamberlain). Distribution of living gymnosperms in India.

Module 2: Vegetative and reproductive structures of Gymnosperms (22 hrs)

Detailed study of the vegetative morphology, internal structure, reproductive structures, and evolution ofthe orders and families (with reference to the genera mentioned).

(a) Class Progymnospermopsida: *Aneurophyton*

(b) Class Cycadopsida: *Heterangium, Lyginopteris, Lagenostoma, Glossopteris, Medullosa, Caytonia.Bennettites, Williamsoniella, Nilsonia, Cycas, Zamia, Pentoxylon*.

(c) Class Coniferopsida: General account of families under Coniferales, range of form and structure of stem, leaves; range of form, structure and evolution of female cones in coniferales such as *Pinus*, *Taxodium, Cupressus, Podocarpus, Agathis, Araucaria, Taxus and Ginkgo*.

(d) Class Gnetopsida: *Gnetum*.

Module 3: Gametophyte development and economic importance of Gymnosperms (2 hrs)

General account on the male and female gametophyte development in Gymnosperms (Cycas). Economicsignificance of Gymnosperms.

References

1. Andrews H N Jr (1961). *Studies in Palaeobotany*. John Wiley and sons.
2. Arnold C A (1947). *An introduction to Palaeobotany*. John Wiley and sons.
3. Beck C E (1995). *Gymnosperm Phylogeny*. Bot. Rev. 51-176.
4. Bhatnagar S P, Moitra A (2000). *Gymnosperms*. New Age International Ltd.
5. Chamberlain C J (1935). *Gymnosperms: Structure and Evolution*. University of Chicago Press.
6. Meyen S V (1984). *Basic features of Gymnosperms' Systematics and Phylogeny as evidenced by theFossil Record*. Bot. Rev.
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9. Biswas C. *The Gymnosperms*. Today and Tomorrows print.
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11. Dallimore W, A B Jackson (1964). *A Handbook of Coniferae and Ginkgoaceae* (IV Edn). Edward Arnold & Co.
12. Delevoryas T (1962). *Morphology and evolution of Fossil Plants*. Holt, Rinehart and Winston.

Evolution: (27 hrs)

Module 1: Introduction (4 hrs)

The Concept of evolution, preformation theory, Baer's law, biogenetic law, theory of catastrophism, natural selection, artificial selection, sexual selection, mutation theory, isolation theory.

Module 2: Origin of life (4 hrs)

Abiogenesis, Biogenesis experiment of Miller (1953). Theory of Organic evolution - Biochemical origin of life, place and time of origin and experimental evidences. Concept of Oparin and Haldane.

Module 3: Evidences for evolution (5 hrs)

Morphology and Comparative anatomy – Embryology, Physiology and Biochemistry, Palaentology, Biogeography. Evolutionary time scale: eras, periods and epochs. Stages in primate evolution including*Homo*.

Module 4: Theories of evolution (5 hrs)

Lamarckism and Neo-Lamarckism, Darwinism and Neo-Darwinism; Mutation theory of De-Vries and the modern mutation theory.

Module 5: Mutation as an evolutionary force (2 hrs)

Mutation and genetic divergence; Evolutionary significance of mutations, genetic assimilations (Baldwin effect), genetic homoeostasis.

Module 6: Speciation (4 hrs)
Genetic drift - Salient features; species concept; subspecies, sibling species, semi species, demes. Typesof speciation - Phyletic speciation and True speciation. Mechanism of speciation - Genetic divergencesand isolating mechanisms. Patterns of speciation - allopatric, sympatric, quantum and parapatricspeciation.
Module 7: Modern theories of evolution (3 hrs)
Modern synthetic theory of evolution, molecular evolution, concepts of natural evolution, molecular divergence and molecular clocks; molecular tools in phylogeny. Plant evolution.

References
1. Gurbachan S Miglani (2002). *Modern Synthetic theory of evolution*.
2. George Ledyard Stebbins (1971). *Process of Organic evolution*.
3. Roderic D M Page, Edward C Holmes (1998). *Molecular Evolution: A phylogenetic approach*. Blackwell Science Ltd.
4. Maxtoshi Nei, Sudhir Kumar (2000). *Molecular Evolution and phylogenetics*. Oxford University Press.
5. Katy Human (2006). *Biological evolution: An anthology of current thought.* The Rosen publishing group, Inc.
6. Monroe W Strickberger (1990). *Evolution*. Jones and Bartlett publishers.

Developmental Biology (18 hrs)
Module 1: Basic concepts of developmental Biology: (3 hrs)
An overview of plant and animal development, Potency, Commitment, Specification, Induction, Competence, Determination and Differentiation; Morphogenetic gradients, Cell-fate and Cell lineages,Stem cells, Genomic equivalence and the cytoplasmic determinants, Imprinting. Mutants andtransgenics in analysis of development.
Module 2: Development in flowering plants: (11 hrs)
(a) Angiosperm life cycle.
(b) Anther: Structure and development, microsporogenesis, male gametophyte development. Palynology: Pollen morphology, exine sculpturing, pollen kit, NPC formula. Applications of palynology- palynology in relation to taxonomy. Viability of pollen grains. Pollination, pollen germination,growth and nutrition of pollen tube.
(c) Ovule: Structure, ontogeny and types. Megasporogenesis. Embryosac – development, types, ultrastructure, and nutrition of embryosac. Female gametophyte development.
(d) Fertilization: Double fertilization; embryo development - different types. Endosperm development, types of endosperm, haustorial behavior of endosperm. Xenia and metaxenia. Polyembryony – types and causes.
(e) Seed formation, dormancy and germination. Apomixis, Parthenogenesis,
Module 3: Morphogenesis and organogenesis in plants: (4 hrs)
Shoot and root development. Leaf development and Phyllotaxy. Transition to flowering,floral meristems and floral development. Homeotic genes in plants. Senescence, programmedcell death and hypersensitive response in plants.

References
1. Scott F Gilbert (2000). *Developmental Bilogy* (IX Edn). Sinauer Associates. (available online).
2. R M Twyman (2001). *Instant notes in Developmental Biology*. Viva Books Private Limited.
3. Lincoln Taiz, Eduardo Zeiger (2002). *Plant physiology* (II Edn). Sinaeur Associates, Inc. Publishers.
4. Robert J Brooker (2009). *Genetics: analysis & principles* (III Edn.). McGraw Hill
5. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and Molecular biology ofPlants*. L K International Pvt. Ltd.
6. Scott F Gilbert (2000). *Developmental Bilogy* (VIII Edn). Sinauer Associates.
7. S S Bhojwani, S P Bhatnagar (1999). *The Embryology of Angiosperms* (IV Edn). Vikas Publishing House Pvt Ltd.
8. Maheswari P (1950). *An introduction to the embryology of Angiosperms*. McGraw Hill.

CORE V: ENVIRONMENTAL BIOLOGY
(Theory -72; Credits 4)

Module 1: Ecology and Environment (3 hrs)

Definition, history and scope of ecology, sub divisions of ecology, ecology vs environmental science. Interdisciplinary nature of environmental science.

Module 2: Autecological concepts - Population Ecology (8 hrs)

(a) Characteristics of populations - size and density, dispersion, age structure, natality and mortality.
(b) Population growth - factors affecting population growth, environmental resistance, biotic potential,carrying capacity, positive and negative interaction, migration, subsistence density, security and optionaldensity. Ecological consequence of overpopulations.
(c) Genecology - ecological amplitude, ecads, ecotypes, ecospecies, coenospecies, k-selection and rselectionpopulations.

Module 3: Synecological concepts - Community ecology (8 hrs)

(a) Ecological processes of community formation, ecotone, edge effect. Classification of communities -criteria of classification, dynamic system of classification by Clement.
(b) Special plant communities - quantitative, qualitative and synthetic characteristics of plant communities, Sorenson's Index of similarity, coefficient of communities.
(c) Dynamic community characteristics - cyclic replacement changes and cyclic no-replacement changes.

Module 4: Dynamic Ecology - Ecological succession (6 hrs)

(a) The concept, definition and reasons of succession. Classification of succession: Changes – autogenicand allogenic, primary and secondary, autotrophic and heterotrophic.
(b) Retrogressive changes or the concept of degradation, concept of climax or stable communities, resilience of communities, ecological balance and survival thresholds.

Module 5: Biosphere and Ecosystem (5 hrs)

(a) Significance of habitat, biodiversity, ecological niche, trophic level, primary and secondary productivity, food chains, food webs, ecological pyramids, energy flow and nutrient cycles.
(b) Comparative study of the major world ecosystems: Different aquatic and terrestrial ecosystems withregard to their productivity, biodiversity, energy flow, food chains and trophic levels.

Module 6: Phytogeography (6 hrs)

(a) Definition, principles governing plant distribution, factors affecting plant distribution, theories of distribution, different types of distribution of vegetations on the earth, continuous and discontinuous distribution.
(b) Climate, vegetation and botanical zones of India.
(c) Remote sensing: Definition and data acquisition techniques. Application of remote sensing in vegetation classification, understanding the key environmental issues and ecosystem management.

Module 7: Environmental pollution (16 hrs)

(a) Definition and classification.
(b) Water pollution: Water quality parameters and standards, different types of pollutants and their consequences. Types of water pollution, prevention and control - water shed management, waste watertreatment. Waste water treatment with aquatic macrophytes.
(c) Air pollution: Air quality standards and index, ambient air monitoring using high volume air sampler, types and sources of air pollutants, air pollution and human health hazards, control of air pollution.
(d) Noise pollution.
(e) Radioactive and thermal pollution: Causes and hazardous effects, effective management.

Module 8: Environmental biotechnology and solid waste management (4 hrs)

Concept of waste, types and sources of solid wastes including e-waste. Bioremediation, Phytoremediation, bioaugmentation, biofilms, biofilters, bioscrubbers and trickling filters. Use of bioreactors in waste management.

Module 9: Global environmental problems and climate change (6 hrs)

(a) Global warming, green house gases, acid rain, ozone depletion. Holistic relationship between air water and land pollution
(b) Factors responsible for climate change, *El-Nino* and *La Nina* phenomenon and its consequences.

(c) Effect of climate change on reproductive biology and biogeography.
(d) Environmental laws, environmental monitoring and bio indicators, environmental safety provisionsin Indian constitution, major environmental laws in free India, ISO-14000.

Module 10: Biodiversity and its conservation (10 hours)

(a) Basic principles of resource management, definition and classification of resources, problems of resource depletion, preservation, conservation and restoration, patterns of resource depletion, resource economics and resource overuse.
(b) Current biodiversity loss - concept of endemism, rare, endangered and threatened species (RET), keystone species, IUCN account of biodiversity, red data book and hot spots, reasons to stop extinction,methods to save species.
(c) Principles of conservation - *ex-situ* and *in-situ* conservation techniques. Biodiversity conservation: Species diversity, community diversity, ecosystem diversity and landscape preservation. Role of biotechnology in conservation of species.
(d) Ecotourism - positive and negative impacts.

References

1. Ahmedullah M, Nayar M P (1987). *Endemic plants of India*.
2. Apha, Awwa, Wep. *Standard methods for the examination of water and waste water*.
3. Barbour M D, et. al., (1980). *Terrestrial plant ecology*. The Benjamin-Cammings Pub. Com.
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17. Michael P (1984). *Ecological methods of field and laboratory investigations*. Tata McGraw Hill.
18. Misra K C. *Manual of plant ecology*. Oxford and IBH Pub. Com. P. Ltd.
19. Odum E P (III Edn) (1991). *Fundamentals of ecology*. Saunders and Com.

CORE LAB I - (8 hours, 4 credits)

Algae

1. Critical study of diagnostic features and identification of the following genera based onmorphological, anatomical and reproductive parts;
   Cyanophyceae - Gleocapsa, Gleotrichia, Spirulina, Microcystis, Oscillatoria, Lyngbya, Anabaena,Nostoc, Rivularia, Scytonema.(b) Chlorophyceae - Chlamydomonas, Gonium, Eudorina, Pandorina, Volvox, Ecballocystis,Tetraspora, Ulothrix, Microspora, Ulva, Shizomeris, Cladophora, Pithophora.Coleochaete, Chaetophora, Drapernaldia, Drapernaldiopsis, Trentepohlia, Fritschiella, Cephaleuros,Oedogonium, Bulbochaete, Zygnema, Mougeotia, Sirogonium.Desmedium, Bryopsis, Acetabularia, Codium, Caulerpa, Halimeda, Neomeris, Chara, Nitella.(c) Xanthophyceae – Vaucheria.(d) Bacillariophyceae - Biddulphia, Pinnularia.(e) Phaeophyceae - Ectocarpus, Colpomenia, Hydroclathrus, Dictyota, Padina, Sargassum, Turbinaria.(f) Rhodophyceac - Brtrachospermum, Gelidium, Amphiroa, Gracilaria, Polysiphonia.
2. Students are to collect and identify algae from different habitat or visit an Algal research station.
3. Prepare and submit a report of the field work/research station visit.

Microbiology

1. Double diffusion agar assay (Ouchterlony technique).
2. Staining of bacteria - Gram staining.
3. Spore staining of bacteria.
4. Staining of capsule in bacteria.
5. Staining of lipid granules in bacteria – Burdon's method.
6. Antibiotic sensitivity test for bacteria.
7. Screening and isolation of microbes for production of organic acids and enzymes.
8. Preparation and maintenance of stock cultures (Bacteria and Fungi).
9. Preparation of fungal spore inoculum and enumeration of spores by Haemocytometer.
10. Preparation of bacterial inoculum by measuring OD and enumeration of bacterial cells by serial dilution and pour plate (or spread plate) method.
11. Solid state and Submerged fermentation for amylase (or any other enzyme) production and quantification of product by suitable assay methods.
12. Optimization of process parameters for enzyme production in submerged fermentation.
13. Partial purification of amylase (or any other enzyme) produced by microbial fermentation using acetone precipitation.
14. Lab level production of metabolites (Wine, Vinegar).
15. Immobilization of yeast cells and sugar fermentation using immobilized cells.
16. Application of immobilized yeast cells for ethanol production.
17. Isolation of amylase producing bacteria from soil.
18. Isolation of microbial DNA and its quantification.
19. Isolation of plasmids and its purification, by minipreparation and midipreparation.
20. Separation of DNA by agarose gel electrophoresis.
21. Identification of bacteria based on 16S rRNA sequencing.
22. Molecular phylogenetic analysis - Phylip and MEGA.

Mycology

1. Critical study of the following types by preparing suitable micropreparations; Stemonitis, Physarum,Saprolegnia, Phytophthora, Albugo, Mucor, Aspergillus, Penicillium, Pilobolous, Saccharomyces,Xylaria, Peziza, Phyllochora, Puccinia, Termitomyces, Pleurotus, Auricularia, Polyporus, Lycoperdon,Dictyophora, Geastrum, Cyathus, Fusarium, Alternaria, Cladosporium, Pestalotia, Graphis, Parmelia,Cladonia, Usnea.
2. Isolation of fungi from soil and water by culture plate technique.
3. Estimation of mycorrhizal colonization in root.
4. Collection and identification of common field mushrooms (5 types).

Plant Pathology

1. Make suitable micropreparations and identify the diseases mentioned with due emphasis on symptoms and causative organisms.
2. Isolation of pathogens from diseased tissues (leaf, stem and fruit) by serial dilution method.
3. Collection and preservation of specimens from infected plants. Submit 5 herbarium sheets/live specimens along with a report.
4. Tests for seed pathology – seed purity test.
5. Calculation of Spore load on seeds using Haemocytometer.

Bryology

1. Detailed study of the structure of gametophytes and sporophytes of the following genera of bryophytes by suitable micropreparation: Riccia, Targionia, Cyathodium, Marchantia, Lunularia, Dumortiera, Reboulia, Pallavicinia, Aneura, Fossombronia, Porella, Anthoceros, Notothylas, Sphagnum, Pogonatum.
2. Students are expected to submit a report of field trip to bryophyte's natural habitats to familiarize with the diversity of Bryophytes.

Ptridophytes

1. Study of morphology and anatomy of vegetative and reproductive organs using clear whole mounts/sections of the following genera: Psilotum, Lycopodium, Isoetes, Selaginella, Equisetum, Angiopteris, Ophioglossum, Osmunda, Marsilea, Salvinia, Azolla, Lygodium, Acrostichum, Gleichenia, Pteris, Adiantum, Polypodium and Asplenium.
2. Study of fossil Pteridophytes with the help of specimens and permanent slides.
3. Field trips to familiarize with the diversity of Pteridophytes in natural habitats.

Environmental biology

1. Analysis of water quality for; (a) Dissolved CO2 (b) Dissolved oxygen (c) COD (d) Total dissolved minerals (e) Quantitative estimation of dissolved chloride ions and dissolved sulphate (f) Total alkalinity.
2. Quantitative estimation of dissolved chloride ions, dissolved sulphate, nitrate and total alkalinity.
3. Physico-chemical analysis of soil: (a) Total water soluble mineral ions (b) estimation of soil organic carbon (Walkey and Black method).
4. Quantitative and qualitative community analysis. Carry out a project on species structure and the frequency, abundance, density of different species and similarity index of different communities in a natural system. Students must be able to explain the structure of vegetation from the given data on the above mentioned characteristics.
5. Phytoplankton counting using Sedgwick Rafter counter.
6. Field visit to natural ecosystem and identification of trophic levels, food webs and food chains, plant diversity (species and community).
7. Students should be aware of the common environmental problems, their consequences and possible solutions.

Gymnosperms

1. Study of the morphology and anatomy of vegetative and reproductive parts of Cycas, Zamia, Pinus, Cupressus, Agathis, Araucaria and Gnetum.
2. Study of fossil gymnosperms through specimens and permanent slides.
3. Conduct field trips to familiarise various gymnosperms in nature and field identification of Indian gymnosperms and submit a report.

Developmental Biology

1. Study of pollen morphology.
2. Embryo excision from young seeds.
3. Pollen germination study.
4. Identification of different types of embryos, polyembryony, endosperm types, types of pollen grains, anther growth stages and types using permanent slides.

SEMESTER VIII

CORE VI: PLANT ANATOMY AND PRINCIPLES OF ANGIOSPERM SYSTEMATICS

(Theory -72 hrs; Credits 4)

Plant Anatomy (36 hrs)

Module 1: Introduction (1 hr)

Scope and significance of plant anatomy, interdisciplinary relations.

Module 2: Meristem (7 hrs)

(a) Apical organization: Stages of development of primary meristem and theories of apical organization,origin of branches and lateral roots. Primary thickening meristem (PTM) in monocots. Reproductiveapex in angiosperms.

(b) Secretory tissues in plants: Structure and distribution of secretory trichomes (*Drocera, Nepenthes*), salt glands, colleters, nectaries, resin ducts and laticifers. Structure of bark and distribution pattern of laticifers in *Hevea brasiliensis.*

Module 3: Secondary structure (10 hrs)

(a) Vascular cambium and cork cambium: Structure and function, factors affecting cambial activity.

(b) Secondary xylem and phloem: Ontogeny, structure and function. Lignification patterns of xylem.

(c) Reaction wood: Compression wood and tension wood. Factors affecting reaction wood formation.

(d) Anomalous secondary growth in dicots and monocots.

(e) Wood: Physical, chemical and mechanical properties.

(f) Plant fibers: Distribution, structure and commercial importance of coir, jute, and cotton.

Module 4: Leaf and node (6 hrs)

(a) Leaf: Initiation, plastochronic changes, ontogeny and structure of leaf. Structure, development and classification of stomata and trichomes. Krantz anatomy, anatomical peculiarities in CAM plants. Leafabscission.

(b) Nodal anatomy: Unilacunar, trilacunar and multilacunar nodes, nodal evolution.

(c) Root-stem transition in angiosperms.

Module 5: Reproductive anatomy (6 hrs)

(a) Floral Anatomy: Anatomy of floral parts - sepal, petal, stamen and carpel; Floral vasculature (*Aquilegia and Pyrola*). Vascular anatomy. Development of epigynous ovary - appendicular and receptacular theory.

(b) Fruit and seed anatomy: Anatomy of fleshy and dry fruits - follicle, legume, berry. Dehiscence of fruits. Structure of seeds. Anatomical factors responsible for seed dormancy and drought resistance.

Module 6: Ecological anatomy (4 hrs)

Morphological and structural adaptations in different ecological groups - hydrophytes, xerophytes, epiphytes and halophytes.

Module 7: Applied anatomy (2 hrs)

Applications of anatomy in systematics (histotaxonomy) and Pharmacognosy. Research prospects in anatomy.

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1. Eames A J, McDaniel (1976). *An introduction to plant Anatomy*.
2. Edred John Henry Corner (1976). *The seeds of dicotyledons* (vol. I, II). Cambridge University Press.
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10. Chowdhuri (Ed). *Indian woods* (6 volumes). Forest research institute, Dehradun
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some Asclepiadaceae with taxonomic significance. Geophytology.
14. Metcalf C R, Chalk L (1950). *Anatomy of Dicotyledons and Monocotyledons*.
15. Metcalf C R, Chalk L (1983). *Anatomy of the dicotyledons: Wood structure and conclusion of the general introduction*. Oxford University press.
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19. Sherwin John Carlquist (2001). *Comparative wood anatomy: Systematic, ecological, and evolutionary aspects of dicotyledon wood*.
20. Tharian George K, Reghu C P, Nehru CR (2000). *By-products and ancillary sources of income*. Natural Rubber: Agro management and Crop Processing, Rubber Research Institute of India, Kottayam.507-510
21. Vasishta P C (1994). *Plant anatomy*. Pradeep publications.
22. Wardrop A B (1961). *The structure and formation of reaction wood in Angiosperm: Problems of tree physiology*. Recent advances in Botany (Vol II). University of Toronto press.
23. Wardrop A B (1964). *Reaction wood Anatomy in Arborescent angiosperms*. Formation of wood in forest trees (Ed, Zimmerman). Academic press, New York.

Principles of Angiosperm Systematics (36 hrs)

Module 1: Scope and significance of Taxonomy (2 hrs)

Historical background of classification - Artificial, natural and phylogenetic systems. Importance of taxonomy.

Module 2: Concepts of Taxonomic hierarchy (2 hrs)

Species/Genus/Family and other categories; species concept and intraspecific categories - subspecies, varieties and forms.

Module 3: Phylogeny of Angiosperms (6 hrs)

Important phylogenetic terms and concepts: Plesiomorphic and Apomorphic characters; Homology andAnalogy; Parallelism and Convergence; Monophyly, Paraphyly and Polyphyly. Phylogenetic tree - Cladogram and Phenogram.

Module 4: Data sources of Taxonomy (4 hrs)

Concepts of character; Sources of taxonomic characters - Anatomy, Cytology, Phytochemistry and molecular taxonomy.

Module 5: Concept and principles of assessing relationships (4 hrs)

Phenetic - Numerical Taxonomy - principles and methods; Cladistic - Principles and methods.

Module 6: Botanical nomenclature (6 hrs)

History of ICBN, aims and principles, rules and recommendations: rule of priority, typification, authorcitation, retention, rejection and changing of names, effective and valid publication.

Module 7: Synthetic approaches to the systematics of angiosperms (4 hrs)

Chemotaxonomy, basic concepts of genome analysis – bar coding.

Module 8: Morphology of Angiosperms (8 hrs)

Habitat and habit; Morphology of root, stem, leaf, bract and bracteoles, inflorescence, flowers, fruits andseeds.

References

1. Lawrence George H M (1951). *Taxonomy of vascular plants*. Oxford and IBH Publ. Co. Pvt. Ltd.
2. Jeffrey C (1968). *An Introduction to principles of Plant Taxonomy*.
3. Cole A J (1969). *Numerical Taxonomy*. Academic Press.
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15 Taylor D V, L J Hickey (1997). *Flowering plants: Origin, evolution and phylogeny*. CBS Publishers& Distributors.
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19. *International Code of Botanical Nomenclature* (latest)
20. Henry A N, Chandrabose M (1980). *An aid to the International Code of Botanical Nomenclature*.

CORE VII: TAXONOMY OF ANGIOSPERMS
(Theory -72 hrs; Credits 4)

Module 1: Classification (5 hrs)

Major systems of angiosperm classification with special emphasis on the conceptual basis of the classifications of; (i) Linnaeus (ii) Bentham & Hooker (iii) Engler & Prantl (iv) Bessey (v) Takhtajan (vi) APG.

Module 2: Tools of Taxonomy (4 hrs)

Functions of field study, herbarium, botanical gardens, BSI, Floras/Taxonomic literature and GIS (Geographic Information System). Construction of taxonomic keys – indented and bracketed - their utilization.

Module 3:Angiosperm Diversity with Special Reference to Tropical Flora (57 hrs)

Study of the following families (Bentham and Hooker) in detail with special reference to their salient features, interrelationships and evolutionary trends

Polypetalae: 1. Rununculaceae 2. Magnoliaceae 3. Annonaceae 4. Cruciferae 5. Capparidaceae 6. Polygalaceae 7. Caryophyllaceae 8. Guttiferae 9. Malvaceae 10. Sterculiaceae 11. Teliaceae 12. Rutaceae 13. Rhamnaceae, 14. Vitaceae, 15. Sapindaceae, 16. Anacardiaceae 17. Leguminasae 18. Rosaceae, 19. Combretaceae 20. Myrtaceae, 21. Melastomaceae 22. Lythraceae 23. Cucurbitaceae 24. Aizoaceae 25. Apiaceae.

Gamopetalae: 26. Rubiaceae 27. Asteraceae 28. Campanulaceae 29. Myrsinaceae 30. Sapotaceae 31. Oleaceae 32. Apocynaceae, 33. Asclepiadaceae 34. Loganiaceae 35. Boraginaceae 36. Convolvulaceae, 37. Solanaceae 38. Scrophulariaceae 39.Bignoniaceae 40.Pedaliaceae 41. Acanthaceae 42. Verbenaceae 43. Lamiaceae.

Monochlamydae: 44. Nyctaginaceae 45. Polygonaceae, 46. Aristolochaceae 47.Lauraceae 48. Loranthaceae 49.Euphorbaceae 50.Moraceae 51.Urticaceae.

Monocots: 52. Orchidaceae, 53. Zingiberaceae, 54. Marantaceae 55. Musaeceae 56.Liliaceae 57. Arecaceae 58.Araceae 59. Cyperaceae, 60. Poaceae

Module 4: Economic Botany (6 Hours)

Importance of plants as food – cereals, pulses, spices, condiments, beverages, fibers, latex, oil yielding and medicinal plants of the families mentioned for detailed studies above.

Ethnobotany: Scope and importance of Ethno-botany, sources and methods of ethnobotanical studies. Tribal communities of Kerala. Tribal plant medicines. Role of tribals in the conservation of biodiversity

References

1. Jain S K (1991). *Dictionary of Indian Folkmedicine and Ethnobotany*.
2. Paye G D (2000). *Cultural Uses of Plants: A Guide to Learning about Ethnobotany*. The New York Botanical Garden Press.
3. Hooker J D. *The flora of British India* (Vol. I – VII).
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5. Cronquist A (1960). *Evolution and classification of flowering plants*. Thomas & Nelson Co.
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8. Radiford A E (1986). *Fundamentals of plant systematics*. Harper & Row.
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13. Takhtajan A L (1997). *Diversity and Classification of Flowering Plants*. Columbia Univ. Press.

CORE VIII: GENETICS AND BIOCHEMISTRY
(Theory -72hrs; Credits 3)

Genetics (36hrs)

Module 1: History of Genetics (4 hrs)

Transmission genetics, Molecular genetics and Population genetics (brief introduction). Mendelism – basic principles (brief study). Extensions of Mendelism, penetrance and expressivity of genes. Nonmendelian inheritance – cytoplasmic inheritance. Sex determination in animals and plants.

Module 2: Linkage and genetic mapping (12 hrs)

Linkage and Crossing over - Stern's hypothesis, Creighton and McClintock's experiments, single crossover, multiple cross over, two-point cross, three-point cross, map distances, gene order, interference andco-efficient of coincidence. Haploid mapping (*Neurospora*), Mapping in bacteria and bacteriophages.Inheritance of traits in humans; pedigree analysis, determination of human genetic diseases by pedigreeanalysis, genetic mapping in human pedigrees.

Module 3: Quantitative genetics (4 hrs)

Polygenic inheritance, QTL, effect of environmental factors and artificial selection on polygenic inheritance.

Module 4: Genetics of Cancer (6 hrs)

Genetic basis of cancer. Proto-oncogenes, oncogenes, conversion of proto-oncogenes to oncogenes. Tumor suppressor genes – functions, role of p53. Viral oncogenes.

Module 5: Population genetics (10 hrs)

(a) Gene pool, allele and genotype frequency. Hardy-Weinberg law and its applications, estimation of allele and genotype frequency of dominant genes, codominant genes, sex-linked genes and multiple alleles. Genetic equilibrium, genetic polymorphism.

(b) Factors that alter allelic frequencies; (i) mutation (ii) genetic drift - bottle neck effect and founder effect (iii) migration (iv) selection (v) nonrandom mating, inbreeding coefficient.

References

1. Benjamin Lewin (2000). *Genes VII*. Oxford university press.
2. Gardner E J, Simmons M J, Snustad D P (1991). *Principles of Genetics* (III Edn). John Wiley and Sons Inc.
3. Snustad D P, Simmons M J (2000). *Principles of Genetics* (III Edn). John Wiley and Sons.
4. Strickberger (2005). *Genetics* (III Edn). Prentice Hall of India Pvt. Ltd.
5. William S Klug, Michael R Cummings (1994). *Concepts of Genetics*. Prentice Hall.
6. Robert J Brooker (2009). *Genetics: Analysis and principles* (III Edn). McGraw Hill.
7. Daniel L Hartl, Elizabeth W Jones (2009). *Genetics: Analysis of genes and genomes* (VII Edn). Jonesand Bartlett publishers.
8. D Peter Snustad, Michael J Simmons (2010). *Principles of genetics* (V Edn). John Wiley and Sons.

Biochemistry (36 hrs)

Module 1: pH and Buffers (4 hrs)

Acids and bases, strength of acids – strong acids, weak acids. Ionization of water – Kw, pH. Dissociation of acids – pKa, Henderson-Hasselbalch equation. Buffers – definition,chemical composition, requirements for a good buffer, buffer action, buffer capacity. Measurement ofpH – colorimetric methods and electrometric methods.

Module 2: Carbohydrates (5 hrs)

Structure and Biological Functions. Monosaccharides: Classification, structure.Oligosaccharides: Structure, formation; common examples – sucrose, lactose. Polysaccharides:Classification, functions – structure of cellulose, starch and glycogen. Sugar derivatives:Glycoproteins, proteoglycans, mucoproteins. Lectins.

Module 3: Lipids (4 hrs)

Classification, properties, functions. Structure of fatty acids, essential fatty acids. Storagelipids – triglycerols. Structural lipids – membrane lipids. Lipid biosynthesis, fat breakdown – βoxidation.

Module 4: Amino acids (2 hrs)

Structure and classification of amino acids. Biosynthesis of amino acids.

Module 5: Proteins (5 hrs)

Classification of proteins based on structure and function. Oligo- and polypeptides. Primarystructure – peptide bond. Secondary structure – Ramachandran plots, α-helix, β sheet.Tertiary structure – forces that stabilize tertiary structure. Quaternary structure, domains, motifand folds. Protein sequencing – Edman method. Functions of proteins.

Module 6: Enzymes (10 hrs)

(a) Principles of catalysis: Activation energy of a reaction. General characters of enzymes - specificity, catalytic power, regulation. IUB system of enzyme classification and naming.

(b) Mechanism of enzyme activity: Formation of ES complex, acid-base catalysis, covalent catalysis, metal ion catalysis, proximity and orientation effect, strain and distortion theory. Factors affectingenzyme activity.

(c) Enzyme Kinetics: Michaelis-Menton kinetics, Lineweaver-Burk plot. Mechanism of multisubstrate reaction – Ping Pong, Bi-Bi mechanism.

(d) Regulation of enzyme activity: Allosteric effect, control proteins, reversible covalent modification, proteolytic activation. Enzyme inhibition – reversible and irreversible inhibition, competitive,non-competitive, uncompetitive inhibition, dixon plo.

(e) Cofactors and coenzymes: Essential ions, Coenzymes; structure and role of metabolite coenzymes – ATP; structure and role of vitamin derived coenzymes – NAD+, NADP+, FAD, FMN, TPP, PLP,Biotin. Isozymes.

Module 7: Nucleotide metabolism (2 hrs)

Functions of nucleotides, nucleotide biosynthesis by *de novo* pathways and salvage pathways.

Module 8: Secondary metabolites (4 hrs)

Classification, biosynthesis, and functions of terpenoids, alkaloids, phenolics, flavonoids, coumarins.

References

1. David T Plummer (1998). *An introduction to practical biochemistry*. Tata Mc Graw Hill.
2. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman and company.
3. Michael M Cox, David L Nelson (2008). *Lehninger Principles of biochemistry* (V Edn). W H Freeman and company.
4. Donald Voet, Judith G Voet (2011). *Biochemistry* (IV Edn). John Wiley & Sons Inc.
5. Carl Branden, John Tooze (1999). *Introduction to protein structure* (II Edn). Garland Publishing.
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9. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and molecular biology ofplants*. L K International Pvt. Ltd.
10. S Sadasivam, A Manickam (1996). *Biochemical methods* (II Edn). New age international Publishers.

CORE IX: RESEARCH METHODOLOGY, BIOPHYSICAL INSTRUMENTATION, BIOSTATISTICS AND MICROTECHNIQUE
(Theory -72 hrs; Credits: 4)

Research methodology (18 hrs)

Module 1: Introduction (2 hrs)

Need for research, stages of research; Generation of a research problem, execution of work, interpretation of results.

Module 2: Review of literature (6 hrs)

(a) Library: (i) Structure of a scientific library, journals (current and back volumes), books.
(ii) Catalogue: Types of catalogues - Card catalogue, computerized catalogue (iii) Classification of books (Universal Decimal System).
(b) Journals: Indexing journals, abstracting journals, research journals, review journals, e-journals. Impact factor of journals, NCBI-Pub Med.
(c) Other sources of references: (i) Reprints - acquisition and filing (ii) Secondary storage devices – pendrive, external hard drive, DVD and CD ROM (iii) Internet, open access initiative, INFLIBNET, INSDOC.
(d) Preparation of index cards: Author index and subject index; Open source bibliography managementsystem.

Module 3: Preparation of project proposals (2 hrs)

(a) Title, Introduction, literature review and abstract (b) Aim and scope (c) Present status (d) Location ofexperiments (e) Materials and methods (f) Justification (g) Expected outcome (h) Date of commencement (g) Estimated date of completion (h) Estimated cost (i) References (j) Funding agencies.

Module 4: Presentation and publication of research outcomes (8 hrs)

(a) Preparation of a dissertation: (i) Consolidation and analysis of data, photographs, illustration, tablesand graphs (ii) Preparation of the outline (iii) Preparation of manuscript - introduction, review ofliterature, materials and methods, results, discussion, bibliography (methods of citing references,arrangement of references), summary (iv) Preliminary pages - title page, certificates,acknowledgements, and contents page.
(b) Preparation of research paper and short communications.
(c) Preparation of review articles.
(d) Proof reading - standard abbreviations for proof correction.
(e) Presentation of research findings in seminars and workshops.

References

1. Anderson J, Durston B H, Poole (1970). *Thesis and assignment writing*. Wiley eastern.
2. Bedekar V H (1982). *How to write assignment and research papers, dissertations and thesis*. Kanak publications.
3. Bercy R (1994). *The research project, how to write it*. Rutledge, London.
4. Clifford Hawkins, Marco Sorghi. *Research: How to plan and speak about it and write about it*. Narosa Publishing Company.
5. Day R.A (1979). *How to write and publish a scientific paper*. Cambridge University press.
6. Joseph Gibaldi (2000). *MLA Handbook for writers of research papers*. Affiliated East West Press Pvt. Ltd.
7. Kothari. *Research Methodology*.
8. Krishnakumar K (1981). *An introduction to cataloguing practice*. Vikas Publishing house.
9. Judith Bell. *How to complete your research project successfully*. UBS Publishers and Distributors Ltd.
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12. www.opengate.com

Biophysical Instrumentation: (18 hrs)

Module 1: Microscopy (8 hrs)

Parts of microscope, principles of microscopy. Types of microscopes - simple and compound; Stereo microscope, Phase contrast microscope, Fluorescence microscope, Polarization microscope, Confocal microscope and electron microscope (TEM, SEM and E-SEM). Micrometry, Photomicrography and microphotography.

Module 2: Principles and applications of instruments (10 hrs)

(a) Basic principles and applications of; (i) pH meter (ii) UV-visible spectrophotometers (iii) Centrifuges (Table top centrifuge and ultra centrifuge).
(b) Chromatography: Principles and application; paper, TLC, Column chromatography, GC, HPLC.
(c) Immunoassay systems, ELISA - ELISA reader.
(d) Electrophoresis: SDS PAGE.
(e) X-ray crystallography.
(f) Haemocytometer.

References

1. Ackerman E A, Ellis L E E, Williams L E (1979). *Biophysical Science*. Prentice-Hall Inc.
2. Chang R (1971). *Basic principles of spectroscopy*. McGraw Hill.
3. Pesce A J, Rosen C G, Pasty T L. *Fluorescence Spectroscopy: An introduction for Biology and Medicine*. Marcel Dakar.
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5. Henry B Bull (1971). *An Introduction to physical biochemistry*. F A Devis Co.
6. Perkampus H (1992). *UV-VIS Spectroscopy and its applications*. Springer-Verlag.
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8. Friefelder D. *Physical Biochemistry*. W H Freeman and Co.
9. Mahadevan A, Sridhar R (1996). *Methods in Physiological Plant Pathology*. Sivakmi Publications.
10. Salle A J (1974). *Fundamental principles of Bacteriology*. McGraw Hill.

Biostatistics (18 hrs)

Module 1 Basic principles of Biostatistics (2 hrs)

Methods of collection and classification of data; Primary and secondary data, qualitative and quantitative data. Frequency distribution, graphical representation, normal distribution.

Module 2: Measures of central tendency (3 hrs)

(a) Mean
(b) Median
(c) Mode

Module 3: Measures of dispersion (3 hrs)

Mean deviation, Standard deviation, variance, standard error, co-efficient of variation.

Module 4: Probability (2 hrs)

Probability - Definition, mutually exclusive events – sum rule, independent events – product rule. Probability of unordered combination of events.

Module 5: Tests of significance (3 hrs)

Statistical inference – estimation - testing of hypothesis - t-test, Chi square test (goodness of fit, independence or association, detection of linkages), F-test, ANOVA.

Module 6: Correlation and Regression (2 hrs)

Linear regression and correlation (simple and multiple).

Module 7: Design of experiments (3 hrs)

(a) Experimental designs: Principles - replication and randomization.
(b) Common designs in biological experiments: Completely randomized design, randomized block design, Latin square design, Factorial design.

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1. Chandel R S (1975). *A handbook of Agricultural statistics*. Achal prakashan Mandir.
2. Gomez K A, Gomez A A (1984). *Statistical procedures for agricultndural research*. John Wiley andsons.
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4. Panse V G, Sukathme P V (1995). *Statistical methods for Agricultural workers*. ICAR.

5. Robert J Brooker (2009). *Genetics: analysis & principles* (III Edn). McGraw Hill.

Microtechnique (18 hrs)

Module 1: Killing and fixing (2 hrs)

Principles and techniques of killing and fixing; properties of reagents, fixation images; properties and composition of important fixatives - Carnoy's Fluid, FAA, FPA, Chrome acetic acid fluids, Zirkle-Erliki fluid.

Module 2: Dehydration, clearing, embedding and sectioning (5 hrs)

(a) Dehydration: Principles of dehydration, properties and uses of important dehydrating and clearing agents - alcohols, acetone, xylol, glycerol, chloroform, dioxan. Dehydration Methods: (i) Tertiary-butylalcohol method (ii) Alcohol-xylol method.

(b) Embedding: Paraffin embedding.

(c) Sectioning: Free hand sections – Prospects and problems; Sectioning in rotary microtome - sledge microtome and cryotome.

Module 3: Staining (3 hrs)

(a) Principles of staining; classification of stains, protocol for preparation of; (i) Natural stains - Haematoxylin and Carmine (ii) Coal tar dyes – Fast green, Orange G, Safranine, Crystal violet, CottonBlue and Oil Red O.

(b) Techniques of staining: (i) Single staining; Staining with Safranine or crystal violet (ii) Double staining; Safranine-Fast green method, Safranine-Crystal violet method (iii) Triple staining; Safranine-Crystal violet-Orange G method.

(c) Histochemical localization of starch, protein, lipid and lignin.

Module 4: Specimen preparation for transmission electron microscopy (3 hrs)

Material collection, fixing, dehydration, embedding, sectioning (glass knife preparation, grid preparation, ultra microtome) and staining.

Module 5: Whole mounts (5 hrs)

(a) Principles and techniques of whole mounting, TBA/Hygrobutol method, Glycerine-xylol method. Staining of whole mount materials (haematoxylin, fast green or Safranine-fast green combination). Significance of whole mounts.

(b) Techniques of smear, squash and maceration.

(c) Mounting: Techniques, common mounting media used - DPX, Canada balsam, Glycerine jelly and Lactophenol. Cleaning, labeling and storage of slides.

References

1. Johanson D A (1940). *Plant microtechnique*. McGraw Hill co.
2. John E Sass (1967). *Botanical Microtechnique*. Oxford IBH Publ. Company.
3. Gray (1964). *Handbook of Basic Microtechnique*. McGraw Hill co.
4. Prasad M K, M Krishna Prasad (1983). *Outlines of Microtechnique*. Emkay Publications.
5. Geoffrey A Meek (1976). *Practical electron microscopy*. John Willey and sons.
6. Krishnamurthy K V (1987). *Methods in Plant Histochemistry*. S Viswanathan printers, Anand book depot, Madras.
7. Toji Thomas (2005). *Essentials of botanical microtechnique* (II Edn). Apex infotech publishing company.

CORE X: PLANT PHYSIOLOGY AND PLANT BREEDING
(Theory -72 hrs; Credits: 4)

Plant physiology (54 hrs)

Module 1: Plant water relations (6 hrs)

Structure and properties of water. Water transport – diffusion, bulk flow. Osmosis – waterpotential. Water absorption by root, pathways of water uptake and transport, xylem andphloem transport, passive and active transport. Aquaporins. Water pathway in the leaf –driving force of transpiration, leaf anatomy for regulating transpiration. Control of stomatalmechanism. Soil-plant-atmosphere continuum.

Module 2: Absorption of minerals (2 hrs)

Soil characters influencing nutrient availability – size and charge of soil particles, soil pH. Entry ofminerals into roots; bulk flow, diffusion. Role of Mycorrhizae in nutrient uptake.

Module 3: Transport of ions, solutes and macromolecules (5 hrs)

Electrical properties of membranes, Membrane potential. Transport across cell membranes: Passive– diffusion, facilitated diffusion, membrane channels; gap junctions, porins, ion channels – gatedNa+K+ pump, ABC transporters.

Module 4: Photosynthesis (12 hrs)

(a) Light harvesting complexes: PS I, PSII; Structure and composition of reaction centers. Basicprinciples of light absorption, excitation energy transfer, mechanism of electron transport,photooxidation of water, proton electrochemical potential – photophosphorylation.

(b) Structure and function of RuBisco, CO2 fixation – Calvin cycle. Photorespiration, roleof photorespiration in plants. CO2 concentrating mechanisms – algal and cyanobacterial pumps, C4cycle, CAM pathway. Photoprotective mechanisms. Synthesis of starch and sucrose,photosynthetic quantum yield and energy conversion efficiency. Transport of photoassimilates –phloem loading and unloading, mechanism of phloem translocation – pressure flow. ThylakoidET inhibitors, Photoinhibition and its tolerance mechanism.

Module 5: Respiration (10 hrs)

(a) Three stages of respiratory metabolism (brief study only). Plant mitochondrial electron transport and ATP synthesis – structure of electron transfer complexes (complex I – IV). ATPase– detailed structure of F1 and Fo subunits, binding change mechanism of ATP synthesis.Comparison of mitochondrial and chloroplast ATP synthesis. Cyanide resistant pathway – alternativeoxidase, its regulation and significance.

(b) Lipid metabolism in oilseeds – glyoxylate cycle, gluconeogenesis.

Module 6: Nitrogen metabolism: (5 hrs)

N cycle. N fixation processes. Biological N fixation – structure of nitrogenase complex, reduction of N. Symbiotic N fixation – nodule formation, leghaemoglobin. Nitrate and ammonium assimilation. Transport of amides and ureides.

Module 7: Stress physiology (5 hrs)

Response of plants to biotic (pathogen and insects) and abiotic (water, temperature – low and high, salt, oxygen deficiency, heavy metal and air pollution) stresses. Mechanisms of resistance to bioticstress and tolerance to abiotic stress.

Module 8: Sensory photobiology (4 hrs)

Structure, function and mechanisms of action of phytochromes, cryptochromes, phytochromemediated plant responses. Photoperiodism and biological clocks – circadian rhythms. Floralinduction and development

Module 9: Plant growth regulators (5 hrs)

Biosynthesis, storage, breakdown, transport, physiological effects, and mechanism of action of plant growth hormones, elicitors.

References

1. Lincoln Taiz, Eduardo Zeiger (2002). *Plant physiology* (II Edn). Sinaeur Associates, Inc. Publishers.

2. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and molecular biology ofplants*. L K International Pvt. Ltd.

3. Reginald H Garrett, Charles M Grisham (2005). *Biochemistry*. Thomson Brooks/Cole
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Principles of Biochemistry (III Edn). Prentice Hall.
5. Frank B Salisbury, Cleon W Ross (1992). *Plant Physiology* (IV Edn). Wadsworth Publishing Company.
6. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2002). *Molecular biology of the cell* (IV Edn). Garland Science, Taylor and Francis group.
7. Gerald Karp (2008). *Cell and Molecular biology: Concepts and experiments* (V Edn). John Wiley &Sons.
8. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher,Hidde Ploegh, Paul Matsudaira (2007). *Molecular cell biology* (VI Edn). W H Freeman & Company.
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12. S Sadasivam, A Manickam (1996). *Biochemical methods* (II Edn). New age international Publishers.

Plant Breeding (18 hrs)

Module 1: Introduction (3 hrs)

Objectives of plant breeding, important achievements and future prospects. Genetic variability and its role in plant breeding. Domestication and centers of origin of cultivated plants.

Module 2: Systems of reproduction in plants (3 hrs)

Reproductive systems and pollination control mechanisms; Sexual reproduction - Cross and self pollination; asexual reproduction, Incompatibility and Male sterility, their types.

Module 3: Hybridization (3 hrs)

Hybridization - role and methods, Inter-varietal, inter specific and inter generic crosses. Back-cross breeding. Heterosis, Inbreeding depression.

Module 4: Breeding for resistance (3 hrs)

Breeding for biotic (disease) and abiotic (drought) stresses; loss due to diseases, disease development, disease escape, disease resistance, vertical and horizontal resistances of biotic stress; methods of breeding for disease resistance.

Module 5: Mutation breeding (4 hrs)

Mutagens and crop improvement. Spontaneous and induced mutations, effects of mutation. Physical andchemical mutagens; principles and working of Gamma gardens, methods of mutation breeding, mutations in oligogenic traits, mutations in polygenic traits, limitations of mutation breeding, achievements of mutation breeding. Role of mutations in Plant Breeding.

Module 6: Modern breeding methods (2 hrs)

Modern trends in plant breeding.

References

1. Allard R W (1995). *Principles of Plant Breeding*. John Wiley and Sons, Inc.
2. Ghahal G S and Gosal S S (2002). *Principles and procedures of Plant Breeding*. Narosa Publishing House.
3. Sharma J R (1994). *Principles and practices of Plant Breeding*. Tata McGraw-Hill Publishers Company Ltd.
4. Singh B D (1996). *Plant Breeding: Principles and methods*. Kalyani Publications.

CORE LAB II - (8 hours, 4 credits)

Plant Anatomy

1. Study of cambia - non storied and storied.
2. Study the anomalous primary and secondary features in, Amaranthus, Boerhaavia,
3. Mirabilis, Nyctanthes, Piper and Strychnos.
4. Study of stomata, trichomes, and laticifers. Determination of stomatal index.
5. Study the anatomical peculiarities of C4 and CAM plants (Leaf/Stem).
6. Study of nodal patterns.
7. Prepare a histotaxonomic key.
8. Study the pericarp anatomy of a legume, follicle and berry.
9. Identification of wood - soft wood and hard wood.

Principles of Angiosperm Systematics

1. Morphology of leaf: Leaf attachment, Stipules, Patterns of leaf, Phyllotaxy, Shapes of leaf lamina, bases, margins and tips, Venation.
2. Inflorescence: Racemose - Simple raceme, Compound raceme, Spike, Spikelet, Catkin, Spadix, Corymb, Simple umbel, Compound umbel, Panicle, Capitulum. Cymose - Solitary cyme, Mono-, Diand polychasial cyme. Special types - Cyathium, Verticillaster, Hypanthodium, Coenanthium.
3. Morphology of stamens: Mono-, Di- and Polyadelphous; Epipetalous, Syngenesious, Synandrous, Polyandrous, Didynamous, Tetradynamous, Basifixed, Dorsifixed, Versatile.
4. Morphology of carpels: Apocarpous, Syncarpous, Gynostegium. Placentation - Marginal, Parietal, Axile, Free central, Basal and Pendulous.
5. Morphology of fruits: Berry, Drupe, Hesperidium, Pepo, Balausta, Amphisarca, Achene, Follicle, Capsule, Legume, Lomentum, Nut, Caryopsis, Cypsela, Samara, Cremocarp, Siliqua, Carcerule, Regma.
6. Aggregate fruits; Composite fruits - Sorosis and Syconus; Pome.
7. Workout plant specimens collected locally for vegetative and reproductive characters.
8. Workout nomenclatural problems regarding priority and author citations.

Plant Taxonomy

1. Work out a minimum of two members from each family with suitable sketches and description in technical terms.
2. Study of local flora, construction of keys and use of floras in the identification up to species.
3. Preparation of dichotomous keys based on 4 sample plant materials from the same family.
4. Students should familiarize with all the economically/ethnobotanically important plants of the families mentioned in the syllabus.
5. DNA Barcoding using RbcL/ Matk/ITS
5. Field study: A field study for not less than 5 days under the guidance and supervision of teachers and preparation of a minimum of 25 herbarium specimens of different categories with supporting field book.

Genetics

1. Workout problems related to linkage, crossing over and gene mapping, human pedigree analysis.
2. Workout problems in population genetics - gene and genotype frequency, Hardy Wienberg equilibrium.

Biochemistry

1. Preparation of buffers of various strength and pH.
2. Differentiating sugars based on osazone formation.
3. Quantitative estimation of reducing sugar using Dinitro salicylic acid (DNS) or Anthrone.
4. Separation and analysis of lipids and amino acids by TLC.
5. Quantitative estimation of protein by Lowry's method.
6. Preparation of molal, molar, normal and percentage solutions and their dilutions.

7. Estimation of total phenolics.
8. Estimation of peroxidase activity.
9. Estimation of catalase activity.
10. Isolation and assay of amylase enzyme from germinating Pea seeds/appropriate plant material.

Research methodology

1. Visit a scientific library or documentation centre and submit a report.
2. Prepare a project proposal.
3. Prepare an outline of dissertation and research paper.
4. Prepare a list of references.
5. Present a small project in the class with the help of LCD projector and submit the CD for evaluation.

Biophysical Instrumentation

1. Micrometry: Calibrate the ocular micrometer stage micrometer on a light microscope and measure the size of an object (e.g., diameter of spore/pollen grains, width of algal filaments).
1. Calibrate the pH meter and test the pH of different sample solutions.
2. Estimate the concentration of the given sample using calorimeter or spectrophotometer.
3. Prepare a plant extract and perform TLC.

Biostatistics

1. Analysis of data to find the mean, median and mode.
2. Analysis of a given data for mean deviation and standard deviation.
3. Test the significance of a given data using t test, X2 test, F-test and ANOVA.
4. Analysis of a set of data for correlation/regression.
5. Determine probability for different types of events.

Microtechnique

1. Students are expected to be thorough with the following techniques.
    (a) Preparation of semi permanent slides.
    (b) Preparation of permanent slides.
    (c) Preparation of whole mounts.
    (d) Maceration.
    (e) Preparation of fixatives (FAA, Carnoys' fluid).
    (f) Preparation of dehydration series (Alcohol, Acetone, TBA).
    (g) Preparation of paraffin blocks.
    (h) Preparation of serial sections.
2. Candidates should prepare and submit 10 permanent slides in which the following categories should be included;
    (a) Free hand sections (single/double stained).
    (b) Serial sections (single/double stained).
    (c) Wood sections and whole mounts.

Plant Physiology

1. Measurement of Photosynthesis - Hill Reaction.
2. Estimation of proline in plant tissues under various abiotic stresses.
3. Estimation of phenol in plant tissues affected by biotic stress.
4. Determination of peroxidase activity in plant tissues affected by biotic/abiotic stresses.
5. Estimation of free amino acids in senescing leaves to understand the source to sink transformation phenomenon.
6. Determination of osmotic potential by tissue weight method.
7. Separation of photosynthetic pigments by TLC/paper chromatography and calculating the Rf value
8. Demonstration of amylase activity and GA effect in germinating cereal seeds.

9. Estimation of total chlorophyll and study of absorption pattern of chlorophyll solution.
10. Separation and collection of leaf pigments by silica gel column chromatography.
11. Determination of nitrate reductase activity.
12. Extraction and estimation of leghaemoglobin from root nodules.

Plant Breeding

1. Hybridization techniques in self and cross pollinated plants
2. Visit a plant breeding station to familiarize with breeding programmes. Submit a report of the visit.

SEMESTER VIII
CORE XI: CELL AND MOLECULAR BIOLOGY
(Theory 72 hrs; Credits: 4)

Module 1: Intracellular compartments in eukaryotic cells (6 hrs)

Major intracellular compartments in eukaryotic cells (brief study only). Detailed structure of mitochondria, chloroplast, peroxisomes and glyoxysomes with reference to their functional interrelationship. Genetic systems in mitochondria and chloroplast, endosymbiont hypothesis on the evolution of mitochondria and chloroplast. Structural organization of cell membranes: Chemical composition; structure and function of membrane carbohydrates, membrane proteins and membrane lipids. Membrane functions.

Module 2: Cell communication and Cell signaling (6 hrs)

(a) Cell communication: general principles. Signaling molecules and their receptors, external and internal signals that modify metabolism, growth, and development of plants.

(b) Receptors: Cell surface receptors – ion-channel linked receptors, G-protein coupled receptors, and Tyrosine-kinase linked receptors (RTK), Steroid hormone receptors.

(c) Signal transduction pathways, Second messengers, Regulation of signaling pathways. Bacterial and plant two-component signaling systems.

Module 3: Life cycle of the cell (6 hrs)

(a) Cell growth and division. Phases of cell cycle, cell cycle control system; extracellular and intracellular signals. Cell cycle checkpoints – DNA damage checkpoint, centrosome duplication checkpoint, spindle assembly checkpoint. Cyclins and Cyclin-dependent kinases. Regulation of plant cell cycle.

(b) Cell division – mitosis and meiosis (brief study only). Significance of meiosis in generating genetic variation.

(c) Programmed cell death – molecular mechanism and control.

Module 4: Cytoskeleton (3 hrs)

Functions of cytoskeleton; Structure, assembly, disassembly and regulation of filaments involved – actin filaments (microfilaments), microtubules, and intermediate filaments. Molecular motors – kinesins, dyneins, myosins.

Module 5: Genetic material and its molecular structure (6 hrs)

(a) Identification of DNA as genetic material: Transformation experiment, Hershey Chase experiment. RNA as the genetic material in some viruses.

(b) Important features of Watson and Crick model of DNA structure, Chargaff's rules, preferred tautomeric forms of bases.

(c) Alternative conformations of DNA – type(s) of right handed and left handed helices, DNA triplex and quadruplex, circular and linear DNA, single-stranded DNA.

(d) Structure and function of different types of RNA - mRNA, tRNA, rRNA, SnRNA, and Micro RNA. RNA tertiary structures. Ribozymes – Hammerhead ribozyme.

Module 6: Genome and chromosome organization in eucaryotes (5 hrs)

(a) c-value paradox, DNA renaturation kinetics, Tm, Cot curve. Unique and Repetitive DNA – mini- and microsatellites.

(b) Structure of chromatin and chromosomes - histones and nonhistone proteins, nucleosomal organization of chromatin, higher levels of chromatin structure. Heterochromatin and Euchromatin, formation of heterochromatin. Chromosomal packing and structure of metaphase chromosome. Molecular structure of the Centromere and Telomere.

Module 7: DNA replication, repair and recombination (10 hrs)

(a) DNA replication: Unit of replication, enzymes and proteins involved in replication (in both procaryotes and eucaryotes). Structure of the replication origin (in both procaryotes and eucaryotes), priming (in both procaryotes and eucaryotes), replication fork, fidelity of replication.
Process of replication – initiation, elongation and termination. Replication in the telomere - telomerase.

(b) DNA repair mechanisms: Direct repair, excision repair – base excision repair and nucleotide excision repair (NER), eucaryotic excision repair – GG-NER, TC-NER. Mismatch repair,

Recombination repair – homologous recombination repair, nonhomologous end joining, SOS response – Transletion DNA polymerase.
(c) Recombination: Homologous and nonhomologous recombination, molecular mechanism of homologous recombination. Site-specific recombination, transposition – types of transposons.

Module 8: Gene expression (20 hrs)

(a) Gene: Concept of gene; structural and genetic definitions – complementation test.
(b) Transcription in procaryotes: Initiation – promoter structure, structure of RNA polymerase, structure and role of sigma factors. Elongation – elongation complex, process of RNA synthesis. Termination – rho-dependent and rho-independent termination.
(c) Transcription in eucaryotes: Types, structure and roles of RNA polymerases. Promoters – important features of class I, II, & III promoters. Enhancers and silencers. General transcription factors and formation of pre-initiation complex. Elongation factors, structure and function of transcription factors.
(d) Post-transcriptional events: Split genes, splicing signals, splicing mechanisms of group I, II, III, and tRNA introns. Alternative splicing, exon shuffling, *cis* and *trans* splicing. Structure, formation and functions of 5' cap and 3' tail of mRNA, RNA editing, mRNA export.
(e) Translation: Important features of mRNA – ORF, RBS. Fine structure, composition and assembly of procaryotic and eukaryotic ribosomes. tRNA charging, initiator tRNA.
(f) Stages in translation: Initiation – formation of initiation complex in procaryotes and eucaryotes, initiation factors in procaryotes and eucaryotes, Kozak sequence. Elongation – process of polypeptide synthesis, active centers in ribosome - 3-site model, peptidyl transferase, elongation factors. Termination – process of termination, release factors, ribosome recycling.
(g) Genetic code: Cracking the genetic code – simulation synthetic polynucleotides and mixed copolymers, synthetic triplets. Important features of the genetic code, proof for the triplet code, Exceptions to the standard code.
(h) Protein sorting and translocation: Cotranslational and posttranslational – signal sequences, SRP, translocon. Membrane insertion of proteins. Post-translational modification of proteins. Protein folding – self assembly, role of chaperones in protein assembly.

Module 9: Control of gene expression (10 hrs)

(a) Viral system: Genetic control of lytic and lysogenic growth in λ phage, lytic cascade.
(b) Procaryotic system: Transcription switches, transcription regulators. Regulation of transcription initiation; Regulatory proteins - activators and repressors. Structure of *Lac* operator, CAP and repressor control of *lac* genes. Regulation after transcription initiation – regulation of amino acid biosynthetic operons - attenuation of trp operon, riboswitches.
(c) Eucaryotic system: Changes in chromatin and DNA structure – chromatin compaction, transcriptional activators and repressors involved in chromatin remodelling, gene amplification, gene rearrangement, alternate splicing, gene silencing by heterochromatization, and DNA methylation. Effect of regulatory transcription factors on transcription. Post-transcriptional control – mRNA stability, RNA interference, micro RNA. Role of small RNA in heterochromatization and gene silencing

References

1. Wayne M Becker, Lewis J Kleinsmith, Jeff Hardin (2007). *The world of the cell* (VI Edn). Pearson.
2. Geoffrey M Cooper, Robert E Hausman (2009). *The Cell: A molecular approach* (V Edn). Sinaeur.
3. Gerald Karp (2008). *Cell and Molecular biology: Concepts and experiments* (V Edn). John Wiley & Sons.
4. Harvey Lodish, Arnold Berk, Lawrence Zipursky, Paul Matsudaira, David Baltimore, James Darnell (2000). *Molecular cell biology* (IV Edn). W H Freeman & Company.
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6. Robert J Brooker (2009). *Genetics: analysis and principles* (III Edn). McGraw Hill.
7. Jocelyn E Krebs, Elliott S Goldstein, Stephen T Kilpatrick (2011). *Lewin's Genes X*. Jones and Bartlett Publishers.

8. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and Molecular biology of plants*. I K International Pvt. Ltd.
9. Daniel L Hartl, Elizabeth W Jones (2012). *Genetics: Analysis of genes and genomes* (VII Edn). Jones and Bartlett publishers.
10. James D Watson, Tania A Baker, Stephen P Bell, Alexander Gann, Michael Levine, Richard Losick (2009). *Molecular biology of the gene* (V Edn). Pearson.
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12. Daniel J Fairbanks, W Ralph Anderson (1999). *Genetics: The continuity of life*. Brooks/Cole publishing company.
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16. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira (2007). *Molecular cell biology* (VI Edn). W H Freeman & Company.
17. James D. Watson, Amy A. Caudy, Richard M. Myers, Jan A. Witkowski (2007). *Recombinant DNA* (III Edn). W H Freeman.
18. William H Elliott, Daphne C Elliott (2001). *Biochemistry and molecular biology* (II Edn). Oxford.
19. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman & company.
20. David P Clark (2010). *Molecular biology*. Elsevier.
21. David R Hyde (2010). *Genetics and molecular biology*. Tata McGraw Hill.
22. D Peter Snustad, Michael J Simmons (2010). *Principles of genetics* (V Edn). John Wiley and Sons.
23. David A Micklos, Greg A Freyer with David A Crotty (2003). *DNA Science: A first course* (II Edn). L K Inter.
24. Benjamin A Pierce (2008). *Genetics: A conceptual approach* (IV Edn). W H Freeman and Company.
25. Anthony J F Griffiths, Susan R Wesler, Sean B Carroll, John Doebley (2012). *Introduction to genetic analysis*. W H Freeman & Company.
26. T A Brown (2002). *Genomes* (II Edn). Bios.
27. Robert H Tamarin (2002). *Principles of genetics*. McGraw Hill.
28. David E Sadava (2009). *Cell biology: Organelle structure and function*. CBS.
29. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2010). *Essential Cell Biology* (III Edn.). Garland Science.
30. Pranav Kumar, Usha Mina (2011). *Biotechnology: A problem approach*. Pathfinder Academy.
31. Burton E Tropp (2012). *Molecular biology: Genes to Proteins* (IV Edn). Jones and Bartlett Learning.
32. Lynne Cassimeris, Viswanath R Lingappa, George Plopper (Eds) (2011). *Lewin's Cells* (II Edn). Jones and Bartlett Publishers.

ELECTIVE- BIOTECHNOLOGY

PAPERI: TSSUE CULTURE AND GENETIC ENGINEERING
(Theory 72 hrs; Credits 4)

Tissue culture (27 hrs)

Module 1: Tissue culture regeneration of plants (5 hrs)

(a) Adventitious regeneration: Direct regeneration, indirect regeneration. Factors influencing adventitious regeneration; genotype, explant – orientation of explant, position on mother plant.
(b) Somatic embryogenesis: General aspects, initiation of embryogenic cultures, maturation ofsomatic embryos, regeneration of plants, factors regulating somatic embryogenesis, differencesbetween somatic and zygotic embryos. Encapsulation of somatic embryos, synthetic seed production;desiccated and hydrated types. Applications and limitations of synthetic seeds.

Module 2: Somaclonal variation (4 hrs)

Isolation of somaclonal variants, molecular basis of somaclonal variation. Origin of somaclonalvariation – pre-existing variability, *in vitro* induced variability; Reasons – changes in ploidy level,changes in chromosome structure, gene mutations, gene amplifications, changes in extra nuclear genes,activation of transposable elements, DNA methylation. Applications of somaclonal variation.

Module 3: Production of ploidy variants (6 hrs)

(a) Haploids: Androgenesis - pretreatment of anther/pollen grains, media and growth regulators, Induction and stage of pollen development, regeneration, androgenic embryos, factors affecting androgenesis. Microspore culture - protocol, advantages over anther culture.
(b) Gynogenesis: Developmental stage at inoculation, *in vitro* maturation of embryo sacs, origin of embryos, triggering factors – pretreatment, medium. Uses and limitations of haploid plants.
(c) Triploids: importance of triploid plants, conventional production of triploid plants, endosperm culture - advantages and limitations.

Module 4: Protoplast culture (4 hrs)

(a) Isolation and purification of protoplasts, culture of protoplasts, cell division and callusformation, plant regeneration.
(b) Protoplast fusion (somatic hybridization) – chemical, mechanical, electrofusion. Selection,isolation of heterokaryons, cybrids and their applications. Applications of protoplastculture.

Module 5: Production of secondary metabolites (4 hrs)

Culture conditions for producing secondary metabolites, selection of high yielding lines, elicitation, immobilization of cells. Hairy root culture – advantages of using hairy root culture, establishment of hairy root culture and production of secondary metabolites.

Module 6: Germplasm conservation (4 hrs)

Importance, methods of conservation: *In situ* and *ex situ* conservation. *In vitro* conservation, short and medium term storage, cryopreservation technique – importance of cryopreservation, pretreatment, freezing methods, cryoprotectants, vitrification.

References

1. Hamish A Collin, Sue Edwards (1998). *Plant tissue culture*. Bios scientific publishers.
2. R A Dixon, R A Gonzales (2004). *Plant cell culture, a practical approach* (II Edn). Oxford University Press.
3. S S Bhojwani, M K Razdan (1996). *Plant tissue culture: Theory and Practice*. Elsevier.
4. Susan R. Barnum (1998). *Biotechnology an introduction*. Thomson Brooks/cole.
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Genetic engineering (45 hrs)

Module 1: Working with Nucleic acids (3 hrs)

Isolation and purification of DNA (genomic and plasmid) and RNA.

Module 2: rDNA Technology- Tools and Techniques (6 hrs)

(a) Vectors – necessary properties of a vector, Construction, important features and specific uses of vectors: plasmid - pBR322, pUC, Lambda phage, M13, artificial chromosomes – YAC, BAC, PAC, HAC. Shuttle vectors, expression vectors.
(b) Vectorless Methods - microprojectiles, electroporation, microinjection, chemical, lipofection
(c) Restriction endonucleases – naming, types and reaction.
(d) Ligases – reaction, methods of blunt end joining - linkers and adaptors

Module 3: Procedure of gene cloning (in bacteria using pBR322 vector system) (4 hrs)

Creation of recombinant DNA, Introduction of recombinant DNA into host cell – preparation of competent host cells, transformation. Selection of transformed cells, identification of recombinant cells – insertional inactivation. Methods of screening and selection of recombinant cells – selectable markers, reporter systems – *Lac Z* system, GFP.

Module 4: Plant transformation (4 hrs)

(a) Agrobacterium tumefaciens mediated gene transfer in plants - details of vector system based on *A. tumefaciens*, binary vector and cointegrate vector. Steps involved in *Agrobacterium* mediated gene transfer to plants.

(b) Details of the creation of Bt plants, Golden rice, *Flavr Savr* Tomato.

Module 5: Chemical synthesis of DNA (3 hrs)

Phosphodiester, phosphotriester, and phosphite-triester method of DNA synthesis (Brief study only). Phosphoramidite method, automated DNA synthesis. Artificial genome synthesis.

Module 6: Advanced transgenic technology (5 hrs)

Inducible expression systems – examples, site-specific recombination for *in vivo* gene manipulation, gene targeting, gene silencing using antisense RNA and RNAi. *In vitro* mutagenesis - site-directed mutagenesis.

Module 7: Gene library (4 hrs)

Genomic and cDNA library. Procedure for the construction of a genomic library using phage λ system. Identification of desirable clones from library – hybridization probing, colony and plaque

hybridization probing, immunological screening. Locating and isolating a gene - *in situ* hybridization, positional cloning, chromosome walking and jumping.

Module 8: Advanced tools and techniques (6 hrs)

(a) PCR - Procedure and applications, variants of PCR - Real time PCR and its applications.

(b) *In vitro* mutagenesis- Oligonucleotide directed, Error- prone PCR, Cassette Mutagenesis. Applications of *In vitro* mutagenesis.

(c) Blotting techniques - procedure and applications of southern, northern, western, and dot blotting. Microarray (gene chip) technology.

(d) Procedure and applications of DNA profiling, Footprinting.

(e) Procedure and applications of ELISA, RIA, Immunoprecipitation, flow cytometry, FISH, GISH.

Module 10: Applications of rDNA technology (5 hrs)

Uses of GM microbes: Bacteria and yeast - producing useful proteins, basic genetic research. Applications of GM animals: In basic research, producing novel proteins; disease studies, prevention and cure diseases0). Uses of transgenic plants: Herbicide, insect and disease resistance, stress resistance. Genetic engineering for increasing nutritional and other novel qualities in plants.

Module 11: Ethical, legal, and social impact of modern biotechnology (5 hrs)

Need for regulation, regulatory agency in India – GEAE. Patents – issues relating to patenting living organisms, their genes and other bioresources. Potential impact of GMOs on the ecosystem. GM food – effect on health and environment. Ethical problems of rDNA technology. Economic issues. Potential misuse of modern molecular biology tools and techniques, bioweapons, bioterrorism.

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ELECTIVE- BIOTECHNOLOGY
PAPER II:GENOMICS, PROTEOMICS AND BIOINFORMATICS
(Theory 72 hrs; Credits 4)

Module 1: Structural genomics (18 hrs)

(a) Basic steps in genome sequencing. Shot gun sequencing of small genomes. Map based sequencing: Hierarchial shot gun sequencing (clone-by-clone approach) - steps involved; Whole genomeshot gun approach - steps involved.

(b) Genome mapping: Genetic mapping and physical mapping. Cytogenetic and linkage map(brief study only). Molecular markers – RFLP, RAPD, AFLP, SSLP, SNP. Construction of linkage maps using molecular markers – E.g., RFLP maps. Physical mapping – restriction mapping, STS, SNP, EST.

(c) Sequence assembly – methods used.

(d) Next generation sequencing strategies - Pyrrosequencing.

(e) Important findings of the completed genome projects: Human genome project,Rice genome project, Arabidopsis genome project, *E. coli* genome project, Wheat genomeproject, Tomato genome project.

Module 2: Functional genomics (10 hrs)

Transcriptome, expression profiling (mRNA profiling). Gene expression analysis using dotblotting and microarrays. Fabrication of microarrays – spotted arrays, *in situ* synthesis. Chromatin immunoprecipitation (ChIP) and its applications. Determination of gene functions -knock out and knock down mutants, antisense RNA and RNAi, gene overexpression.

Module 3: Comparative genomics (5 hrs)

Orthologs and Paralogs, gene identification by comparative genomics, comparative genomics as atool in evolutionary studies. Metagenomics.

Module 4: Proteomics (5 hrs)

Proteome, proteomics. Separation and identification of cellular proteins by 2D gel electrophoresis and mass spectrometry. Protein expression analysis using Proteinmicroarray, protein localization using GFP, other applications of GFP.

Module 5: Bioinformatics (27 hrs)

(a) Submission and retrieval of databases – BankIt, ENTREZ.

(b) Sequence analysis – significance. Methods of sequence alignment – paired sequence alignment,multiple sequence alignment, scoring matrices. Sequence comparison – dot matrix method,dynamic programming for sequence alignment; Global - Needleman Wunch algorithm; Local – SmithWaterman algorithms. Database similarity search – query sequence search; BLAST - different versions;FASTA - different versions. Tools for multiple sequence alignment – CLUSTAL X/W

(c) Gene prediction strategies, ORF search, gene prediction programs – Grail/Exp, GENSCAN, ORF finder. RNA secondary structure prediction; Protein structure andfunction prediction - tools used. Protein visualization tool - Rasmol.

(d) Applications of bioinformatics in evolutionary studies – molecular phylogenetics, molecular clock. Construction of phylogenetic trees - tool Phylip.

(e) Computer assisted drug design - concept, methods and practical approaches. Various computationalmethods applied to design drugs.

(f) Bioinformatics for enzyme and protein design.

Module 6: Ethical, legal, and social impact of modern biotechnology (7 hrs)

Genome data availability – Problems with public availability of sequence data, privacy concerns,legal problems, gene and DNA sequence patenting, patenting transgenics, stem cell research - EST,gene therapy – problems and concern over germline gene therapy. Biosafety.

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ELECTIVE- ENVIRONMENTAL SCIENCE

PAPER I: NATURAL RESOURCES AND THEIR MANAGEMENT
(Theory 72hrs; Credits 4)

Module 1: Natural resources and their management (3 hrs)

Natural resources – renewable and nonrenewable. Preservation, conservation, and restoration of resources. Recycling, reuse, and substitution.

Module 2: Principles of resource management – Water resources (5 hrs)

Distribution of water resources, threats to water resources. Principles and approaches to surface water management, watershed management – catchment infiltration models, rainwater harvesting and storage, recharging of ground water. Management of degraded water resources. Drinking water quality and water treatment - desalination, ion-exchange, reverse osmosis, and disinfection of water.

Module 3: Principles of resource management – Energy resources (6 hrs)

(a) Energy sources – resource and reserves. Current national and global energy scenario.

(b) Fossil fuels: Oil, Coal, Natural gas, Shale – sources, exploration, exploitation; environmental consequences of overexploitation.

(c) Nuclear energy: Nuclear fission and fusion, nuclear minerals, nuclear fuel cycle, nuclear fuel production, nuclear reactors. Advantages and disadvantages of nuclear power. Environmental consequences – safety, terrorism, waste disposal and management.

(d) Renewable and alternate energy sources – solar energy and isolation, photovoltaic cells; hydropower; tidal power; wind power; geothermal energy; ocean energy; fuel cells – advantages and disadvantages, environmental consequences.

(e) Bio-energy: biomass as energy source, biomass production, energy farming, biomass conversion processes – thermochemical and biochemical. Biodiesel. Environmental consequences of biomass resource harnessing.

Module 4: Principles of resource management – Land resources (3 hrs)

Land as a resource, land degradation and its causes, desertification – causes and prevention.

Module 5: Principles of resource management – Food resources (4 hrs)

Food sources, effect of agriculture on the environment. World food problems, methods and strategies to alleviate food problems.

Module 6: Principles of resource management – Mineral resources (4 hrs)

Mineral resources: Formation of mineral deposits. Types of mineral resources, environmental impact of mineral exploration, mining, processing and utilization. Conservation of mineral resources.

Module 7: Principles of resource management – Biological resources (28 hrs)

(a) Forests as biological resources – importance, types of forests, deforestation, reforestation, conservation of forests.

(b) Biodiversity and its importance: Types of biodiversity - wild biodiversity, agro-biodiversity, domesticated biodiversity. Values of biodiversity, ecosystem functions and biodiversity, mobile links and valuating ecosystem services. Drivers of biodiversity loss. Tools and techniques for biodiversity estimation: Biodiversity indices; methods of biodiversity monitoring.

(c) Uses of biodiversity – source of food, medicine, raw material, aesthetic and cultural values. Threats to biodiversity; natural and anthropogenic, species extinctions, IUCN threat categories, red data book. Extinction: Types, Causes – population growth, overconsumption, pollution, climate change. Ecological extinction, biological extinction.

Principles and strategies for biodiversity conservation - *In-situ* conservation: sanctuaries, biosphere reserves, national parks, nature reserves, preservation plots. *Ex-situ* conservation: botanical gardens, zoos, aquaria, homestead garden; herbarium; *In-vitro* Conservation: germplasm and gene Bank; tissue culture: pollen and spore bank, DNA bank. GEF-World Bank initiatives. Biodiversity hotspots and their characteristics, global distribution. National and international programmes for biodiversity conservation. CITES and TRAFFIC, Indian Biodiversity Act 2002 and Rules.

(d) Biological Invasions: Introduction -Elton's hypothesis – Invasion patterns and process -biological attributes for invasion: Reproductive potential, Allelopathy -Phenotypic plasticity -fitness to the new environment. Hypotheses for invasion success: Natural enemy hypothesis -evolution of invasiveness hypothesis, empty niche hypothesis, novel weapon hypothesis, disturbance hypothesis and Propagule

pressure hypothesis. Invasive alien species of India (plants and animals).
(e) Impacts and management of invasions: Impacts of exotics on biodiversity, productivity, nutrient cycling. Management: Bio-control programmes, mechanical and chemical control -Positive utilization. Quarantine and EIA of biological invasion.

Module 8: Environmental economics (8hrs)

(a) Definition, scope and basic theories of environmental economics; sustainable growth.
(b) Economics of natural resources, environment cost-benefit analysis.
(c) Agricultural development and environment: Modern agriculture and its impact on environment – monoculture plantations, use of insecticides, pesticides, chemical fertilizers, hybrid seeds, water consumption, desertification, watershed problem, soil erosion, deforestation, depletion of biodiversity. Sustainable agriculture – alternate methods in agriculture.
(d) Industrial development and environment: impact of modern large scale industries on environment, problems related to modernization and urbanization. Green policies of industrialization.

Module 9: Society and Environment (8 hrs)

(a) Social perspectives of environment – Global and Indian issues.
(b) Social impacts of growing human population and affluence, production and distribution of food, hunger, poverty, malnutrition, famine.
(c) Social impacts of water crisis, global climate change, ozone depletion, nuclear accidents, acid rain, consumerism and waste products.
(d) Problems related to major dams and other developmental projects, resettlement and rehabilitation.
(e) Environment and human health – epidemiological issues.

Module 10: Environmental ethics (3 hrs)

Importance and need of environmental ethics. Moral relation among humans, nonhumans, and natural environment. Position of humans in the world, human responsibility to care the world, animal rights.

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ELECTIVE – ENVIRONMENTAL SCIENCE
PAPER II: ENVIRONMENTAL MONITORING AND MANAGEMENT
(Theory 72 Hrs; Credits 4)

Module 1: Environmental Management (8 hrs)

(a) Concepts, strategies and basic principles of environment management. Management of physical, social, and economic environment. Concepts and scope of environmental planning, regional planning and management. Cost-benefit analysis and Resource economics.
(b) Environmental modeling: Simulation modeling, input-output modeling, Linear programming, Software and resource management.
(c) Tool box for environmental management – An overview of Ecological foot prints, SEA, Ecological Economics, conflict resolution strategies. Eco-funds.
(d) Environmental auditing and Standards -Eco labeling and certification, accreditation – need, objectives and benefits; Corporate social responsibility and Corporate environmental responsibility, ISO standards for environmental management systems (EMS) -ISO 14000, 14001 and 26001; OHSAS 18001.

Module 2: Ecosystem Management (8 hrs)

(a) An overview -Population, Resources and Ecosystem management -Exponential growth in human numbers and the implications.
(b) Major management concepts and methodologies: The five basic laws of Ecology and their relevance for ecosystem management; paradigm shifts in the management of Ecosystems - influence of economics in ecology.
(c) Management practices for various ecosystems: grasslands, forests, mountains, wetlands and coastal areas.
(d) Environmental planning and management of; waste lands, reclaimed lands, mining areas, human settlements, industrial lands and agricultural lands.
(e) Eco-restoration/remediation; local knowledge and management systems; environmentally sound management of Biotechnologies; the common property resources and their management.

Module 3: Solid waste Management (6 hrs)

Municipal solid wastes (MSW) - quantities and characteristics, waste collection and transport, waste processing, resources recovery and recycling, incineration, pyrolysis, aerobic and anaerobic systemscomposting, vermicomposting and sanitary landfills and biodigesters (Biogas). Management of plastic and e-waste. Better management strategies (any two model case studies).

Module 4: Toxicology (10 hrs)

(a) Definition, scope and history of Toxicology, Acute and chronic toxicity, selective toxicity, dose, synergism and antagonism.
(b) Toxic chemicals in the Environment – Air, water and Soil. Biochemical aspects of As, Cd, Pb, Hg, CO, O3, PAN, pesticides, MIC, Dioxins, Furans and carcinogens in air, Bioaccumulation & biomagnification.
(c) Occupational toxicology - hazardous chemicals, disorders exposing from chemical exposure at work, assessment of occupational hazards.
(d) Dose-Response relationships: Graded response, quantal response, Time action curves, Threshold Limit value (TLV); LC50; Margin of safety; Toxicity curves; Cumulative toxicity and LD50 & CTF.
(e) Toxicity testing: Bioassay – Definition, purpose, criteria for selection of test organism, methodology, estimation of LC50, Limitation and importance of Bioassay, Acute Toxicity (single); Sub acute Toxicity; Chronic Toxicity; Teratogenicity, Carcinogenicity and Mutagenicity.
(f) Bio-monitoring of Toxic Chemicals - Objectives, programs and parameters, concepts of bio indicators. Bio-transformation of Xenobiotics.

Module 5: Environmental Impact Assessment (8 hrs)

(a) Introduction, definition, history, aim, principles, concept and scope. Baseline data collection, Methods and steps – Ad hoc method, checklist method, matrices, Map overlays method, network method, index method.
(b) Impact assessment and impact evaluation: E1A Processes, Stages, E1A Statement. Environment management plan - Risk assessment and disaster management programme. National Policy on EIA.
(c) Regulatory Framework: Environmental Impact Assessment Notification 2006 and Coastal Zone

Notification 1991; Environmental Clearance Process in India; Legislative requirements (discharge requirements and area restrictions); Environmental Appraisal procedure for mining, industrial, thermal power, nuclear power and multipurpose river valley projects. EIA case studies. Life Cycle Assessment (LCA) and its significance.

Module 6: Remote Sensing and GIS (12 hrs)

(a) Principles and concepts of Remote Sensing. Electromagnetic spectrum; spectral characteristics of surface features (rocks, soils, vegetations, water). Space imaging -Landsat, SPOT, IRS, NOAA, Seasat, ERS, RADARSAT, INSAT. Satellites and their sensors, geometry and radiometry.

(b) Digital Image Processing: Principles, Image Rectification and restoration, Image enhancement and Mosaicing. Image classification. Supervised, Unsupervised, Ground truth data and training set manipulation, Classification accuracy assessment.

(c) Geographical Information System (GIS): Basic principles and terminologies, Raster and vector data, Map projection, Topology creation, Overlay analysis, Data structure and Digital cartography; Software used in GIS Surveying: Leveling, Triangulation, Geodetic survey; Global Positioning System (GPS) - Basic principles, Applications to environmental studies.

Module 7: Environment versus Development (4 hrs)

Dominance of man on earth. Limits of growth. Industrial revolution and resource utilization, environmental consequences. Modern agriculture and green Revolution - environmental impacts. Conflicts of interest - mega developmental projects and issues of 3 Rs, environment and development.

Module 8: Sustainable Development (8 hrs)

(a) Principles of sustainability - Reliance on solar energy, biodiversity, population control, nutrient cycling. Sustainability indicators.

(b) Our Common future and the idea of Sustainable Development - Concepts and dimensions. Basic needs - Imperatives relating to sustainable development. Johannesberg Conference 2002 and follow up Conference on sustainable development. Securing Sustainable futures -Millennium development goals and strategies; the earth charter; need and scope for evolving participatory, community based environmental management strategies. Education for sustainability. Building sustainable societies and lifestyles. Ecological Foot Print analysis and its significance. Environmental concerns in traditional societies.

Module 9: Environmental laws and policies (8 hrs)

(a) Historical background of environmental law and policy in India.

(b) The salient features of the following acts and rules: The water (Prevention and control of pollution) act, 1974; The air (Prevention and control of pollution) act, 1981; The environmental (Protection) act,

1986; The public liability insurance act, 1991; The wildlife protection act, 1972; The forest conservation act, 1980; The biodiversity act, 2002; The hazardous wastes (Management and handling) rules, 1989; The noise pollution (Regulation and control) rules, 2000. Manufacture, storage and import of hazardous chemicals rules 1989, Biomedical waste (Management and Handling) rules 1998.

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ELECTIVE - MICROBIOLOGY
PAPER I: FOOD, AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY
(Theory -72 hrs; Credits 4)

Food Microbiology (27 hrs)

Module 1: Food - a substrate for microorganisms (2 hrs)

Factors influencing microbial activity in food, chemical changes brought about by microbes, microbes important in food microbiology.

Module 2: Microbial flora in food and food spoilage (5 hrs)

Microbial flora of fresh food and their spoilage – cereals, sugar and sugar products, fruits, vegetables, poultry, eggs, shell fish and fin fish, milk and milk products, beverages, bread and canned foods.

Module 3: Microbiology of fermented food (3 hrs)

Fermented milk - butter milk, cultured butter milk, Yoghurt, Kefir; Cheese production; bread; oriental food; Sauerkraut.

Module 4: Food preservation (7 hrs)

General principles of food preservation: (1) aseptic handling (2) high temperature - boiling, steam under pressure, pasteurization and sterilization (3) low temperature – freezing and refrigeration (4) Dehydration (5) Osmotic pressure - in concentrated sugars with brine (6) chemicals, organic acids, smoking (7) radiation - UV and ionization.

Module 5: Food borne diseases (5 hrs)

Diseases caused by spoiled foods, diseases caused by food additives. Food borne diseases caused by bacteria - Salmonellosis, Gastroenteritis, Shigellosis, Listeriosis, Staphylococcal food poisoning, Botulism, Travellers' diarrhoea. Fungal intoxication - Aflatoxin and related components. Virus intoxication.

Module 6: Food quality (5 hrs)

Microbial examination of food - Microscopic techniques, culture techniques. Microbiological criteria for food control. Enforcement and control agencies – international agencies, federal agencies, state agencies, professional societies, private agencies, processing industry and agencies of co-operative programmes.

Agricultural microbiology (18 hrs)

Module 1: Microbes as Biofertilizers (14 hrs)

(a) Microbes as biofertilizers - bacteria, fungi, algae. Production of biofertilizers - strain selection and preparation of biofertilizers. Green manuring. Microbes producing antimicrobial agents, siderophores.
(b) Nitrogen fixing microbes – free living organotrophs, free living prototrophs, diazotrophs. Association of microbes with grasses, legumes, nodulation in nitrogen fixation legumes; nif gene - Azolla-Anabaena.
(c) Phosphate solubilizers – Bacteria and fungi as phosphate solubilizers. Mycorrhizal relationship – definition, forms and distribution of mycorrhiza. Ecto- and Endomycorrhiza. Vescicular and Arbuscular mycorrhiza, Ericaceous, Orchidaceous mycorrhiza. Physiology and function of mycorrhiza. Nutrient uptake and other effects. Carbon flow in mycorrhizal plant association. Production of mycorrhizal biofertilizers.

Module 2: Microbes as Biopesticides (4 hrs)

Microbial herbicides, bacterial insecticides - use of Pseudomonas, Bacillus. Viral insecticides. Entomopathogenic fungi.

Environmental microbiology (27 hrs)

Module 1: Microbial biodiversity (2 hrs)

Nature as a habitat of microbes, microbial diversity in various ecosystems.

Module 2: Methods in microbiology (7 hrs)

Isolation and cultivation of microbes from environment - serial dilution and pour plate method, spread plate method, streak plate method, isolation using selective or enrichment media. Methods of culturing anaerobes. Culture characteristics of microbes. Bacterial growth curve, staining techniques. Biochemical tests for bacterial identification - carbohydrate fermentation, triple sugar-Iron agar test,

IMVIC test, Litmus Milk reactions, Hydrogen sulphide test, Catalase test, Oxidase test. Uncultivable microbes.

Module 3: Soil and aquatic microbiology (7 hrs)

(a) Soil as a habitat for microbes. Factors influencing soil microbial growth. Microorganisms and the formation of different soils – tropical soil, temperate soil, bog soil, cold moist area soil, desert soil, geologically heated hyperthermal soil.

(b) Microbes and their role in fresh water, brackish water and marine environments. Contamination of aquatic environment by pathogenic microbes. Detection of coliform bacteria - membrane filtration technique, Colilert defined substrate test, Multiple tube fermentation test. Quantification of Coliforms - MPN test.

(c) Waste water treatment - primary, secondary and tertiary treatment.

Module 4: Role of microbes in environment (7 hrs)

Role of microorganisms in Carbon, Nitrogen, Phosphorus, Iron and Sulphur cycles. Microbes - as pollution indicators. Biological magnification. Biodegradation of recalcitrants, Jetfacts, paper, computer chips, paints, textiles, leather, rubber, metal, concrete, wood. Role of microbes in the disposal of waste and production of organic compost, biogas. Microbial leaching; Microbial bio-films. Bio-deterioration and biodegradation of petroleum, xenobiotics, heavy metals and microbial plastics.

Module 5: Environmental biotechnology (4 hrs)

Microbes in biotechnology, bioremediation - microbial and enzymatic; *in situ* and *ex situ.* Bioaugmentation – principles, enzymes used in bio-augmentation, bio-filtration-bio-filters, microorganisms used in filters, mechanism of bio-filtration, phyto-extraction and phyto transformation. Genetically modified microbes - beneficts and hazards. Metagenomics.

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22. Kanika Sharma. *Manual of Microbiology: Tools and Techniques*.

ELECTIVE - MICROBIOLOGY
PAPER II: INDUSTRIAL MICROBIOLOGY
(Theory 72; Credits 4)

Module 1: Introduction to industrial microbiology (3 hrs)
Range of fermentation processes, microbial biomass, microbial enzymes, microbial metabolites and transformation processes.

Module 2: Selection and strain improvement strategies (5 hrs)
Isolation of industrially important microorganisms - primary and secondary screening. Detection and assay of fermentation products – physical-chemical, biological assays. Preservation of microbes – storage at reduced temperature, storage in dehydrated forms.

Module 3: Types of fermentation (5 hrs)
Solid state fermentation and submerged fermentation; batch, continuous and fed batch fermentation. Homo- and heterofermentation. Aerobic and anaerobic fermentation. Static and stirred fermentations.

Module 4: Media for microbial growth and fermentation (5 hrs)
Typical media, media formulation; water, energy and carbon source, nitrogen sources, minerals and vitamins, buffers, precursors, metabolic regulators, oxygen requirement.

Module 5: Bioreactors (10 hrs)
Brief study on stirred tank fermenter, air-lift fermenter, packed tower fermenter, tray fermenter, rotary drum fermenter.

Module 6: Microbial fermentation (10 hrs)
(a) Sterilization - media, fermenter, air.
(b) Inoculum preparation, inoculation.
(c) Aeration, agitation, pH control, temperature control, antifoam agents.
(d) Process parameter optimization: One factor at a time and statistical optimizations (brief study only).
(e) Scale up of fermentation (lab scale, pilot plant, industrial scale).

Module 7: Downstream processing (10 hrs)
(a) Separation of microbial cells – Filtration, precipitation, centrifugation.
(b) Cell disruption – liquid shear, freezing-thawing, ultrasonication, osmotic shock, enzyme treatment.
(c) Concentrating and purifying the products - ultrafiltration, crystallization, solvent precipitation, reverse osmosis, chromatography.

Module 8: Production of industrially important products (20 hrs)
(a) Antibiotics - Penicillin, Streptomycin.
(b) Amino acids - Lysine, Glutamic acid.
(c) Enzymes - Amylase, Cellulase, Pectinase.
(d) Organic acids - Lactic acid, Acetic acid, Gluconic acid.
(e) Biofuels – Bio-ethanol, Bio-butanol.
(f) Biopolymers - PHB, PLA.
(g) Alcoholic beverages - Wine, Beer.
(h) Microbial cells - SCP, Baker's yeast.

Module 9: Immobilization of cells and enzymes (4 hrs)
Methods of cell and enzyme immobilization. Applications of immobilized cells and enzymes.

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5. Richard G Burns, J Howard Slater. *Experimental Microbial Ecology*.
6. Arnold L Demain, Julian E Davies. *Manual of Industrial Microbiology and Biotechnology.*
7. Rita Singh, S K Ghosh. *Industrial Biotechnology.*
8. John I D'Souza, S G Killedar. *Biotechnology and Fermentation process*.
9. Michael J Waites, Neil L Morgan, John S Rockey, Gary Higton. *Industrial Microbiology: An introduction.*

10. A H Patel. *Industrial Microbiology*.
11. Wulf Crueger, Anneliese Crueger. *Biotechnology: A text book of industrial microbiology*.
12. B McNeil, L M Harvey. *Practical fermentation technology*.
13. Henry C Vogel, Celeste L Todaro. *Fermentation and biochemical engineering handbook*.
14. S C Prescott, Cecil Gordon Dunn. *Industrial Microbiology*.
15. Mansi EL-Mansi, Charles F A Bryce. *Fermentation microbiology and Biotechnology.*

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Institute for Intensive Research in Basic Sciences (IIRBS)

Integrated Interdisciplinary Programme

(5 – years Integrated)

SYLLABUS
For
(M.Sc. - ZOOLOGY Degree
Part of Integrated Interdisciplinary M.Sc. Programme)
(for Semesters VII, VIII, IX, X)

Abstract of the IIRBS - M.Sc. Degree (Zoology)

Part of Integrated Interdisciplinary M.Sc. Programme Programme

Semester	Course code	Course	Hours/ week	Credits	Total Credits
VII		Core Paper – 1: Animal Taxonomy and Systematics	4	4	**24**
		Core Paper – 2: Evolutionary Biology	4	4	
		Core Paper – 3: Endocrinology and Reproductive Physiology	4	4	
		Core Paper – 4: Animal Behaviour	4	4	
		Core Paper – 5: Advanced Environmental Science	4	4	
		Core Lab Course – 1	8	4	
VIII		Core Paper – 6: Advanced Cell Biology & **Molecular Biology**	4	4	**24**
		Core Paper – 7: Developmental Biology	4	4	
		Core Paper – 8: Advanced **Biochemistry**	4	4	
		Core Paper – 9: Immunology	4	4	
		Core Paper – 10: Advanced Genetics	4	4	
		Core Lab Course – 2	8	4	
IX		Core Paper – 11: Applied Microbiology	4	4	**12**
		Elective Paper - I	4	4	
		Elective Paper - II	4	4	
		Elective Papers offered			
		1.Bioinformatics			
		2.Recombinant DNA Technology			
		3.Enzymology			
		4.Nanobiology			
		Major Project - Starts			
X		Major Project & Viva Voce			**20**
		Grand Total			**80**

SEMESTER VII

Zoology Core Paper - 1

Animal Taxonomy and Systematics

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Taxonomy basic concepts **12 hrs.**

Taxonomy and systematics, importance of taxonomy, levels of taxonomy - alpha, beta and gamma taxonomy, micro and macro taxonomy. History of Classification, Three domain concept in systematics, two, five and six kingdom classification. Hierarchy of categories and higher taxa - Linnean Hierarchy. Higher categories - genus, family, order, class and phylum (brief account only). Concept of species - typological, nominalistic, biological and evolutionary. Intraspecific Catagories; Variety, Subspeicies, Race, Cline. Process of typification, different zoological types and their significance.

Module II. Methods and approaches in Taxonomy **5 hrs.**

Classical and modern methods - Typological, Phenetics, Evolutionary, Phylogenetic, Cladistics and Molecular Taxonomy. Phylocode, Tree of Life and Bar-coding of Life. Taxonomic characters of different kinds.

Module III. Practice of taxonomy **15 hrs.**

Taxonomic procedures – collection, preservation, curetting and identification. Taxonomic keys as tool of identification, different types of keys, merits and demerits. Use of computer softwares in taxonomic identification. Taxonomic nomenclature - International Code of Zoological Nomenclature (ICZN), Rules and formation of Scientific names of different taxa. Principles of nomenclature - law of priority, Homonymy and Synonymy. Taxonomic publications - description of new taxa, synopses and reviews, taxonomic revisions, monographs, atlases, field guides and manuals, catalogs and checklists. Ethics in taxonomy-authorship, suppression of data, undesirable practices in taxonomy.

Module IV. Invertebrate Phylogeny **20 hrs.**

Origin of Protists. Prokaryotes and Eukaryotes. Levels of organization in animal kingdom. Recent trends in the classification of protists. Origin of metazoa, Possible theories of metazoan origin, phylogenetic relationship among lower metazoa. Phylogeny and adaptive radiation in Poriphera. Cnidaria – Phylogeny and adaptive radiation. Acoelomata, Placozoa, Mesozoa, and Pseudocoelomata. Phylogeny and adaptive radiation in Annelida. Phylogeny of Arthropods - Monophyly and Polyphyly. Arthropoda and adaptive radiation. Phylogenetic position of Molluscs, Adaptive Radiation in Molluscs. Phylogeny of Lesser Protostomes. Echinoderms – phylogeny and adaptive radiation. Hemichordata - Position in the animal kingdom, phylogeny and evolutionary significance.

Module V. Phylogeny of Vertebrates **10 hrs.**

Lower chordates - ancestory, Lower Vertebrates and their Phylogeny, Ancestory and Phylogenic relationship among major groups of fishes. Tetrapod phylogeny. Modern Amphibians, diversity, distribution. Reptiles – origin and adaptive radiation. Origin and phylogenic relationship of birds. Mammals – origin and phylogeny.

Module VI. Molecular Phylogenetics 10 hrs.

Phylogenetic trees – rooted and unrooted trees, true and inferred trees, gene trees and species trees, monophyletic groups and clads, methods of tree construction – distance matrix method, maximum parsimony method, maximum likelyhood method, comparision method. Molecular clocks, molecular divergence, genetic distance, significance of Molecular clocks hypothesis in evolution.

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SEMESTER VII

Zoology Core Paper - 2

Evolutionary Biology

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Concepts in Evolution 10 hrs.

Pre - Darwanian, Lamarck, Darwin and Wallace and Post Darwanian. Concepts of variation, adaptation, struggle, fitness and natural selection, Modern evolutionary synthesis. Contributions of Margulis (Endosymbiotic theory), Eldredge and Gould (Punctuated equilibrium), Debates in evolutionary biology.

Module II. Origin and Evolution of Life 10 hrs.

Origin of basic biological molecules, abiotic synthesis of organic monomers and polymers, concept of Oparin - Haldane, Miller-Urey Experiments. Critical analysis of Oparin's Theory. The RNA world. Idea of Panspermia. The First Cell. Evolution of Prokaryotes - origin of eukaryotic cells - evolution of unicellular eukaryotes, genome evolution. Anaerobic metabolism- origin of photosynthesis and aerobic metabolism.

Module III. Geological Timescale 10 hrs.

Geological time scale - eras, periods and epochs, Major events in evolutionary timescale. Fossils- fossilization and its significance. Tools and techniques in estimating evolutionary time scale. Mass extinction and its consequences. Anthropocene.

Module IV. Population Genetics 10 hrs.

Gene pool, gene frequency, Hardy-Weinberg Law. Rate of change in gene frequency through natural selection, migration and random genetic drift. Founder effect. Bottleneck phenomenon, Isolating mechanisms and speciation. Micro Macro and Mega evolution. Co-evolution, Cropping and Red Queen principle. Developmental genes and gene co-option. Evolution of plasticity and complexity.

Module V. Developmental and Evolutionary Genetics 7 hrs.

The idea of Evo-Devo, Heterochrony, Heterotopy, Heterometry and Heterotypy. Developmental genes and gene co-option. Evolution of plasticity and complexity. Evolution of sex.

Module VI. Primate Evolution and Human Origins 10 hrs.

Stages in Primate evolution- Prosimii, Anthropoidea and Hominids. Factors in human origin, hominid fossils. Human evolutionary genetics - Cytogenetic and molecular basis of origin of man-African origin of modern man - Mitochondrial Eve, Y chromosomal Adam,- early migration,hunter- gatherer societies. Evolution of human brain- communication, speech and language. Evolution of culture.

Module VII. **Evolution at molecular level** 15 hrs.

Mutation - substitution mutation, recombination, deletion and insertions, inversions. Mutation rates, spatial distribution of mutations, Neutral theory, Neutralist versus Selectionist. role of mutations and selection in molecular evolution. Rose Mary and Peter Grant (Molecuar evolution in Darwinian finches). Gene and genome evolution, Gene duplications and evolution of multigene families, Mobile genetic elements – transposable elements, genetic

and evolutionary effects of transpositions. Retroposition, retroposons. Horizondal Gene Transfer (HTG) and its importance in evolution.

REFERENCES

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Web Resources

http://www.talkorigins.org

http://www.ucmp.berkely.edu

http://www.academicearth.org

SEMESTER VII

Zoology Core Paper - 3

Endocrinology and Reproductive Physiology

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Endocrine Physiology **25 hrs.**

Concept of endocrinology an introduction; Endocrine system; Classes of hormones, modes of hormone secretion, concepts of feed-back inhibition and feed-forward activation. Endocrine control of various physiological mechanisms in invertebrates. Comparative aspects of endocrine physiology in vertebrates. Structure of pituitary gland; Physiological actions of pituitary hormones. Neurohypophysis: synthesis and storage of oxytocin and vasopressin; Regulation of the release of neurohypophyseal hormones. Structure of adrenal gland; Synthesis of corticosteroid, structural diversity of glucocorticoids among vertebrates, role of glucocorticoid in gluconeogenesis; Catecholamine biosynthesis, its storage and release mechanism, physiological actions of adrenal medullary hormones; hormonal control of water and electrolyte balance; Importance of adrenocortical and adrenomedullary interaction. Thyroid gland. Thyroid hormone synthesis and its regulation, paradigms of thyroid hormone action in poikilotherms and homeotherms. A comparative account of parathyroid gland and ultimobranchial body/C cells, synthesis of parathyroid hormone, calcitonin and of vitamin D3; Hormonal control of feeding behaviour and gastrointestinal tract functioning including acid release, gall bladder contraction and relaxation, pancreatic enzyme secretion, and GI tract motility; Pancreatic hormones and glucose homeostasis.

Module II. Neuroendocrinology **25 hrs.**

General organization of neuroendocrine organs and nervous system. Neuroanatomy: form, varieties and distribution of neurons; Structural characteristics of neurons; Neurophysiology: electrical properties of neurons and propagation of nerve impulses; Synapse: types, structure and function. Neurotransmitter and its release; Neuromodulation: neurotransmitter vs neuropeptides, Synaptic transmission: role of G-protein coupled, glutamate and on-channel linked receptors; GABA/glutamate neurons in adult preoptic area. The hypothalamo-hypophyseal axis. Hormones from hypothalamus: chemistry and physiology of releasing and release inhibiting hormones; Regulation of hypothalamic hormone secretion. Hypothalamo-hypophyseal interactions with the gonads, adrenal and other endocrine organs. Biological clock and the pineal gland: synthesis and regulation of melatonin, role of pineal in circadian rhythms, regulation of pineal by SCN and vice versa, physiological actions of melatonin, biological clock and clock gene expression, fluoride and pineal. Sympathetic and parasympathetic nervous systems. Neuroendocrine regulation of immune system; Stress hormones and immune responses; Melatonin, immune responses and cancer therapy. Neuroendocrine disorders: genetic versus environmental cause.

Module III. Physiology of Reproduction **22 hrs.**

Structure of male reproductive system. Spermatogenesis: structural and molecular events, experimental approaches to study spermatogenesis; Seminiferous epithelial cycle; Sertoli cell: structure and function; Leydig cells. Regulation of testicular functions. Epididymal maturation of spermatozoa; Capacitation, Signal transduction pathway in acrosome reaction; Male sterility: azoospermia, oligozoospermia, asthenozoospermia, varicocele; Genetic basis for male infertility. Structure of female reproductive system. Oogenesis; Oocyte maturation

and its regulation; Ovulation: factors involved in follicular rupture; Luteinization and luteolysis; Follicular atresia.; Hormonal regulation of reproductive cycle in female: menstrual cycle in human, estrous cycle in rat; Female reproductive disorders: amenorrhea, polycystic ovary. Hormonal and immunocontraception.

REFERENCES

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Christina Wang, (ed). *Male Reproductive Function*, Kluwer Academic Publishers.

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SEMESTER VII
Zoology Core Paper - 4
Animal Behaviour

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Introduction **15 hrs.**
Historical background, Patterns of behaviour, Objectives of behaviour, Mechanism of behaviour; Stimulus - Response, Causal factors, Quantitative aspects - Duration, interval frequency. Scope of ethology. Methodology in ethology, Ethology and its relation to other schools of studying animal behaviour. Development of Animal Behaviour – Genes and Environment, Environmental difference and Behavioural differences, Genetic differences and Behavioural differences, Single-Gene effects on behaviour.

Module II. Neurophysiological Aspects of Behaviour **15 hrs.**
Neural basis of behaviour, Stimulus filtering and behaviour, Reflexes, types of reflexes, Reflex action, Kinesis - orthokinesis, klinokinesis, Taxes - different kinds of taxis; sun-compass orientation, dorsal- light reaction, Fixed action patterns. Sherrington's neuro-physiological concepts in behaviour - Latency, summation, fatigue. Hormonal control of behaviour, Factors influencing effects of hormones on behaviour.

Module III. Motivation – Definition **2 hrs.**
Goal oriented drive, internal causal factor, Homeostatic and Non-homeostatic drives. Hormones and behaviour, Psycho-hydrologic model of motivation.

Module IV. Learning **5 hrs.**
Short and long term memory, Habituation, Classical conditioning (Pavlov's experiments), Instrumental conditioning, Latent learning, Insight learning, Trial and error learning, Instinct, Imprinting.

Module V. Communication **10 hrs.**
Evolution of communication, Sensory mechanisms: Electrical, Chemical, Olfactory, Auditory and Visual. Dance language of honey bees, Pheromonal communication (Ants and mammals). Pheromones in mammals: Lee Boot effect, Whitten effect, Bruce effect, Coolidge effect, Vandenbergh effect. Adaptive value of communication.

Module VI. Reproductive Behaviour **5 hrs.**
Reproductive strategies, Mating systems, Courtship, Sexual selection- patterns, competition for mates. Parental care, parental manipulation, evolutionarily stable strategy, cost benefit analysis of parental care with suitable case studies. Role of hormones in reproductive behaviour.

Module VII. Complex Behaviour **5 hrs.**
Orientation, Navigation, Migration (Fishes and birds), Navigation cues. Biological rhythms - Circadian, Circannual, Lunar periodicity, Tidal rhythms. Genetics of biological rhythms.

Adaptations to stress- basic concept of environmental stress, acclimation, acclimatization, avoidance and tolerance. Conflict behaviour- stress-displacement activities- Ritualization.

Module VIII. Social Behaviour **15 hrs.**

Sociobiology, Aggregations - schooling in fishes, flocking in birds, herding in mammals, Group selection, Kin selection and inclusive fitness, altruism, reciprocal altruism, group selection, co-operation, territoriality, alarm call. Social organization in in honey bee, honey bee as super organism. Social organization in primates. Hormones and pheromones influencing behaviour of animals.

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SEMESTER VII

Zoology Core Paper - 5

Advanced Environmental Science

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Ecology and Environment **10 hrs.**

Physical Environment - biotic and abiotic interactions. Concept of Homeostasis and limiting factors; Concepts of habitats- host as habitat, niche, niche width and overlap, fundamental and realized niche, resource partitioning, character displacement. Cybernetic nature of ecosystem, stability through feedback control and through redundancy of components; resistance and resilience stability. Gaia hypothesis. Ecosystem monitoring- GIS, Remote sensing, GPS; EIA- tools and techniques, ecosystem modelling.

Module II. Ecosystem - Structure and Function **10 hrs.**

Pathways in ecosystem, energy in the environment-Laws of thermodynamics, energy flow in the ecosystem. Primary productivity and productivity measurements. Decomposition, Biogeochemical cycles- patterns and types (Gaseous and Sedimentary). Tropical versus Temperate Ecology. Ecosystem development - Ecological succession, concept of climax, plant and animal interaction and community stability, evolution of ecosystem.

Module III. Population and community Ecology **15 hrs.**

Population Ecology: Group properties, Concept of rate. Natality and mortality. Population age structure, Growth forms and concept of carrying capacity. Population fluctuations, density dependent and density independent controls. Life history strategies, r & k selection.
Population structure, aggregation, Allee's principle, isolation, dispersal and territoriality. Population interactions- types, positive and negative, interspecific and intraspecific interactions. Ecological and evolutionary effects of competition. Concept of metapopulation, Metapopulation structure, Levin's model of metapopulation, Comparison of Metapopulation and Logistic population model. Concept of community: **C**ommunity structure and attributes, Species diversity in community and its measurements (Alpha diversity, Simpsons index, Shannon index, Fishers index. Beta diversity, Sorensens similarity index, Whittakers index, Evenness, Gamma diversity). Guild and its functioning in the community

Module IV. Soil ecology **5 hrs.**

Soil formation, soil profile, major soil types, soil properties - (physical and chemical), mineral (inorganic) constituents of soils, soil organic matter, soil biota, microbial control of soil nutrient availability, plant-soil feedbacks and ecosystem development, soil quality degradation, resilience, soil carbon sequestration, Climate change-mitigation and adaptation

Module V. Weather and Climate **15 hrs.**

Definitions and scope of climatology, weather and climate, components of climate system, earth's thermal environment, earth intercepts solar radiation, seasonal variation in intercepted solar radiation, air temperature in relation to altitude, global circulation of air masses, wind and earth's rotation on ocean currents, influence of temperature on moisture content of air, global pattern of precipitation , influence of topography on regional pattern of precipitation. classification of climate-Koeppen's classification and Thornthwaite's scheme, climatic types

and zones. Global climatic phenomena-*El Nino* and *La Nina*, causes and factors of climate change. Effect of climate change on ecosystems and human welfare. Climate of India - Climatic regions of India, tropical monsoon climate - onset, rain bearing systems, break in the monsoon, retreat of monsoon. Monsoon in Kerala, oceanic and continental influence.

Module VI. Environmental economics 5 hrs.

The role of environmental economics, recent developments, economics and the environment, decision making and the environment, the economic control of the environment, the need for Environmental Public Policy, environmental economics and environmental auditing. The costs of environmental regulations, the benefits of environmental regulations. National environmental policy, objectives, principles, strategies and actions.

Module VII. Environmental Management 12 hrs.

Basic principles: Management of physical, social, and economic environment. Concepts and scope of environmental planning, regional planning and management. Cost - benefit analysis and Resource economics. Environmental modelling - simulation modeling, input-output modeling, Linear programming, Software and resource management. Tool box for environmental management – An over view of Ecological foot prints, SEA. Eco restoration/remediation; local knowledge and management systems. EIA – as a tool for environment management. Corporate social responsibility and corporate environmental responsibility. Sustainable Development - Definition and concept, strategies, constraints and barriers for Sustainable Development.

REFERENCES

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SEMESTER VII
Zoology Core Lab Course - 1

(8 hrs. / Week) **Credits - 4**

1. Development of dichotomous key using appropriate software or online tools.
2. Preparation of Cladogram based on the specimens provided (at least five museum specimen).
3. Construction of Phylogenetic tree using the software PHYLIP.
4. Thyroidectomy in rats.
5. Steroid and thyroid hormone assay by ELISA.
6. Effect of insulin on blood sugar, hepatic and muscle glycogen of the rat/human.
7. Estimation of thyroxine from human blood.
8. Histology of testis and ovary of different age groups of rats to understand the sequence of events related to spermatogenesis and folliculogenesis and ageing effect. (Permanent slides)
9. Vaginal smear preparation of Rat.
10. In vivo bio- assay for estrogen.
11. In vivo bio- assay for testosterone.
12. In vivo bio- assay for luteinizing hormone.
13. In vitro biochemical assay for a hormone (LH or PRL).
14. Sperms count and motility: Role of epididymal proteins, mono- and di-valent cations and pH in control of sperm motility.
15. Study the geotaxis behaviour of earthworm.
16. Study of the orientational responses of larvae to volatile and visual stimuli.
17. Study of fish in response to three temperatures (Normal and + 5^0C) of water in a microenvironment and preparation of an ethogram.
18. Assessment of density, frequency and abundance of plants/animal in a community using various techniques i.e. transect, quadrate etc.
19. Insect diversity in soil.
20. Principles of GIS, GPS and RS technology.
21. Interpretation (visual and automated) of remote sensing information for landscape differentiation.
22. Estimation of primary productivity in a water body.
23. Quantitative estimation of salinity, phosphates and nitrates in water samples.
24. Determination of soil organic carbon and chlorides.
25. **Field Study:** Conduct Two days field study covering Forest/ grassland or River/ Wetland/ Marine ecosystems. Record ecosystem components (Soil, water, flora, fauna) and their interactions. Prepare a field study report and submit. There will be Viva voce based on the Field study.

SEMESTER VIII

Zoology Core Paper - 6

Advanced Cell Biology & Molecular Biology

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Endomembrane system: **10 hrs.**

Endomembrane concept, membrane flow, Structural organization of Endoplasmic Reticulam and Golgi Complex, targeting of proteins to ER, , insertion of proteins into ER membrane, Protein folding and exporting of proteins and lipids from ER to Golgi Complex, protein sorting and export from Golgi Complex to different cellular compartments, molecular mechanism of vesicle transport and vesicle fusion.

Module II. Cell Interactions **8 hrs.**

The Extra Cellular Matrix, Interactions of cells with Extra Cellular Materials – Integrins, Focal adhessionsand Hemidesmosomes : Anchoring of cells to their substratum. Interactions of cells with other cells – selectins, cadherins. Tight junctions, Gap junctions, Plasmodesmata mediated intercellular communications. Cell wall –structure, composition, function and biogenesis.

Module III. Cell Signalling **12 hrs.**

An overview of cell signaling system, Extracellular messengers (signaling molecules) Cell surface Receptors: G- Protein coupled receptors, Receptor tyrosine kinases (RTK), Ion channel receptors, Cytokine receptors (Tyrosine kinase linked receptors).

Second messengers: Cyclic-AMP, Cyclic-GMP, Inositol 1, 4, 5-trisphosphate (IP3), Di-acyl glycerol (DAG).

Signaling pathways: G-protein coupled receptor (GPCR) and cyclic AMP pathway –GPCR pathway in sensory perception, Receptor protein tyrosine kinase and Ras-MAP kinase pathway, Calcium phosphatidyl- inositol pathway, Regulation of signaling pathways - Convergence, divergence and crosstalk among different pathways.

Module IV. Cell Death and its significance **6 hrs.**

Programmed Cell Death or Apoptosis, molecular mechanisms of apoptosis – cascade of Caspase proteins, pro apoptotic regulators, trophic factors induced inactivation of pro apoptotic regulators. Tumor Necrosis Factor and related Death Signals. Significance of Apoptotic mechanisms. Aging and senescence.

Module V. Chemical Structure of DNA **10 hrs.**

Chemistry of DNA, Forms of DNA (A, B, C, D, T, and Z), DNA topology: DNA supercoiling, DNA-protein Interactions: General features, Interaction of Helix-turn Helix motif, B-sheet, Zn-DNA binding domains, etc with DNA. Organization of DNA into chromosomes - Packaging of DNA and organization of chromosome in bacterial cells; Packaging of DNA in eukaryotic nucleosome and chromatin condensation, assembly of nucleosomes upon replication.

Module VI. DNA replication & repair **10 hrs.**

Semiconservative replication, Initiation of chromosomal DNA replication and its regulation in prokaryotes, assembly of replisome and progress of replication fork, termination of replication. Structure and function of DNA polymerase, replication in eukaryotes. DNA repair - Nucleotide Excision Repair (NER), Base Excision Repair (BER), Ribonucleotide Excision Repair (RER), Mismatch Repair (MMR), Homologous Recombination (HR), Non - Homologous End - Joining (NHEJ).

Module VII. Gene Expression 10 hrs.

Flow of information through cells, Transcription - RNA polymerases, transcription in prokaryotes, transcription in eukaryotes Translation - Structure and role of t-RNA in protein synthesis, ribosome structure, basic features of genetic code and its deciphering, translation (initiation, elongation and termination in detail in prokaryotes as well as eukaryotes). Processing of proteome - Posttranslational processing of proteins (protein folding, processing by proteolytic cleavage, processing by chemical modification, Inteins), Protein degradation.

Module VIII. Regulation of Gene Expression 6 hrs.

Regulation of gene expression in prokaryotes - Operon concept, positive and negative regulation. Examples of lac-, ara, and trp- operon regulation; Regulation of gene expression in eukaryotes: Transcriptional, translational and processing level control mechanisms.

REFERENCES

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SEMESTER VIII

Zoology Core Paper - 7

Developmental Biology

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Early development **15 hrs.**

Germ plasm and determination of primordial germ cells, Gametogenesis – spermatogenesis, Oogenesis, structure of male and female gametes. Fertilization - Molecular mechanism of Fertilization, significance, Biochemistry of egg activation. Cleavage – process, types. Blastulation - types, fate map, significans of mid-blastula transition. Gastrulation – types of morhogenetic movements. Germ layer concept, derivatives of germ layers.

Module II. Axis and Pattern Formation – vertebrate model **15 hrs.**

Morphogenesis, Significance of axis formation in embryonic patterning – anterior posterior, dorsal ventral, left right axes. Axis formation in amphibian development – Spemann's constriction experiments, transplantation experiments. Embryonic induction, competence – Spemann organizer, Nieuwkoop centre and mesodermal signalling, Molecular basis of mesoderm induction, inducer molecules associated with organizer, Left-right axis formation.

Module III. Axis and Pattern Formation – invertebrate models **10 hrs.**

Early development and axis specification in *Caenorhabditis elegans.* Early development of *Drosophila*. Molecular mechanism of Anterior-posterior patterning in *Drosophila* - Maternal effect genes, zygotic genes, gap genes, pair rule genes, segment polarity genes; homeotic selector genes, realisator genes. Dorsal-ventral patterning and left right patterning.

Module IV. Postembryonic Development **12 hrs.**

Metamorphosis - Morphological changes associated with Amphibian metamorphosis – growth of new structures, cell death and remodelling during metamorphosis. Hormonal regulation of amphibian metamorphosis. Insect metamorphosis – role of imaginal discs. Hormonal control of insect metamorphosis.

Regenaration – different types; stem cell mediated, epimorphosis, morpholaxis, and compensatory. Mechanism of epimorhic regeneration in Salamander leg, Morphollactic regeneration in Hydra, Compensatory regeneration in mammalian liver. Lens regeneration in amphibia.

Module V. Teratogenesis **5 hrs.**

Malformations and disruptions, Gene – phene relationship, Autophene, Allophene and Pleiotrophy; Teratogenic agents – alcohol, retinoic acid, drugs and chemicals, heavy metals, pathogens, environmental oestrogens.

Module VI. Applied aspects of Developmental Biology **5 hrs.**

Human Infertility – types and causes (in brief); *In vitro* fertilization and other assisted reproductive technologies (ART). Cloning experiments - (Amphibians, Mammals and Human), ethical issues.

Module VII. Stem cells **10 hrs.**

Definition, Pluripotent, multipotent stem cells, embryonic stem cells & adult stem cells, Types of embryonic stem cells - Hematopoietic stem, neural stem cells, cord blood stem cells; Stem cells and therapeutic cloning, Stem cells and regenerative medicine, Transgenic stem cells, Stem cell banks, Ethical issues associated with stem cell experiments.

REFERENCES

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SEMESTER VIII

Zoology Core Paper - 8

Advanced Biochemistry

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Carbohydrate Metabolism 12 hrs.

Digestion and absorption of carbohydrates, Glycogen metabolism - Glycogenesis, Glycogenolysis, Adenylate cascade system, $Ca+^{2}$ Calmodulin - sensitive phosphorylase kinase. Key enzymes and regulation of glycogen synthesis. Glycolysis, Kreb – cycle, Regulation of carbohydrate metabolism. Minor metabolic pathways of carbohydrates: Pentose Phosphate pathway, Glucuronic acid metabolism, Galactose metabolism. Glyoxalate pathway. Cori's cycle

Module II. **Bioenergetics and Biological Oxidation** 12 hrs.

Phosphoryl group transfers and ATP. Enzymes involved in redox reactions. The electron transport chain - organization and role in electron capture. Oxidative phosphorylation - Electron transfer reactions in mitochondria. F1F0 ATPase - Structure and mechanism of action. The chemiosmotic theory. Inhibitors of respiratory chain and oxidative phosphorylation - Uncouplers and ionophores. Regulation of oxidative phosphorylation. Mitochondrial transport systems - ATP/ADP exchange, malate / glycerophosphae shuttle, creatine -phosphate shuttle.

Module III. Metabolism of Proteins 12 hrs.

Synthesis of biologically significant compounds from different amino acids with special reference to glycine, glutamic acid, phenylalanine, tyrosine and tryptophan. Catabolism of amino acid nitrogen -Transamination, deamination, ammonia formation and the urea cycle. Catabolism of carbon skeletons of amino acids. Conversion of amino acids to specialized products. Metabolism of purines - De novo and salvage pathways for biosynthesis. Purine catabolism. Biosynthesis and catabolism of pyrimidines.

Module IV. Metabolism of Lipids 8 hrs.

Alpha oxidation and omega oxidation of fatty acids. Metabolism of cholesterol, synthesis, regulation, transport and excretion. Biosynthesis of triglycerides, phospholipids and sphingolipids. Metabolism of ketone bodies - Ketogenesis. Metabolism of lipoproteins. Eicosanoid metabolism

Module V. Metabolism of Nucleic Acids 8 hrs.

Biosynthesis and degradation of purine and pyrimidine nucleotides and its regulation. Purine salvage pathway. Role of ribonucleotide reductase. Biosynthesis of deoxyribonucleotides and polynucleotides including inhibitors of nucleic acid biosynthesis.

Module VI. Metabolism of Vitamins and Minerals 8hrs.

Biosynthesis of Ascorbic acid, thiamine, pantothenic acid and Folic acid. Major and minor nutrients. Role of Calcium, Phosphorus, Magnesium, Sodium, Potassium, Chloride, Sulphur and Iron. Free radicals and antioxidants, Generation of free radicals. Reactive oxygen species. Free radical scavenger systems. Lipid peroxidation. Preventive antioxidants.

Module VII. Significance of Biochemistry in Health **12 hrs.**

Disorders of carbohydrate metabolism: Inborn errors associated with carbohydrate metabolism, Hypo - and hyper - glycemia, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, various types of glucose and galactose tolerance tests; glycogen storage diseases, pentosuria, galactosemia, lactose intolerance, galactosuria. **Disorders of lipid metabolism**: Plasma lipoproteins, cholesterol, triglycerides & phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's and Niemann-Pick disease, ketone bodies, Abetalipoproteinemia. **Other inborn errors**: Phenylketonuria, alkaptonuria, albinism, tyrosinosis, Lesch-Nyhan syndrome, sickle cell anemia, thalassemias and anemias, uremia, hyperuricemia, porphyria. **Enzymes in Health Diagnosis:** Principles of diagnostic enzymology , Enzyme assays – aspartate aminotransferase , creatinine kinase, lactate dehydrogenase, SGOT, SGPT, CPK, cholinesterase, LDH.

REFERENCES

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SEMESTER VIII

Zoology Core Paper - 9

Immunology

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Overview of the Immune System **10 hrs.**

Types of Immunity- Innate and acquired, Passive and active. Pattern recognition receptors - scavenger receptors and Toll – like receptors. Humoral and cell - mediated immune responses. B-cell and T-cell maturation and differentiation. Effector T cells, cytotoxic T cells, NK cells, ADCC. Cells and organs of the immune system: primary and secondary lymphoid organs, Hematopoiesis.

Module II. Antigens and Antibodies and Complement System **15 hrs.**

Properties of immunogens, haptens, epitopes, structure and classes of immunoglobulins, biological activities and effector functions, Monoclonal antibodies and abzymes. Polyclonal antibodies. Antigen processing and presentation. Genetic model compatible with Ig structure. Multi- gene organization of Ig genes. Variable region gene arrangements. Generation of antibody diversity. Expression of Ig genes and regulation of Ig genes transcription. Antibody genes and antibody engineering. Antigen- Antibody reactions. Biological consequences of antigen-antibody reaction. Complement activation Classical, Alternate and Lectin Pathways. Regulation of complement system. Biological consequences of complement activation. Complement deficiencies.

Module III. Immune Effector Mechanisms **10 hrs.**

Inflammation – inflammatory response and mediators. Types of Inflammation- acute and chronic. Anti-inflammatory agents. Chemokines. Role of cytokines in immune system. Properties and functions of Cytokines. Therapeutic uses of cytokines. Allergy and hypersensitivity. Genetics of allergic response in humans. Immune tolerance and autoimmunity: establishment and failure of tolerance. Cell mediated cytotoxicity.

Module IV. Major Histocompatibility Complex **10 hrs.**

General organization and inheritance of MHC. MHC molecules and genes. Genomic map of H-2 Complex in the mouse. HLA Complex in humans. MHC-peptide interaction. Expression of MHC molecules on different cell types. Regulation of MHC expression. MHC and graft rejection. MHC and disease susceptibility. Biological significance of MHC. HLA typing.

Module.V. Immunity in Health and Disease **15 hrs.**

Immune response during bacterial (tuberculosis), Parasitic (Malaria) and viral (HIV) infections. Congenital immunodeficiency diseases (SCID, WAS, CVI, Ataxia, CGD, LAD). Acquired Immunodeficiency Disease (AIDS). Organ- specific autoimmune diseases. Systemic auto-immune diseases. Animal models for autoimmune disease. Evidences implicating CD4+ T cell, MHC and TCR in autoimmunity. Induction of autoimmunity. Treatment of autoimmune diseases. Transplantation immunology. Immunologic basis of graft rejection. Clinical manifestation of graft rejection. General and specific immunosuppressive therapy. Clinical transplantation. Tumour immunology. Vaccines, Whole organism vaccines, Purified macromolecules as Vaccines, Recombinant vector vaccines, Synthetic peptide vaccines, Multivalent subunit vaccines.

Module VI. Immunological Techniques **12hrs.**

Serological Reactions, Agglutination and precipitation techniques. Radio-allergosorbent Test (RAST). Immunoprecipitation. Immunofluorescence. Flow cytometry and fluorescence. Immunofluorescence assays: Florescence activated cell sorter (FACS) technique, Immunoelectron microscopy. Immunoelectrophoresis, Radio Immunoassay, Cytotoxicity assay, ELISA, Cytokines assays: ELISPOT

REFERENCES

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SEMESTER VIII

Zoology Core Paper - 10

Advanced Genetics

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Molecular Organization of Chromosomes 10 hrs.

Structure of eukaryotic chromosome, nucleosome model. Chromosome condensation - euchromatin and heterochromatin. Repetitive nucleotide sequences in eukaryotic genomes, kinetics of renaturation: Cot and Cot curve. Unique and repetitive sequences. Mini and micro satellites. Molecular structure of centromere and telomere. Chromosome banding techniques.
Chemistry of DNA, Forms of DNA (A, B, C, D, T, and Z), DNA topology: DNA supercoiling, DNA-protein Interactions: General features, Interaction of Helix-turn Helix motif, B-sheet, Zn-DNA binding domains, etc with DNA.

Module II. DNA replication & repair 10 hrs.

Semiconservative replication, Initiation of chromosomal DNA replication and its regulation in prokaryotes, assembly of replisome and progress of replication fork, termination of replication. Structure and function of DNA polymerase, replication in eukaryotes. DNA repair - Nucleotide Excision Repair (NER), Base Excision Repair (BER), Ribonucleotide Excision Repair (RER), Mismatch Repair (MMR), Homologous Recombination (HR), Non - Homologous End - Joining (NHEJ).

Module III. Fine structure of Gene & Genetic code 10 hrs.

Concept of gene: Conventional and modern views. Modern findings on the nature of gene: Interrupted genes in eukaryotes, exons and introns - R loops, significance of introns. Genes – within - genes (overlapping genes). Transposable elements in Bacteria -IS elements, composite transposons, Tn3 elements, Transposable elements in Eukaryotes - P elements, Retrotransposons, pseudogenes, multi-gene families. Gene synthesis (in vitro synthesis) - works of Khorana and Kornberg. Genetic code - Basic features of genetic code, deciphering of genetic code, nature and characteristics of genetic code, redundancy and Wobble.

Module IV. Gene Expression 10 hrs.

Flow of information through cells, Transcription - RNA polymerases, transcription in prokaryotes, transcription in eukaryotes Translation - Structure and role of t-RNA in protein synthesis, ribosome structure, translation (initiation, elongation and termination in detail in prokaryotes as well as eukaryotes). Processing of proteome - Posttranslational processing of proteins (protein folding, processing by proteolytic cleavage, processing by chemical modification, Inteins), Protein degradation.

Module V. Regulation of Gene Expression 5 hrs.

Regulation of gene expression in prokaryotes - Operon concept, positive and negative regulation. Examples of lac-, ara, and trp- operon regulation; Regulation of gene expression in eukaryotes: Transcriptional, translational and protein processing level control mechanisms.

Module VI. Genetic Linkage, Recombination & Chromosome Mapping 10 hrs.

Chromosome theory of heredity, Linkage and recombination of genes in a chromosome, crossing over as the physical basis of recombination, Stern's Experiment; molecular

mechanisms of recombination (Holliday model), Gene conversion, Recombination mapping with two-point and three -point test cross in **Drosophila.** Genetic mapping by tetrad analysis in **Neurospora. Mitotic** recombination. Genetic recombination in Phage, rII locus, complementation test, deletion mapping, conjugation mapping, mapping by interrupted mating, mapping with molecular markers and mapping using somatic cell.

Module VII. **Genomic mapping and sequence analysis** 12 hrs.

Mapping genomes - physical maps, EST, SNPs as physical markers, radiation hybrids, FISH, optical mapping, gene maps, integration of physical and genetic maps; sequencing genomes: high-throughput sequencing, strategies of sequencing, recognition of coding and non-coding regions and annotation of genes, quality of genome-sequence data, base calling and sequence accuracy. Human genome project: History and concepts, gateways, goals, role of sequencing, distribution of GC content, CPG islands, main conclusions, current activities. Tracing human migrations with autosomal, Y0chromosomal and mitochondrial markers.

Module VIII. Epigenetics 5 hrs.

Epigenetics - a brief history of epigenetics - overview and concepts; chromatin modifications and their mechanism of action, concept of 'histone-code' hypothesis, RNAi and heterochromatin assembly, role of noncoding RNAs; Chromatin structure and epigenetics marks, chromatin remodeling. DNA methylation, genomic imprinting epigenetics and human disease, epigenetic determinants of cancer.

REFERENCES

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Russel,J,P., 2010. *Genetics.*Pearson International Edn.

Snustard,P and M. J. Simmons, 2010. *Principles of Genetics*. John Wiley and Sons

Strickberger, M.W.1968.*Genetics.* Macmillan Publishing Co.

Vogel F. and Motulsky A. G. (1997). *Human Genetics: Problems and Approaches*. Springer Verlag.

Watson et al., 2004. *Molecular Biology of Gene (5thedn*.). Pearson Education Inc. N. Delhi, India.

SEMESTER VIII
Zoology Core Lab Course - 2

(8 hrs. / Week) **Credits - 4**

1. Determination of mitotic index in the squash preparation of onion root tip.
2. Squash preparation of grasshopper testis to study meiotic stages.
3. Squash preparation and identification of salivary gland chromosomes in *Drosophila* / *Chironomus* larva.
4. Effect of drugs on cell division (Colchicine or any other inhibitor).
5. Cell fractionation and Differential Centrifugation to isolate mitochondria and nuclei.
6. Study of the developmental stages of Drosophila.
7. Preparation of Shell-less cultures of chick embryos.
8. Chorioallantoic membrane grafting with chick embryo limb buds.
9. Blastoderm mounting of chick embryo using vital stains.
10. Quantitative estimation of blood glucose by Folin-Wu/Anthrone /DNS/O-Toluidine/Enzymatic method.
11. Estimation of proteins by Biuret/ Lowry **etal.** method.
12. Quantitative estimation of blood urea/ creatine/ uric acid.
13. Quantitative estimation of cholesterol in the blood.
14. Estimation of alkaline and acid phosphatases.
15. Separation of lymphocytes from whole blood.
16. Separation of T and B lymphocytes.
17. Blood Grouping of Man.
18. WIDAL Test.
19. Rocket Immuno electrophoresis
20. Isolation of genomic DNA.
21. PCR amplification and analysis by agarose gel electrophoresis.
22. Restriction digestion and mapping.
23. Southern hybridization of genomic DNA with suitable gene as probe.
24. Isolation of total histones, and resolution on SDS-PAGE.
25. Preparation and characterization of soluble-chromatin (10 and 30 nm chromatin-fibers).

SEMESTER IX

Zoology Core Paper - 11

Applied Microbiology

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Medical microbiology **20 hrs.**

Human pathogenic bacteria and infections **-** Bacterial infections of respiratory tract, Bacterial infections of gastro intestinal tract and food poisoning, Bacterial urinary tract infections, Bacterial infections of genital tract and reproductive organs, Bacterial infections of central nervous system, Skin and soft tissue infections, Bone and joint infections, Eye ear and sinus infections, Cardiovascular infections, Anaerobic infections, Zoonotic infections. Infections associated with immunodeficiency and immune suppression, Pyrexia of unknown origin. Laboratory Procedures for Microbiology - Collection, transport, processing and identification of pathogens - cultural, biochemical, serological and molecular methods. Antibiotic susceptibility testing. Antimicrobial drug resistance - Mechanism and spreading. Antiseptics and disinfectants. Brief account of biomedical waste management-types of biomedical waste and waste treatment.

Module II. Environmental Microbiology **20 hrs.**

Diversity of microorganisms in air and their significance, Droplet nuclei, aerosol. Outdoor and indoor microflora. Determination of the microbial content of the air. Aeroallergens. Mode of transmission of airborne diseases. Control of air borne microorganisms. Microflora associated with water. Major waterborne diseases and their preventive measures. Sewage treatment system (primary, secondary, tertiary and final). Bacterial indicators of water safety and their assessment. Disinfection of potable water. Interactions between soil and microorganisms. Rhizosphere, mycorhizosphere and actinorrhizae. Bioremediation – Definition, Bioremediation of petroleum, pesticides (DDT), air pollutants and natural products (cellulose, xylan, lignin).

Module III. Industrial Microbiology **12 hrs.**

Biotechnological applications of microbes in the commercial production of the following: Alcoholic beverages: Beer, Whisky, Organic acids: Citric, lactic and acetic acid, Microbial enzymes: amylases, proteases and lipases, Microbial enzymes in textile, leather, wood industries and detergents & clinical diagnostics, Antibiotics: penicillin, tetracycline, Amino acids: Glutamic acid, lysine. Vitamins:Commercial production of Vitamin B12 and Riboflavin Production of Biofertilizers, Biopesticides, Single Cell Protein (SCP), steroid conversion and biotransformation.

Module IV. Food and Dairy Microbiology **15 hrs.**

Production and preservation of the following fermented foods - Soy sauce fermentation by Moulds, Fermented vegetables – Saurkraut, Fermented Meat – Sausages, Production and application of Bakers Yeast, Application of microbial enzymes in food industry, Food borne infections and microbes associated with them. Clostridium, Salmonella, Shigella, Staphylococcus, Campylobacter, Listeria. Mycotoxins in food with reference to Aspergillus species. Quality assurance : Microbiological quality standards of food. Microbiology of fermented milk products (acidophilus milk, yoghurt, cheese). Role of microorganisms in

beverages – tea and coffee fermentations. Vinegar Fermentation, microbiology of wine industry.

Module V. Agriculture Microbiology **5 hrs.**

Microbes in Biocontrol - Concept & applications, Biopesticides- concept & classification, advantages. Major biopesticides based on bacteria, viruses & fungi (Bacillus thuringiensis (Bt) toxin, Boverin, DeVine, Collego). Production and application of Rhizobium, Azospirillum, Azotobacter,phospho bacteria and Cyanobacteria.

REFERENCES

Aneja, K.R. 2010. *Experiments in Microbiology, Plant Pathology and Biotechnology*, 4th edition. New Age International Publishers, New Delhi.

Aneja, K.R. et al. 2008. *A Text book of Basic and Applied Microbiology*. New Age

Brooks, G.F., Butel, J.S., and Ornston, L.N.1995. *Jawetz, Melnick & Adelberg's Medical*

Casida, L.E. 1997. *Industrial Microbiology*. New Age International Publishers.

Coyne, M.S. 1999. *Soil Microbiology: An Exploratory Approach*, Delimer.

Demain, A.L. and Davies, J.E. 1999. *Manual of Industrial Microbiology and Biotechnology*.

Frazier W.C. and Westhoff C.D. 2008 *Food Microbiology*. Tata Mc Graw Hill Publishing Company Limited, New Delhi.

Madigan, M.T. and Martinko, J.M. 2006. *Brock Biology of Microorganisms*, Pearson Educational International.

Prescott, L.M. et al. 2005. *Microbiology*, McGraw Hill International Edition, USA.

Stokes, J., Ridway, G.L. and Wren, M.W.D. 1993. *Clinical Microbiology*, 7th Edn. Edward Arnold – a division of hodder and Stoughton.

Subba Rao, N.S. 1982. Advances in Agricultural Micobiology, Oxford and IBH Publn. Co., New Delhi.

Thomas J. Montville, Karl R. Matthews 2008. *Food Microbiology: An Introduction*. ASM Press, U.S.A.

Tilak, K.V.B.R. and Pal, K.K. and Dey, R. *Microbes for Sustainable Agriculture*. 2010. I.K. International Publishing House. New Delhi.

SEMESTER IX

Zoology Elective Paper - 1

Bioinformatics

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Bioinformatics – Introduction **10 hrs.**

Aim and branches of Bioinformatics, Application of Bioinformatics, Role of internet and www in bioinformatics. Basic biomolecular concepts: Protein and amino acid, DNA & RNA, Sequence, structure and function. Forms of biological information, Types of Nucleotide Sequence: Genomic DNA, Complementary DNA (cDNA), Recombinant DNA (rDNA), Expressed sequence tags (ESTs), Genomic survey sequences (GSSs). DNA sequencing methods: Basic and Automated DNA sequencing, DNA sequencing by capillary array and electrophoresis, Gene expression data.

Module II. Bioinformatics Databases **30 hrs.**

Major content of the databases, Primary databases - Nucleotide sequence databases: GenBank, EMBL, DDBJ ; Composite Databases - NRDB, UniProt, Literature Databases - Open access and open sources, PubMed, PLoS, Biomed Central. 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). Sequence Databases – Nucleotide sequence Databases (GenBank, EMBL,DDBJ). Protein sequences Databases (Swiss -Prot, 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 - GenBank, FASTA, 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). 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). Bioinformatics Database search engines - Text - based search engines (Entrez, SRS, DBGET/ LinkDB). Sequence similarity based search engines (BLASTBLASTand FASTA). Motif-based search engines (ScanPrositeScanProsite and eMOTIF). Structure similarity based search engines (VAST and DALI). Proteomics tools at the ExPASy server, GCG utilities and EMBOSS.

Module III. Sequence Analysis **12 hrs.**

Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues and xenologues, Scoring matrices: basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, matrix derivation methods and principles. Sequence alignment - Measurement of sequence similarity; Similarity and homology. Pairwise sequence alignment - Basic concepts of sequence alignment, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, gap penalties, use of pairwise alignments for analysis of Nucleic acid and protein sequences and interpretation of results.

Module IV. Genomics and Proteomics **20 hrs.**

Large scale genome sequencing strategies. Genome assembly and annotation. Genome databases of Plants, animals and pathogens. Metagenomics - Gene networks, basic concepts, computational model such as Lambda receptor and lac operon. Prediction of genes, promoters, splice sites, regulatory regions: basic principles, application of methods to prokaryotic and eukaryotic genomes and interpretation of results. Basic concepts on identification of disease genes, role of bioinformatics -OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays. Basic concepts in identification of Drought stress response genes, insect resistant genes, nutrition enhancing genes. Application of sequence based and structure - based approaches to assignment of gene functions. Gene/Protein function prediction using Machine learning tools viz. Neural network, SVM etc. Proteomics - Protein arrays: basic principles. Computational methods for identification of polypeptides from mass spectrometry. Protein arrays: bioinformatics - based tools for analysis of proteomics data (Tools available at ExPASy Proteomics server); databases (such as InterPro) and analysis tools. Protein - protein interactions: databases such as DIP, PPI server and tools for analysis of protein - protein interactions

REFERENCES

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Baxevanis, A.D. and Francis Ouellellette, B.F. 2009. *Bioinformatics - a Practical Guide to the Analysis of Genes and Proteins*. Wiley India Pvt Ltd.

Bourne P. E and Weissig H, 2003. *Structural Bioinformatics*.Wiley -Liss. USA.

David W. M. 2004. *Bioinformatics, Sequence and Genome Analysis* (2ndedn). CSHP, New York.

Krane, D. E and M.L. Raymer. 2006. *Fundamental concepts of Bioinformatics*. Pearson Education, New Delhi.

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Masaru Tomita and Takaai Nishioka, 2005. *Metabolomics.The Frontier of Systems Biology*. Springer Japan.

Mount D. 2004. *Bioinformatics : Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press, New York.

Pengcheng Fu and Sven Panke, (Eds.) 2009. *Systems Biology and Synthetic Biology*. John Wiley & Sons, Inc. N.J, USA.

Teresa K. Attwood, David J. Parry 1999. Smith Introduction to bioinformatics. Pearson Education.

Tisdall J. D, 2001. *Beginning Perl for Bioinformatics*.O'Reilly Media Inc.CA,USA

SEMESTER IX

Zoology Elective Paper - 2

Recombinant DNA Technology

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Introduction to Recombinant DNA Technology **20 hrs.**

Outline process of genetic engineering and recombinant DNA technology, Isolation of genes, exonuclease & endonuclease Concept of restriction and modification - Restriction endonucleases - types of restriction endonucleases, classification and uses. DNA modifying enzymes - Nucleases, Polymerases, Phosphatases and DNA ligases. Different Kinds of Vectors - Plasmids, Phage vectors, Cosmids, Phagemids, Virus vectors – for animal cells; vector for plant cells;, Shuttle vectors and expression vectors- YACs, BACs, PACs, BIBACs, Protein Expression Vectors.

Module II. Host-vector system **12 hrs.**

Cloning vectors for *E. coli*., Cloning vectors for Eukaryotes- methods of transformation - Cloning strategies, construction of genomic libraries and cDNA Libraries. Probe construction, recombinant selection and screening, Molecular cloning. DNA Sequencing -- Protein Engineering: Site Directed Mutagenesis -- Reporter Gene Assays -- DNA Protein Interactions: EMSA, DNA Footprinting.

Module III. Analysis of expression. **20 hrs.**

Analysis of recombinant DNA (Selection methods – antibiotics, expression basis, GUS expression), sequencing (chemical degradation; chain termination and automated sequence).mutagenesis, altered expression and engineering genes. Site-directed mutagenesis. DNA amplification using polymerase chain reaction (PCR): key concepts, Analysis of amplified products. Southern blot, Northern blot and Western blot Applications of PCR : Ligase chain reaction. RFLP, RAPD, DNA Finger printing. Strategies of gene delivery, in vitro translation, expression in bacteria and yeast, expression in insects and insect cells, expression in mammalian cells, Chromosome engineering, Targeted gene replacement, gene editing, gene regulation and silencing.

Module IV. Application of rDNA Technology. **20 hrs.**

Recombinant DNA Technology in basic research – mapping and sequencing of genes, in analyzing gene expression, rDNA generated proteins as reagents in laboratory experiments and to generate antibody probes. rDNA in medicine and pharmaceuticals – Humulin, Recombinant chymosin, Recombinant human growth hormone, Recombinant blood clotting factor VIII, Recombinant hepatitis B vaccine, in diagnosis of HIV. Gene therapy – haemopoietic cells, genetically engineered bone marrow cells, skin fibroblasts, hepatocytes, myoblast and genetically modified lymphocytes. rDNA in agriculture – insect resistant crops (Bt toxin), herbicide resistant crops, golden rice. Transgenic organisms, glofish, ethical and environmental issues with transgenic organisms.

REFERENCES

Glover, DM. and BD. Hames .1995. *DNA Cloning: A Practical Approach*. IRL Press, Oxford.

Innis, M.A., D.H. Gelfand and J.J. Sninskey .1995. *PCR Strategies*. Academic Press, San Diego.
Old, R.W and S.B. Primrose. 1996. *Principles of Gene Manipulation: An Introduction to Genetic Engineering*. Blackwell Scientific Publications, Oxford.
Persing, D.H., K T.F Smith, F.C. Teower and T.J.While. 1993. *Diagnostic Molecular Microbiology*. ASM Press, Washington D.C.
Tvan R.S. 1997. *Recombinant Gene Expression Protocols*. Humana Press Inc., Tokowa.
Watson J.D.,Gilman M., Witkowski,J., and Zoller M. 1992. *Recombinant DNA*. Scientific American Books, New York.

SEMESTER IX

Zoology Elective Paper - 3

Enzymology

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Introduction to Enzymology **12 hrs.**

Introduction and historical developments in enzymology. Protein Structure - Primary, secondary, tertiary and quaternary structure, techniques used in enzyme characterization. Enzyme classification - IUB enzyme classification. Enzyme Activity - Principle and techniques of enzymatic analysis, factors affecting enzyme activity, Extraction and Purification of enzyme - Objectives and strategy, separation techniques, test of purity.

Module II. Enzyme Kinetics **20 hrs.**

Enzyme Kinetics – Definition, Bioenergetics and Catalysis. Single substrate kinetics - Equilibrium and Steady state kinetics, significance of Km, Vmax & Kcat. Pre - steady state and Relaxation kinetics. Multisubstrate kinetics - General rate equation, compulsory order, random order and ping - pong mechanisms and their primary and secondary plots. Enzyme inhibition and its kinetics - Reversible and irreversible inhibition, competitive, non - competitive and uncompetitive, mixed, partial, substrate and allosteric inhibition. Thermal kinetics - Effect of temperature on reaction rate, enzyme stability, Arrhenius equation and activation energy.

Module III. Mechanism of Enzyme Action **20 hrs.**

Enzyme activators, co-enzymes and co-factors in enzyme catalysis, Enzyme and substrate specificity, Investigation of active Centre, Factors affecting catalytic efficiency, Experimental approaches to determine enzyme mechanisms. Enzyme mechanisms - Lysozyme, Chymotrypsin, Carboxypeptidase, Restriction endonuclease, Aspartate transcarbomylase. Isoenzymes and its physiological significance, Ribozymes and Abzymes. Allosteric enzymes and sigmoidal kinetics - Protein ligand binding, Co-operativity, MWC & KNF models, Regulation of enzyme activity. Control of metabolic pathways.

Module IV. Enzyme engineering **10 hrs.**

Chemical modification of enzymes - methods of modification of primary structure, catalytic and allosteric properties, use of group specific reagents. Enzyme Immobilization, Enzymes in non conventional media, production of enzymes – extraction, bacterial fermentation, purification, storage.

Module IV. Applied Enzymology **10 hrs.**

Sources of enzymes for commercial applications, Enzymes as analytical reagents, Enzymes as biosensors, Applications of enzymes in pharmaceutical industries, Application in therapeutics, Industrial applications of enzymology, enzymes in food and fermentation industry, biodetergents, enzymes in agriculture

REFERENCES

Dixon M., E. C. Webb, CJR Thorne and K. F. Tipton. *Enzymes*. Longmans, London.
Fersht A. *Enzyme Structure and mechanism*: Reading, USA.

Heinemann B. 2004. *Principles of Enzymology for Technological Applications.*For Elsevier India.
K. J. Laider and P. S. Bunting. *The chemical kinetics of enzyme action* . Oxford University
Kumaresan V. 2006. *Biotechnology* 6th Edn. . Saras Publications, Nagercoil, India
Press, London.
Price N. C. and Lewis Stevens. *Fundamentals of Enzymologist.* Oxford Univ. Press.
Purohit S. S., Kakrani H. N., Saluja A. K. 2003. Pharmaceutical Biotechnology. Student Edition Publishers, Jodhpur, India.

SEMESTER IX

Zoology Elective Paper - 4

Nanobiology

(4 hrs. / Week, Total content 72 hrs.) **Credits - 4**

Module I. Biopolymers and Bio logical Nanomachines **12 hrs.**

DNA - structure, geometry, topology and modification; Proteins - enzymes and structural proteins; lipids - fatty acids, phospholipids, glycolipids, protein - lipid assembly and biomimetic nanostructures; lipid nanoparticles, micelle; polysaccharides - starch, cellulose, agar, agarose, pectin, xanthan etc. Biological nanomachines – definition, DNA polymerases - DNA pol I , DNA pol II and DNA pol III; helicases, ligases, topoisomerases, recombinase, transposase, RNA polymerases - RNA pol I , RNA pol II and RNA pol III .

Module II. Nanomachines in protein metabolism **12 hrs.**

Ribosome structure - 30S, 50S, 40S and 60S sub units; tRNA & Mrna - structure, 5' UTRs, 3'UTRs, polyA tail; protein synthesis; structure of protein - primary, secondary, tertiary and quaternary structures, peptides, proteasome - structure and function; antibodies – structure, monoclonal antibodies, single chain antibodies; phage display of peptides.

Module III. Nanomotors **8 hrs.**

Types - rotary motors - bacterial flagella, ATP synthase; Linear molecular motors - actomycin responsible for muscle contraction; dynein - microtubule system; Kinesin - microtubule system; transport of vesicles.

Module IV. Nanometerials and methods of preparation **15 hrs.**

Types of nanomaterials - nano rods, nanowires, nanoparticles, nanocapsules, nano membranes, nano meshe, nano fibres, nano catalysts, carbon nano tubes. Methods of preparation of nanomaterial - top down and bottom up approaches, emulsifiers, homogenizers, MOCVD etc. Nanobioassemblies - Different types of inorganic materials used for the synthesis of hybrid nano-bio Assemblies. Nanomaterial characterization - AFM, HR-TEM, Particle size analyzer, Zetasizer. Devices used in nano biology - Micro & Nano fluidics, Micro - fabricated Devices for cell biological applications, micro - fabricated devices to study directed cell migration, Q dots and imaging applications, single molecular analysis, biosensors, Lab-on-a-chip. Formulation of nanocrystals, nanoemulsions, polymeric micelles. Introduction to liposome and solid lipid nanoparticles (SLN). Fate of nanoformulations in body.

Module V. Applications of Nano Biology **25 hrs.**

Nano biotechnology - Bioelectronics systems based on photosystem, Devices based on bacteriorhodopsin, bio polymers. Food industry applications - lipid and starch nano carriers, flavors, nanosalt, oil in water emulsions, breathing bags, nanosensors, taste, color. Nanomedicine - nano carriers for drug delivery, nanoparticle mediated delivery of siRNA, nanotechnology in drug discovery, nano - formulation of herbal medicine, dermal delivery ; nano - scafolds and their use in cell culture, organ culture and tissue engineering, nano - cosmetics. Regulatory aspects in the approval of nano medicine, Toxicological considerations in Nano medicine and nano-delivery systems. Nanotechnology in molecular imaging.

Environmental applications - Nano clays, nano adsorbents, zeolites, release of nutrients and pesticides, biosensors - green technologies, molecular biomimetic, nano remediation - Identification and characterization of Hazardous waste, nano pollution, air - water - soil contaminants, identification and characterization of organics and inorganics, Treatment of industrial waste waters using nano - particles.

REFERENCES

Boisseau P., P. Houdy and M.Lahmani, (Eds.). 2009. *Nanoscience : Nanobiotechnology and Nanobiology* . Springer, Heidelberg.

Challa S., S. R. Kumar, J. H. Carola. 2006. *Nanofabrication towards biomedical application: Techniques, tools, Application and impact*. John Wiley and sons.

Ehud Gazit. 2007. *Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology*. Imperial college Press.

Garti N. and Amar-yuli I. 2011.*Nanotechnologies for Solubilization and Delivery in Food, Cosmetics and Pharmaceutics*. DEStech publications.

Harry F. Tibbals. 2010. *Medical Nanotechnology and Nanomedicine*. CRC Press.

Jo Anne Shatkin. 2008. *Nanotechnlogy: Health and Environmental risk*. CRC press.

Mao Hong fan, Chin-pao Huang, Alan E Bland, Z Honglin Wang, Rachid Sliman and Ian Wright. 2010. *Environanotechnology* . Elsevier.

Tuan Vo-Dinh. 2007. *Nanotechnology in Biology and Medicine: Methods, Devices and Application*. CRC press.

5 Year Integrated interdisciplinary M.Sc (Integrated)
Course Structure and Syllabus for
Five-Year Integrated M. Sc. Course in Physics:

Semester- VII

CORE 1
IPC 1001 Mathematical Methods in Physics (4)

Matrix Algebra: Definition, Algebra of matrices, Special matrices, Eigen-values and Eigenvectors,LU-Decomposition, Solution of Linear system by LU-Decomposition.
Complex variables: Analytic functions, Cauchy-Riemann conditions, Cauchy's Integral theorem and Integral formula, Laurent expansion, Singularities, Evaluation of residues, Residuetheorem.
Second order differential equations: Partial differential equations of theoretical physics,separation of variables – ordinary differential equations, singular points, series solutions –Frobenius' method.
Special Functions: Gamma and Beta functions, Relation between Gamma and Beta functions,Duplication formula, Error function, Bessel's Functions of different kinds, Integral representations of Bessel's Functions, Orthogonality of Bessel's Functions, Modified Bessel's Functions, Legendre Polynomials, Recurrence relations, Rodrigue's formula, Orthogonality of Legendre Polynomials, Associated Legendre Function, Hypergeometric Functions and its integral representation.
Fourier Series: General Properties, Advantage and uses of Fourier series, Applications of Fourier series.
Integral Transform: Laplace Transform, Inversion, Convolution Theorem, Applications of Laplace Transform; Fourier Transform, Inversion, Fourier Sine and Cosine transform, Convolution Theorem, Fourier transforms of derivatives. Applications of Fourier Transform.

Text books

1. Hans J. Weber George B. Arfken, *Mathematical Methods for Physicists*, (2005), Academic Press.
2. L. A. Pipes, *Applied Mathematics for Engineering and Physics* (1958) McGraw-Hill.

References:

1. Charlie Harper, *Introduction to Mathematical Physics* (2003), Prentice-Hall India.
2. Erwin Kreyszig, *Advanced Engineering Mathematics* (1999), Wiley.
3. N. P. Bali, A. Saxena and N.C. S. W. Iyengar, *A Text Book of Engineering Mathematics* (1996), Laxmi Pushiations (P) Ltd.

CORE II
IPC 1002 Electrodynamics (4)

Electrostatics: The concept of a scalar potential. Poisson's and Laplace's equations for scalar potential. Green's theorem, Electrostatic field energy density. Solutions of Laplace's equation in rectangular, spherical and cylindrical coordinates using the method of separation of variables. Multipole expansion of potential due to a localized charge distribution. Dipole and quadrupole fields. Interaction energy of dipole and quadrupole in an external field. Electrostatics in matter; Polarization and electric displacement vector. Electric field at the boundary of an interface. Clausius - Mossotti equation.

Magnetostattics, Time Varying Fields and Maxwell's Equations: Foundations of Magnetostatiscs, Scalar and Vector potentials, Magnetic moment of a current distribution. Macroscopic magnetostatics, Magnetization. M and H vectors, Maxwell's displacement current. Maxwell's equations. Vector and scalar potential. Lorentz and Coulomb gauge. Conservation of energy and momentum of a system of charged particles and electromagnetic fields. Field energy and field momentum.

Solutions of Maxwell's Equations and Radiation: Plane waves in dielectrics medium. Polarization, reflection and refraction at a plane interface between dielectrics, Fresnel's equations. Phase velocity and group velocity, spreading of a pulse propagating in a dispersive medium, propagation in a conductor, skin depth. Wave guides and cavity resonator. Radiation due to localized oscillatory source, near and far zones, radiated power due to an electric dipole, magnetic pole, example of a centre - fed linear antenna as an electric dipole radiator. Retarded green's function. Lienard-Wichert potentials and fields for a point charge. Larmor's formula for power radiated by a slowly moving accelerated charge. Thomson scattering, Rayleigh scattering and application to nanoparticles.

Text Book: *Classical Electrodynamics,* J. D. Jackson

References

1. *Introdiuction to Electromagnetic Fields and Waves*, D. R. Corson and P. Lorrain
2. *Introduction to electromagnetics,* D. J. Griffiths
3. *Electromagnetic Theory,* J. A. Statton, McGraw Hill

CORE III

IPC 1003: Classical Mechanics and Relativity (4)

Constrained Motion: Constraints, Classification of Constraints, Principal of Virtual Work,D'Alembert's principal and its applications

Lagrangian formulation: Generalized coordinates, Langrange's equations of motion, properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi integrals and energy conservation, Concept of symmetry, invariance under Galilean transformation, velocity dependent potential.

Hamilton's formulation: Hamilton's function and Hamilton's equation of motion, configuration space, phase space and state space, Lagrangian and Hamiltonian of relativistic particles and light rays.

Canonical Transformations: Generating function, Conditions for canonical transformation and problem.

Poisson Brackets: Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, (statement only), invariance of PB under canonical transformation. **(4)**

Rotational Motion: Rotating frames of reference, inertial forces in rotating frames, Larmour precision, electromagnetic analogy of inertial forces, effects of Coriolis force, Focoult's pendulum.

Central Force: Two body central force problem, stability of orbits, condition for closure, integrable power laws, Kepler's problems, orbits of artificial satellites, Virial theorem. **(5)**

Relativity: Special theory of relativity, Lorentz's transformation, covariant four – dimensional formulations, force and energy equations in relativistic mechanics **(5)**

Text Book: Classical Mechanics by H.Goldstein, Pearson Education Asia.

References:

1. Classical Dynamics of Particles and Systems by Marion and Thomtron, Third Edition, Horoloma Book Jovanovich College Publisher.
2. Classical Mechanics by P.V.Panat, Narosa Publishing Home,, New Delhi.
3. Classical Mechanics by N.C.Rana and P.S.Joag, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
4. Introduction to Classical Mechanics by R.G.Takawale and P.S.Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.

CORE IV

IPC 1004 Quantum Mechanics (4)

Introduction to quantum mechanics: Schrödinger wave equation, interpretation of wave function, probability current density. Solutions:one dimensional square well and barrier,. Linear harmonic oscillator, Heisenberg and quantum mechanical treatments. Spherically symmetric potential in three dimensions, hydrogen atom.

Scattering theory and WKB approximation method: Scattering cross sections and coefficients, scattering by spherically symmetric potentials, scattering by a coulomb field. Born approximations, WKB approximations, boundary conditions in the quasi classical case,

Angular momentum, spin and identical particles: Angular momentum, various commutation relations, eigenvalues and eigenfunctions of the angular momentum, spin, spin operators, Pauli's spin matrices, spinors, the principle of in distinguishaility of identical particles, Pauli's exclusion principle,

Perturbation theory: Perturbation independent of time, first and second order, the effect of the electric field on the energy levels of an atom (Stark effect), perturbations depending on time, first order transitions, constant perturbation, fermi golden rule, interaction of an atom with electromagnetic radiation, the Einstein's A & B coefficients.

Relativistic wave equations: Klein-Gordon equation for a free particle and particle under the influence of an electromagnetic potential, Dirac's relativistic Hamiltonian, Dirac's relativistic wave equation, significance of negative energy states,

Text Book: Quantum theory by L.I.Schiff. (Tata McGraw, New Delhi)

References:

1. Quantum Mechanics by L. D. Landau and E. M.Lifshitz (Pergamon, Berlin)
2. Introduction to Quantum Mechanics; D.J.Griffith
3. Quantum Mechanics by A.K.Ghatak and Loknathan.
4. A Modern Approach to Quantum Mechanics by J.S. Townsend, Viva Books, 2010
5. Quantum Mechanics, B.C. Reed, Viva Books, 2010

CORE V

IPC 1005 Statistical Physics (4)

Formalism of Equilibrium Statistical Mechanics: Concept of phase space, Liouville's theorem, basic postulates of statistical mechanics, ensembles: microcanonical, canonical, grand canonical, and isobaric, connection to thermodynamics, fluctuations, applications of various ensembles, equation of state for a non-ideal gas, Van der Waals' equation of state, Meyer cluster expansion, virial coefficients.

Quantum Statistics: Formalism of Fermi-Dirac and Bose-Einstein statistics. Applications of the formalism to: (a) Ideal Bose gas, Debye theory of specific heat, properties of black-body radiation, Bose- Einstein condensation, degeneracy, BEC in a harmonic potential. (b) Ideal Fermi gas, properties of simple metals, Pauli paramagnetism, electronic specific heat, white dwarf stars.

Phase Transitions and Critical Phenomena: Thermodynamics of phase transitions, metastable states, Van der Waals' equation of state, coexistence of phases, Landau theory, critical phenomena at second-order phase transitions, spatial and temporal fluctuations, scaling hypothesis, critical exponents, universality classes.

Ising Model: Ising model, mean-field theory, exact solution in one dimension, renormalization in one dimension.

Nonequilibrium Systems: Systems out of equilibrium, kinetic theory of a gas, approach to equilibrium and the H-theorem, Boltzmann equation and its application to transport problems, master equation and irreversibility, simple examples, ergodic theorem. Brownian motion, Langevin equation, fluctuation-dissipation theorem, Einstein relation, Fokker-Planck equation.

Text Book: Statistical Physics, Landau and Lifshitz, Pergamon Press

References:

Statistical Physics, R. K. Patharia, Pergamon Press
Statistical Physics, Kerson Huang, John Wiley and Sons
Statistical Physics, S. K. Ma, World Scientific Publishing, Singapore

CORE VI
Semester – VIII
IPC: Electronics and Instrumentation (4)

Electronic Devices Varactor diode, photo-diode, Schottky diode, solar cell, metal-semiconductor junction. Principle of Operation and I-V Characteristics of FET, MOSFET, Basics of CCD

Integrated Analog Electronics : Basics of operational amplifiers, voltage gain, input and output impedance of inverting amplifier, non-inverting amplifier; phase inverter, scale changer, integrator, differentiator. voltage multiplier, limiter, clipper, clamper and peak-to-peak detector, difference amplifier, instrumentation amplifier, active filters (low-pass, high-pass, band-pass, band-reject/ notch), RC phase shift and Wein bridge oscillators; comparators, schmitt trigger, multivibrators, AMV and MMV using 555 timer, waveform generation, power supply circuits, analog computation using op-amps. D/A converters, binary weighted, ladder type, A/D converters, simultaneous, counter type, successive approximation type, dual slope converter, comparison of converter types.

Digital Electronics: Introduction to various logic families; Combinational Circuits, adders, subtracters, multiplexers, demultiplexers, encoders, decoders, Sequential circuits, flip-flops, RS, JK, Master Slaves, T and D Flip-Flops, controlled registers, shift registers, synchronous and asynchronous counters, controlled counters, up/down counters, ring counter Memories ROM, PROM, EROM, EEPROM, RAM static and dynamic, Basic idea of computer organization, microprocessor system design, data communication and interfacing

Introduction of measurements and measurement systems: Measurement Basics (range, resolution, linearity, hysteresis, reproducibility and drift, calibration, accuracy and precision. Effect of loading), errors and noise in measurements, noise reduction techniques

Analog Instruments: Classification and principles of operation analog electronic voltmeter, DC voltmeter with chopper amplifier

Introduction of DC and AC Bridges: Wheatstone Bridge, Kelvin Double Bridge, Maxwell's Bridge. Amplification, signal conditioning and signal recovery (idea of superheterodyning), Idea of computer based data acquisition, PID controller and Supervisory Control System (SCADA)

Digital Instruments Advantages of digital over analog processing. Digital voltmeter and frequency meter

Transducers: Definition, classification, principle of analog transducer: resistive (strain gauge, thermistor and RTD), capacitive, piezoelectric, thermocouple and LVDT, digital transducer and optical transducers. Actuators Pneumatic cylinder, Relay, Solenoid **(4)**

Text Books:

Electronic Devices: Solid State Electronic Devices – B. G. Streetman, PHI, Physics of Semiconductor Devices – S. M. Sze.

Electronics Circuits & Systems: Integrated Electronics - Millman & Halkias, McGraw Hill, Operational Amplifiers and Linear Integrated Circuits - R. F. Coughlin, F. F. Driscoll, PHI., Operational Amplifiers and Linear Integrated Circuits - R. A. Gayakwad, PHI.

Digital Electronics: Digital Computer Electronics - Malvino, TMH.

Instrumentation: Electrical and Electronic Measurements and Instrumentation - A. K. Sawhney, Electronic Instrumentation - H. S. Kalsi, Modern Electronic Instrumentation & Measurement Techniques - Helfrick & Cooper

References: Electronic Devices and Circuits – T.F. Bogart Jr., J.S.Beasley and G.Rico,Pearson Education, 6th edition,2004. **Microelectronics** – Millman and Grabel, Tata McGraw Hill, 1988. **Electronics Fundamentals and Applications** ,J. D. Ryder, , Prentice Hall of India , New Delhi ,1987. **Electrical and Electronic Measurements and Instrumentation**, Sawhney, Dhanpatrai and Sons, New Delhi , 1982.

CORE VII

IPC: Atomic, Molecular and Modern Spectroscopy (4)

1. Atomic Physics: Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Relativistic corrections for energy levels of hydrogen; Hyperfine structure and isotopic shift; Spectral terms of two electron atoms, terms for equivalent electrons, L-S and J-J coupling schemes, Singlet-Triplet separation for interaction energy of L-S coupling. Lande Interval rule, Zeeman, Paschen Back & Stark effect; width of spectral lines
2. Molecular Spectroscopy: Rotational, vibrational and electronic spectra of diatomic molecules; Frank – Condon principle and selection rules, Raman Effect, Rotational Raman spectra. Vibrational Raman spectra. Stokes and anti-Stokes lines and their Intensity difference, Rule of mutual exclusion, Importance of neutral hydrogen atom, Molecular hydrogen, Fluorescence and Phosphorescence
3. NMR Spectroscopy: Nuclear spin, nuclear resonance, saturation, chemical shift, de shielding, spin-spin interaction, coupling constant J, basic ideas about instrumentation of NMR, applications.
4. Mass Spectroscopy: Ion production, fragmentation, ion analysis, ion abundance, mass spectroscopy, instrumentation and application.
5. Mossbauer Spectroscopy: Spectral parameters and spectrum display, Isomer shift, quadruple splitting, hyperfine interaction and applications

Text Books:

1. "Introduction to Atomic Spectra", H.E. White, McGraw-Hill
2. “Atomic Physics”, G. P. Harnwell & W.E. Stephens, McGraw-Hills Book Company, Inc.
3. “Fundamentals of Molecular Spectroscopy” C. N. Banwell & E. M. McCash, Tata McGraw-Hill
4. “Modern Spectroscopy”, J. M. Hollas, John Wiley
5. “Preparation of Molecular Physics” A. Beisen, McGraw-Hill.
6. The Feynman Lectures on Physics by R. B. Feynman, R. B. Leighton, M. Sands, Narosa Publishing House

CORE VIII

IPC Condensed Matter Physics (4)

Crystal Structure: Crystalline and amorphous solids, unit cell, reciprocal lattice, lattice planes and Directions, HCP structure, diamond structure, various types of crystal defects, Burger vector

Thermal Properties of Materials: Phonons, heat capacity, Thermal expansion and conductivity Density of states in 1D and 3D, Vibration of lattice - mono- and di-atomic chains.

Electrical Properties of Materials: Density of energy states and Fermi energy, Electrical conductivity from Quantum Mechanics consideration, Electron Scattering and sources of resistance in metals, Electron-Scattering Mechanism and variation of resistivity with temp, Band theory of solids, and origin of energy gap, Bloch functions, Kronig Penny model, periodic & nonperiodic potential, Hall Effect & Hall coefficient.

Semiconductors: General properties and band structure, carrier statistics, impurities, intrinsic and extrinsic semiconductors, p-n junctions, equilibrium fields and densities in junctions, drift and diffusion currents, Hall Effect & Hall coefficient, Generation and recombination of carriers, Theory of p-n junction.

Magnetic Properties of Materials: Classification of magnetic materials, Quantum theory of para & ferromagnetism. Weiss theory of paramagnetism, Crystal field splitting, Magnetic ordering, Magnetization, Hysteresis, theory of ferromagnetism, Weiss Molecular theory, temperature dependence of spontaneous magnetization, Ferromagnetism domains, Bloch wall, Antiferromagnetism, Ferrimagnetism.

Superconductivity: type-I and type-II superconductors, Meissner effect, Concept of energy gap, Optical properties of SC, London equation, BCS theory, Giaver and Josephson tunneling.

Dielectrics and Ferroelectrics: polarization, A.C effects, Clausius-Mossotti relation, ferro electric hysteresis loop, antiferroelectricity, piezo-electricity. 4

References

1. C. Kittel: Introduction to Solid State Physics, Wiley Eastern Ltd., New Delhi - 1988.
2. S. O. Pillai: Solid State Electronics Engineering Materials,Wiley Eastern Ltd. New Delhi, 1992.
3. A. J. Dekker: Solid State Physics, Macmillan, 1962
4. Asheroft & Mermim: Solid State Physics

CORE IX

IPC: Fiber Optics and Integrated Optics (4)

1. **Overview of Optical Fibers:** Structure of optical fibers. Step-index and graded index fibers; Single mode, multimode and W-profile fibers. Ray Optics representation. Meridional and skew rays. Numerical aperture and acceptance angle. Multipath dispersion materials – Material dispersion - Combined effect of material and multipath dispersion - RMS pulse widths and frequency response - Model Birefringence - Attenuation in optical fibers - Absorption - Scattering losses - Radiative losses. Photonic crystal fibers.

2. Wave Propagation in Step-index Fibers: Modes in an ideal step-index fiber - Weakly guiding solutions - Time dispersion - Material Dispersion and Waveguide dispersion in single-mode fibers.

3. **Wave Propagation in Graded-index Fibers:** Modes in graded index fibers. Approximate solution (WKB Approximation). No. of propagating modes. The equivalence of WKB Approximation and the ray model. Inter model and Intra model dispersion in graded-index Fibers. Mode coupling.

4. Optical Sources: Light -Emitting Diodes and laser diodes. Fiber lasers. Power launching and coupling techniques. Source of Power coupling. Fiber to Fiber joints and splitting techniques.

5. **Photo Detector and Sensors:** Photo Detectors, PIN Photodiodes and Avalanche photodiode. Noise performance. Fiber Optics sensor and photonic circuits. Optical fiber fabrication and cabling. fiber assessment. (measuring techniques for fiber characteristics); Measurement of attenuation, index profile, numerical aperature. Time domain and frequency domain dispersion measurement. Application of fiber optics. **(11)**

Text Book: *Optical Communication Systems* by John Gowar.

References:

Optical Fiber Communication Systems by Gerd Keiser.
Introduction to Optical fibers: A.K. Ghatak and K. Thayagarajan

CORE X

IPC Modern Computational Techniques & Programming (3)
Theory & Lab work using Matlab and Maple software for solving problems of following topics:

1. **Approximation Methods and Errors:** Accuracy and precision, Truncation and round-off errors.
2. **Roots of Equations**: Bracketing Methods (false position, bisection), Iteration Methods (Newton-Raphson and secant).
3. **Systems of linear algebraic equations:** Gauss elimination, matrix inversion and LU decomposition methods.
4. **Curve fitting and Interpolation :** Least squares regression, Linear, multiple linear and nonlinear regressions, Cubic spline. Newton's divided difference and Lagrange interpolating polynomials.
5. **Numerical differentiation and integration:** Divided difference method for differentiation, Newton-Cotes formula, Trapezoidal and Simpson's rules, Romberg and Gauss quadrature methods.
6. **Ordinary differential equations:** Euler's method and its modifications, Runge-Kutta methods,Boundary value and Eigen value problems.
7. **Partial differential equations:** Finite difference equations, Elliptic equations, Laplace's equation and solutions, Parabolic equations, Solution of the heat conduction equation. Finite element method: General approach, Application to 1-dimensional and 2-dimensional problems.

REFERENCES:

1. Numerical Mathematical Analysis, J.B. Scarborough, John Hopkins (1966).
2. Introductory Methods of Numerical Analysis, S.S. Sastry, Prentice Hall of India (1983)
3. Numerical Methods for Engineering, S.C. Chopra and R.C. Canale, McGraw-Hill (1989).
4. Numerical Methods for Scientists and Engineers, Prentice Hall of India (1988).
5. Electromagnetics and Calculation of Fields, Nathan P-Ida and J.P.A. Bastos, Springer-Verlag (1992).

CORE XI

Semester IX

IPC Nuclear Physics and Engineering (4)

1. Properties of Nucleus:

Charge distribution, spin and parity, nuclear angular momentum, nuclear magnetic dipole moment, stability of nuclei, nature of the nuclear force.

2. Nuclear Models:

Liquid drop model, magic number, shell model and Collective model

3. Nuclear Fission and Fusion:

Fission: energy released in fission, nuclear reactors, condition for criticality, typical layout of nuclear reactor, and **Fusion:** energy released in fusion, Lawson's criterion for fusion, source of Stellar energy (carbon-nitrogen and proton-proton cycle).

4. Accelerators:

Motion of charged particle in electric and magnetic field, Van de Graff, Cyclotron, Linear accelerators and neutron generator

5. Classification of particles:

Elementary particles and their numbers (charge, spin, parity, isospin, strangeness, etc.), Gellman- Nishijima formula, Fermions-Bosons, Leptons and Hadrons, Mesons and Baryons, C, P, T invariance, Quark model.

Text Book: *Concepts of Nuclear Physics*, B. L. Cohen

References:

5. *Nuclear Physics,* R. R. Roy and B. P. Nigam
6. *Subatomic Physics,* H. Frauenfelder and E. Henley, Printice Hall, 1974.
7. *Concepts of Particle Physics,* Gottfried and Weisskoff, Oxford, 1986.

LAB I

IPC 1004: Physics Laboratory- (0-0-3-2)

1. Determination of Band gap of a semiconductor
2. Determination of Planck's constant using white light and colour filter
3. Determination of dielectric constant of a given insulating material
4. Determination of elastic constants of a given material using Hyperbolic & Elliptic fringes
5. Measurement of variation of Electrical conductivity of metals and alloys with temperature
using four point probe methods
6. Determination of Wavelength and d_ (between D1 & D2) of sodium vapor light using Michelson Interferometer
7. Thermal expansivity using interferometric technique
8. Measurement of wavelength of light by Fabry Perot Interferometer
9. Understand how a Fabry-Perot Interferometer works and use it to observe the hyperfine splitting of spectral lines. or
10. Assemble and align Fabry-Perot interferometer, and use it to measure differential wavelength for the Na doublet.
11. Measurement of Hall voltage and Hall Coefficient of a semi-conducting material.
12. Current-Voltage characteristics of an anodic vacuum arc with different materials as consumable anode (Cu, Al, Ni)
13. Current-Voltage characteristics of dc glow discharge
14. Breakdown voltage determination of a Zener diode from it characteristic curve
15. FET / MOSFET characteristics and amplifier design
16. Determination of ionization potential of Lithium
17. Determination of half-life of In / Co60
18. Testing the elegance of fit of Poisson distribution to cosmic ray bursts by chi-square test
19. Determination of e/m of electron by Normal Zeeman effect using Fabry-Perot etalon
20. Calibration of a vacuum gauge (Pirani) with the aid of McLeod gauge.
21. Determination of Lande-g factor of a paramagnetic sample using electron spin resonance

Physics Lab XI - Advanced Material Science Laboratory (2)
Section A: Physical Characterization

1. Stress-strain properties of materials
2. Deflection test of metal beams.
3. Mechanical testing of materials
4. Preparation of high T_c compounds and T_c measurements.
5. Hall voltage measurement
6. Contact angle measurement
7. Experiment on piezoelectric effect
8. To study hysteresis property of ferromagnetic material.
9. To find out the surface morphology and roughness of a treated and untreated film by using Atomic Force Microscope (AFM) in its semi – contact mode
10. To study the variation of mass with temperature with the help of TGA (Thermogravimetric Analysis) setup
11. To study the morphology of a sample using SEM and to study elemental analysis by EDX method.
12. To determine the thermodynamic constants and glass transition temperature of a given polymer sample using Deferential Scanning Calorimeter (DSC)
13. To measure the frequency dependence of dielectric constant of a ferroelectric material (BaTiO3) using an 'Impedance meter'.
14. To characterize the given sample (e. g. Benzoic acid) using Fourier Transform Infrared Spectroscopy (FTIR) technique.
15. To find the band gap of a wide band gap semiconductor film by measuring its absorbance of light using UV-visible spectrophotometer.

IPC Physics Lab X - Electronics and Instrumentation Laboratory (2)

1. Design and performance study of two stage CE, RC coupled BJT amplifier with feedback
2. Determination of operational amplifier parameters: open loop gain, input impedance and output impedance, offset voltage and CMRR
3. Design and performance study of regulated dc power supply
4. Design and performance study of inverting, non-inverting and unity gain, differentiator, integrator amplifier using op-amp
5. Design and performance study of a constant current source
6. Design and performance study of a voltage controlled oscillator
7. Design and performance study of Schmidt trigger circuit
8. Design and performance study of astable multivibrator and mono-stable multivibrator
9. Design and performance study of function generator, RC phase shift oscillator, Wien bridge oscillator
10. Design and performance study of active filters (Low pass, high pass, band pass, band reject)

11. Design and performance study of logarithmic and anti-logarithmic amplifier for linearization of nonlinear measuring instruments.
12. Design and performance study of 8-bit ADC using ADC-0808
13. Design and performance study of thermocouple based temperature controller
14. Combinational circuits: Adders, multipliers, magnitude comparators.
15. Sequential circuits : Flip flops, counters, shift registers.(ripple counter with D type flip-flops; J-K flip-flop and its application to counting)
16. Experiment on multiplexing and de-multiplexing
17. Design of resistive bridge with error amplifier

∗ All the above mentioned experiments should preferably be simulated using MultiSIM before breadboarding and their performance may be compared with those obtained by simulation.

LAB 3
IPC Physics Lab IX - Lasers and Advanced Optics Laboratory (2)

1. Measurement of screw parameters using a laser beam.
2. Measurement of Electro optic coefficient using Kerr effect.
3. Measurement of Magneto optic effect using Faraday effect
4. Optical characterization of thin film (measurement of thickness, uniformity, surface quality and adhesion).
5. Measurement of thickness of thin films using Michelson interferometer.
6. Measurement of coherence length using Michelson interferometer.
7. Measurement of atomic spectra of discharge lamp (H_2, He, Ne).
8. Construction and reconstruction of an object using holography.
9. Nondestructive testing using double exposure holography.
10. Optimization of Nd-YAG laser for drilling hole with $\phi = 2mm$, h=2mm.
11. Characterization of drill with optical microscope.
12. Micromachining (SS, AL) using Nd-YAG laser.
13. Diffraction of light by straight edge.
14. Reflection of white light from a metal surface and determination of n and k.
15. Resolving power of a plane transmission grating.

Electives

IPE Nonlinear Optics (3)

Nonlinear Optical Phenomena:

Introduction to nonlinear optics, description of nonlinear optical interaction, phenomenological theory of nonlinearity, nonlinear optical susceptibilities, second and third order optical susceptibilities. Sum and difference frequency generation, second harmonic generation, phase matching of SHG, quasi phase matching, electric field induced SHG (EIFISH), optical parametric amplification, third harmonic generation, two-photon absorption. Stimulated Raman scattering and stimulated Brillouin scattering.

Two level atoms:

Nonlinear Optics in two level approximations, Density matrix equation, closed and open two level atoms, steady state response in monochromatic field, Rabi oscillations, dressed atomic state, optical wave mixing in two level systems.

Intensity dependent phenomena:

Intensity dependent refractive index, self focusing, self phase modulation and spectaral broadening, optical continuum generation by short optical pulse. Optical phase conjugation,Aberration correction by OPC, Application of OPC in signal processing.\ Self induced transparency, spatial and temporal solitons, solitons in Kerr media, photorefractive and quadratic solitons, optical vortices. Pulse compression.

Bistability:

Optical bistability, Steady state bistability, absoptive bistability, Dispersive bistability, Optical switching.

Ultra fast Phenomena:

Ultra fast pulse generation with and without mode locking, Range Gating with ultra short pulse, four dimensional imaging, Generation of femto second pulses, Femto second Laser gyroscope, Soliton pulses. Coherent transients, Optical Nutation, Free induction decay, photon echo.

Text Book: Nonlinear Optics: Robert Boyd, Academic Press

References:

Nonlinear Optics in signal processing: W.Easan and A.Miller, Chapman and Hall
Physics of Nonlinar Optics: Guang- Sheng -He and Song-Hao Lin, World Scientific
Flytzanis and L.Oudar; Nonlinear Optics: Device and Applications, Springer Verlag, (1986)

IPE Nanophotonics (3)

Foundations for Nanophotonics: Photons and electrons: similarities and differences, freespace propagation. Confinement of photons and electrons. Propagation through a classically forbidden zone: tunneling. Localization under a periodic potential: Band gap. Cooperative effects for photons and electrons. Nanoscale optical interactions, axial and lateral nanoscopic localization. Nanoscale confinement of electronic interactions: Quantun confinement effects, nanoscale interaction dynamics.

Quantum Confined Materials: Inorganic semiconductors, quantum wells, quantum wired, quantum dots, quantum rings. Manifestation of quantum confinement: Optical properties nonlinear optical properties. Quantum confined stark effect. Dielectric confinement effect, superlattices. Quantum confined structures as Lasing media.

Photonic Crystals: Basics Concepts, Features of Photonic Crystals, wave propagation, photonic bansgaps, light guiding. Theoretical Modeling of Photonic Crystals. Methods of Fabrication. Photonic Crystal Optical Circuitry. Nonlinear Photonic Crystals. Photonic Crystals and Optical Communications. **A**pplication to high efficiency emitters, miniaturized photonic circuits and dispersion engineering. Photonic Crystal Sensors.

Microstructure Fibers: Photonic crystal fiber, photonic band gap fibers (PBG), band gap guiding, single mode and multi mode, dispersion engineering, nonlinearity engineering, devices using crystal fibers.

Plasmonics: Metallic nanoparticles, nanorods and nanoshells, local field enhancement. Collective modes in nanoparticle arrays, particle chains and arrays. suface plasmons, Plasmon waveguides. Applications of Metallic Nanostructures.

Nanophotonic Devices : Resonant cavity quantum well lasers and light-emitting diodes, fundamentals of Cavity QED, strong and weak coupling regime, Purcell factor, Spontaneous emission control, Application of microcavities, including low threshold lasers, resonant cavity LED. Microcavity-based single photon sources.

Books:

1. Nanophotonics, Paras N Ptrasad, John Wiley & Sons (2004)
2. Photonic Crystals: Towards Nanoscale Photonic Devices; Jean Michel Lourtioz, Springer ; ISBN 354024431X
3. Fundamentals of Photonic Crystal Fibers; Fredric Zolla- Imperial College Press. ISBN 1860945074
4. Photonic Crystals; John D Joannopoulos, Princeton University Press; ISBN 0691037442
5. Photonic Crystals: Modelling Flow of Light; John D Joannopoulos , R.D. Meade and J.N.Winn, Princeton University Press (1995)

IPE Plasma Science and Technology (4)

1. Statistics and thermodynamics of plasmas

Thermodynamic equilibrium of plasmas, Thermodynamics of ideal gases, Dissociation and ionization equilibrium in Gas mixtures, Statistics and thermodynamics of equilibrium and non-equilibrium plasma, Determination of plasma composition, Thermodynamic and transport properties of plasma, computation of plasma composition and other thermodynamical parameters

2. Fluid dynamics

Fluid mechanics of plasmas, Plasma equilibrium in magnetic field, Magnetic field diffusion in plasmas, Instabilities of low temperature plasmas

3. Plasma models and Plasma Radiation

Concepts about Local Thermal Equilibrium (LTE), PLTE, Corona and CR models of plasma, Black body radiation, Gaseous radiations, Radiation mechanisms in plasmas, Radiations from homogeneous & non-homogeneous plasma layer

4. Design principles of plasma reactors

Design principles and construction of plasma torches and thermal plasma reactors, Efficiency of plasma torches in converting electrical energy in to thermal energy, Designing aspects of low pressure plasma reactors

5. Plasma Production Techniques

Arc Plasma, Coronal discharges, Photo plasmas, Shock wave generated plasma, Atmospheric pressure glow discharges, Dielectric barrier discharges

6. Plasma Diagnostic Techniques

Laser based diagnostics, Microwave and Laser interferometer, Laser induced fluorescence, Thomson scattering, Absorption spectroscopy

7. Industrial Applications of Plasmas

Cold Plasma Processing Applications

Applications of non-equilibrium plasmas, Plasma chemistry and production of active species, Plasma etching, Sputtering and thin film deposition, PECVD, Plasma polymerization and surface modifications

Thermal Plasma Processing Applications

Applications of equilibrium plasmas, High enthalpy source, Plasma Spraying, Spheroidizing and preparation of fine powders, Synthesis of nano particles and tubes, TPCVD, Synthesis of materials and metallurgy in arc plasmas, Plasma cutting and Welding

REFERENCES:

1. Principles of plasma discharges and materials processing, M. A. Lieberman and A. J. Lichtenberg, (John Wiley and Sons, 2005)
2. Plasma Physics and Engineering, A. Friedman and L. A. Kennedy, (Taylor and Francis, New York, 2004)
3. Cold Plasma in Materials Fabrication from Fundamentals to Applications, A. Grill, (IEEE Press, New Jersey, 1994)
4. Thermal Plasmas- Fundamentals and Applications, M. I. Boulos, P. Fauchais and E. Pfender, (Plenum Press, New York and London, 1994)
5. Plasma Technology, B. Gross, B. Greyz and K. Miklossy, (Iliffe Books Ltd., London, 1968).
6. Industrial plasma engineering: Vol. 1 & 2, J. R. Roth, (IOP, 1995 & 2001)
7. Handbook of Advanced Plasma Processing Techniques, Eds. R.J. Shul and S.J. Pearton, (Springer-Verlag, Heidelberg, 2000)

IPE Advanced Experimental Techniques (3-0-0-3)

X-ray Diffraction Methods: (8)

Classification of crystal system, Bragg's law and Laue conditions, Powder methods, crystal size analysis, Rietvold method of structural analysis, X-ray fluorescence spectroscopy, applications of emission spectra for compounds and alloys, Applications of absorption spectra for solid solutions and transitional metal compounds, Neutron spectroscopy. X-Ray Reflectivity

Spectroscopy (6)

Atomic absorption spectrophotometer and its application to environmental analysis, UV-visible spectroscopy and its application, IR-spectroscopy and its application, AES, XPS, Introduction to RBS, SIMS, and its applications. Raman Spectroscopy (UV and Vis)

NMR, EPR spectroscopy (7)

Principles of magnetic resonance, Instrumentation and specimen preparation techniques, chemical shift, spectral analysis, basic principles of ESR. Some applications to simple solids and liquids. An Introduction to Mossbauer spectroscopy.

Microscopy & Optical Microscopy (4)

Optical microscopy, metallurgical microscope, TEM, SEM and AFM, specimen preparation, instrumentation and applications, Electron Energy Loss Spectroscopy, Nano indenter and NanoTribometer

Thermochemical analysis (4)

Thermoanalytical techniques, Instrumentation and applications of TGA, DTA, DSC.

Electrochemical Techniques (6)

Electrochemical Instrumentation, Coulometry, polarography, cyclic voltametry, application to oxidation-reduction reaction, pulse technique and stripping voltametry.

Vacuum Technology & Thin film Deposition Technique (6)

Application to Vacuum Technology, Types of vacuum pumps, different technique of thin film deposition CVD, PVD, MBE, MOCVD.

Mass spectrophotometic technique, TLC, HPLC, GC-MS etc. (4)

Text Book:

Mossbauer Effect: An Introduction to Inorganic and Geo Chemist by G. M. Banchroft, McGraw Hill, 1973

References:

1. Spectroscopy, Vol. I, II and III, ed. By Straughan and Walker, John Wiley.
2. Analytical Chemistry by G. D. Christian, 6th edition, John Wiley & Sons.
3. Analytical Chemistry by D. Kealey & P. J. Haines, Viva Books Pvt. Ltd.

IPE **Nanostructures and Nanomaterials (3-0-0-3)**

Module-I

Introduction to Nanotechnology & Nanomaterials, Nanoscale, Effect of Nano scale on Material Properties: Thermal, Mechanical, Electrical, Magnetic and Optical Properties.

Module-II

New Behaviour: Size confinement, Interfacial Phenomena, Surface to Volume Ratio, Surface
Tension, Quantum Mechanics (Importance of Nanomaterials & its effect on Bulk Properties,
Nanomaterials. 07

Module-III

Nanostructured Materials: Properties and Applications of Nanocrystals, Nanoparticles (Emphasis
on Surface to Volume Ratio, Surface Tension, Surface Energy), Nanowires, Nanotubes, Oxide
Nanostructures, Nanorods, Biomolecules, Nanostructured Polymers, Nanostructured Coatings &
Nanocatalist. 10

Module-IV

Introduction to Nanomaterials Fabrication Techniques: Top-Down Process, Bottom-Up Process
& Self Assembly. 04

Module-V

Introduction to Nanomaterials Characterization Methods: AFM, Scanning Probe Microscopy,
Nanoindentation, Raman Spectroscopy, XPS & FTIR. 06

Module-VI

Applications of Nanomaterials: Structural and Functional Applications, Electronics Applications
& Biological Applications. 03

Text Book: C. P. Poole Jr. and F J Ownes, Introduction to Nanotechnology, Wiley (2003).

Reference:

D. Tomanek and R. J. Enbody, Science and Applications of Nanotubes, Kluwer (2003).
Davies, Introduction to semiconductor Devices, Wiley (2002).

IPE Thin Film and Vacuum Technology (3-0-0-3)

Module-I

Thermodynamics and Thin Film growth

Module-II

Vacuum Technology: Gas Laws, Kinetic Theory of Gases, Conductance and Throughput, Gas
Sources in a Vacuum Chamber, Vacuum Pumps.

Module-III

Physical Vapor Deposition: Sputtering (Plasma Physics (DC Diode), rf Plasmas, Magnetic Fields
in Plasmas, Sputtering Mechanisms), Evaporation.

Module-IV

Chemical Vapor Deposition: Mechanisms, Materials, Chemistries, Systems.

Module-V

Etching: Wet Chemical Etching (Mechanisms, Materials and Chemistries), Dry Plasma Etching/Reactive Ion Etching (Mechanisms, Materials and Chemistries).

Module-VI

FILM Formation and Structure: Capillarity Theory, Atomistic Nucleation processes, Cluster
Coalescence, Grain Structure of Films.

Module-VII

Thin Film Characterization: Structural, Chemical

Text Book:

Thin Film Deposition and Patterning: R. K. Waits, American Vacuum Society, 1998.

References:

The Materials Science of Thin Films: M. Ohring, Academic Press, Boston, 1991
Physics of Thin Films: Ludmila Eckertova, 2nd Plenum Press New York, 1986
Thin Film Phenomena: Kasturi L. Chopra, (McGraw-Hill, 1969

IPE: Biophysics (3-0-0-3)

Introduction: Laws of Physics and Chemistry, introduction to crystallography, Introduction to chromatorgraphy, electrophoresis . (5)

Physico-Chemical Techniques to study Biomolecules: hydration of macromolecules, diffusion of osmosis, sedimentation, ultracentrifuge, rotational dissusion, light scattering, small angle Xscattering, Mass spectrometry. (10)

Spectroscopy: UV spectroscopy, circular dichroism, Fluorescence spectroscopy, IR, Raman and Electron spin spectroscopy, NMR spectroscopy. (5)

Molecular Modeling & Macromolecular Structure: building the structure of H_2O_2, , nucleic acid structure, monomers, polymers, double helical structure of DNA, Polymorphism and nanostructure of DNA, structure of RNA, protein structure: amino acids, virus structure (5)

Energy Pathways in Biology: free energy, couple reactions, group transfer potential, pyridine nucleotides, photosynthesis, energy conversion pathways, membrane transport. (5)

Biomechanics: strained muscles, mechanical properties of muscles, cardiovascular system. (5)

Neurobiophysics: nervous system, physics of membrane potentials, sensory mechanisms. (5)

Origin and evolution of life: prebiotic earth, theories of origin and evolution of life, laboratory experiments on formation of small molecules. (5)

Textbooks:

1. “Cell and Molecular Biology-Concepts and Experiments” by G.Karp, 2nd ed. John Wiley & Sons, Inc. Singapore, 1999.

2. “Principles of Physical Biochemistry ” by K.van Holde, W.C. Johnson, and P.S.Ho. Prentice Hall, 1998.

IPE Microwave Devices and Systems (3-0-0-3)

Introduction to rf & microwave – Bands (allocation and regulations)

Microwave Transmission lines, transmission line equations (and solution), standing waves and
standing wave ratio, line impedance and admittance, Smith chart, impedance matching, microwave coaxial connectors

Rectangular Waveguides, TEM, TE & TM mode, power transmission and loss, excitation of
modes, characteristics,

Rectangular cavity resonator, Q-factor of a cavity resonator,

waveguide tee, magic tee, waveguide corners, bends, twists, directional couplers (S-matrix),

hybrid couplers, circulators, isolators,

Microwave bipolar transistor, Heterojunction bipolar transistor (HBT), tunnel diode, microwave
FET, high electron mobility transistor (HEMT),

Transferred electron device (TED): Gunn effect diode,

Avalanche transit time devices:

Linear beam tubes (O-type): Lead inductance and interelectrode capacitance effects, resonant
cavities klystron, reflex klystron, helix travelling wave tube (TWT), coupled cavity TWT

Cross-field tubes (M-type): Cylindrical and linear magnetron, forward wave cross-field amplifier
(FWCFA), backward wave cross-field amplifier (amplitron), backward wave cross-field oscillator (carcinotron)

Microstrip lines, parallel strip lines, coplanar strip lines, shielded strip lines

Monolithic microwave integrated circuits

Recommended books:

Microwave Devices and Circuits, Samuel Y. Liao, PHI

IPE Physics of Dielectrics and Ferroelectrics (3-0-0-3)

Theory of polarization, Matters in an ac field. Polarisation, Macroscopic electric field, Depolarization field, Lorentz field, Field of dipoles inside cavity, Dielectric constant and polarizability, Clausius-Mossotti relation, fallacy of Clausius-Mossotti relation, fallacy of defining polarization via charge distribution, Polarization as an Adiabatic flow of current, Berry

Phase theory, the quantum of polarization, Spontaneous polarization, Polarisation in an applied

electric field,

Ferroelectric crystal, Landau Primer of ferroelectricity; 2^{nd} order transition, 1^{st} order transition,

soft optical phonons, classification of ferroelectric crystal, crystallographic signature of ferroelectricity. Landau-Ginzburg theory; displacive and order-disorder transitions, reduced size

and boundary effects, antiferroelectricity, piezoelectricity, ferroelasticity.

Analogies and difference between ferroelectrics and ferromagnetism; origin of spontaneous

polarization, ferroelectric random access memories, Magnetoresistive random access memories,

Multiferroics, Magnetoelectric coupling, composites

Textbooks:

IPE Non-conventional Sources of Energy (3-0-0-3)

Module I: Conventional Energy Sources: World's reserve of commercial energy sources and their availability – various forms of energy – renewable and conventional energy systems – comparison – coal, oil and natural gas – availability – statistical details – applications – merits and demerits.

Module II: Non-Conventional Energy Sources: Renewable energy sources – solar energy – nature of solar radiation – components – solar heaters – crop dryers – space cooling – solar ponds, solar cookers – water desalination – photovoltaic generation basics – merits and demerits of solar energy.

Module III: Direct Energy Conversion: Need for DEC, Carnot cycle, limitations, Principles of DEC. Thermo-electric generators, Seebeck, Peltier and Joule Thompson effects, figure of merit, materials, applications, MHD generators, principles, dissociation and ionization, hall effect, magnetic flux, MHD accelerator, MHD engine, power generation systems, electron gas dynamic conversion, economic aspects. Fuel cells, principle, faraday's laws, thermodynamic aspects, selection of fuels and operating conditions.

Module – IV: Principles Of Solar Radiation: Role and potential of new and renewable source, the solar energy option, Environmental impact of solar power - Physics of the sun, the solar constant, extraterrestrial and terrestrial solar radiation, Solar radiation on tilted surface, Instruments for measuring solar radiation and sun shine, solar radiation data.

Module – V: Solar Energy Collection: Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors.

SOLAR ENERGY STORAGE AND APPLICATIONS: Different methods, sensible, latent heat and stratified storage, solar ponds. Solar applications - solar heating/ cooling techniques, solar distillation and drying, Solar Photovoltaic systems-fundamentals, characteristics, classification, solar cell modue, panel, array construction, maximum PV O/P and load matching, power point tracker, balance and applications.

Module – VI: Wind Energy: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, Betz criteria

Module – VII: Bio-Mass: Principles of Bio-Conversion, Anaerobic /aerobic digestion, types of

Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, I.C.
Engine operation, and economic aspects.

Module – VIII: Geothermal Energy: Resources, types of wells, methods of harnessing the
energy potential in India.

Ocean Energy And Hydro Resources: Principles, utilization, setting of OTEC plants, thermodynamic cycles. Tidal and Wave energy: Potential and conversion techniques, mini-hydel
power plants, their economics, Micro-Hydro scheme, water turbine, classifications, characteristics, selection, generators, present status, fuel cell, hydrogen energy, PEM fuel cell.

References:

1. Renewable Energy Resources / Tiwari and Ghosal / Narosa
2. Kothari D.P., “Renewable energy resources and emerging technologies”, Prentice Hall of
India Pvt. Ltd.
3. Ashok V. Desai, "Nonconventional Energy", New Age International Publishers Ltd.
4. Non-conventional energy resources, B. H. Khan, McGraw Hill.