SRIDEV SUMAN UTTARAKHAND UNIVERSITY, BADSHAHITHAUL, TEHRI GARHWAL

SYLLABUS: BOTANY COURSE FOR M.Sc. STUDENTS (4 SEMESTERS)

OBJECTIVES OF THE COURSE

To teach the fundamental concepts of Botany and their applications, the syllabus pertaining to M.Sc. (2 Year Degree Course) in the subject of Botany has been prepared as per provision of UGC module and the demand of the academic environment. The syllabus contents are duly arranged unit-wise and contents are included in such a manner that due importance is given to requisite intellectual and laboratory skill. The M.Sc. course of Botany consists of 2 year course with semester system – in all 4 semesters (Two semesters in each year).

Total Marks : 2000 (1000 per year and 500 per semester) of core and elective disciplines

M.Sc. Semester I

Paper No.	Title	Paper Code	Max. Marks (100)	
			Ext.	Int.
I	Microbiology (Bacteria, Viruses and Lichens)	BOT101	80	20
II	Mycology and Plant Pathology	BOT102	80	20
III	Phycology and Bryology	BOT103	80	20
IV	Pteridophyta, Gymnosperms and Palaeobotany	BOT104	80	20
	Lab Course	BOT10P	80	20

M.Sc. Semester II

Paper No.	Title	Paper Code	Max. Marks (100)	
			Ext.	Int.
I	Taxonomy of Angiosperms	BOT201	80	20
II	Cytogenetics and Molecular Biology	BOT202	80	20
III	Economic Botany	BOT203	80	20
IV	Plant Morphology, Anatomy and Embryology	BOT204	80	20
	Lab Course	BOT20P	80	20

M.Sc. Semester III

Paper No.	Title	Paper Code	Max. Marks (100)	
			Ext.	Int.
I	Plant Physiology and Biochemistry	BOT301	80	20
II	Plant Ecology and Remote Sensing	BOT302	80	20
III	Plant Biotechnology	BOT303	80	20
IV	Elective (Any one of the following) (a) Plant Health Management (b) Diversity and Cultivation of	BOT304/E1	80	20

	Mushrooms (c) Applied Plant Anatomy (d) Ecosystem Analysis, GIS and Remote Sensing (e) Environmental Management with Reference to Western Himalaya.	BOT304/E2 BOT304/E3 BOT305/E4 BOT305/E5		
	Lab Course	BOT30P	80	20

M.Sc. Semester IV

Paper No.	Title	Paper Code	Max. Marks (100)	
			Ext.	Int.
I	Plant Breeding and Biostatistics	BOT401	80	20
II	Conservation Biology	BOT402	80	20
III	In-vitro Technologies and Industrial Applications	BOT403	80	20
IV	Elective Paper(Any one of the following) (a) Forest Ecology (b) Industrial Microbiology (c) Ethnobotany (d) Palynology and pollination Biology (e) Seed Pathology	BOT404/E1 BOT404/E2 BOT404/E3 BOT404/E4 BOT404/E5	80	20
	Lab Course	BOT40P	80	20

SYLLABUS

SEMESTER I

Paper I (BOT101): Microbiology (Bacteria, Viruses and Lichens)

Unit 1:

1. General account of Microorganisms: History of microbiology, classification of microorganisms- five kingdom classification,characteristic features of bacteria and actinomycetes,

2. Culture Study of Microorganisms: Methods of isolation and culture of microorganisms; measurement of microbial growth; microbial genetics.

Unit 2:

1. Morphology and structure of Bacterial cells: Morphology of Bacterial cells based on size, shape and arrangement, fine structure of bacterial cells (of both Gram-negative and Gram-positive Bacteria) - capsule cell wall, cell appendages (flagella, fimbrae and pilli).

2. Structure of plasma membrane, cytoplasmic inclusions- mesosomes, chlorosome.

Unit 3:

1. Morphology and structure of viruses: History, morphology, fine structure, shape and classification of viruses.

2. Microphages and Prions, Tobacco mosaic virus (TMV), T_4.
3. Bacteriophage and HIV- their fine structure, genome organization and multiplication, bacteriophage therapy.

Unit 4

1. Role of microorganism: Root nodules, *nif* gene organization, role of microorganisms in soil (decomposition and nutrient cycling), water and air; role in industry- production of antibiotics, bio-fertilizers and bio-pesticides.
2. General account of lichens: Occurrence, classification, morphology, anatomy, reproduction and their importance.

SUGGESTED READINGS:

1. Doelle, H.W. and C.G. Heden 1986. Applied Microbiology, Kluwer Academic Press, London
2. Pelczar, M.J., Chan, ECS and Kreig, N.R. 1993. Microbiology, Concept and Applications. Mc Graw Hill, New York.
3. Ross, F.C. 1983. Introductory Microbiology. Charles E. Merril. Publ. Co. Columbus, Ohio.
4. Alexander, M. 1991. Microbial Ecology. John Wiley and Sons. New York.
5. APHA. 1971. Standard Methods for the Examination of water and Waste Water. Washington DC
6. Atlas. R. M. Principle of Microbiology.
7. Board, R.G. and D.W., Lovelock 1975. Some Method for Microbiological Assay. Acadmic Press. New York
8. Casida, L.E. 1968. Industrial Microbiology. John Wiley and Sons, New York.
9. Clifford, H.T. and W. Stephenson 1975. An Introduction to Numerical Classification, Academic press, New York.
10. Doelle, H.W. and C.G., Heden 1986. Applied Microbiology. Kluwer Acad. Press, London.
11. Kaushik, P. 1996. Introductory Microbiology. Emkay Publ, Delhi.
12. Miller, B.M. and W. Litsky 1976. Industrial Microbiology. Mc Graw Hill New York.
13. Mukherjee, K.G. and Ved Pal Singh, 1997. Frontiers in Applied Microbiology. Rastogi Publ. Meerut.
14. Norris, J.R. and D.W. Ribbons 1970. Methods in Microbiology. Academic Press, London.
15. Power, C.B. and H.F. Daginawala 1996. General Microbiology 2 Vols. Himalaya Pub. House, New Delhi.
16. Ross, F.C. 1983. Introductory Microbiology. Charles E. Merril Publ. Co. Columbus. Ohio.

Paper II (BOT102): Mycology and Plant Pathology

MYCOLOGY

Unit 1

1. History of Mycology; India and abroad.
2. General characters of Fungi: Substrate relationship in fungi; Cell ultra-structure; unicellular and multicellular organization, nutrition (saprobic, biotrophic, symbiotic); reproduction (vegetative, asexual, sexual).
3. Recent trends in the classification.

Unit 2

1. Phylogeny of Fungi; General account of *Mastigomycotina*, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina; Fungi in industry, medicine and as food.
2. Mycorrhizae; Fungi as bio-control agents.

3. Symptoms, causal organisms of plant pathogens belonging to various fungal classes i.e. *Mastigomycotina, Zygomycotina, Acomycotina, Basidiomycotina* and *Deuteromycotina.*

PLANT PATHOLOGY

Unit 3

1. History of plant pathology in India: Losses caused by pathogens and pests; types of pathogens; symptoms of different diseases.
2. Plant-microbe interaction: pathogenesis: prepenetration, penetration and post penetration events, and factors affecting disease development (host factors, environmental factors, virulence and susceptibility).
3. Dissemination of pathogens: Means of dissemination (active and passive dissemination)

Unit 4

1. Disease control: Cultural practices, chemical methods (insecticides, systemic and nonsystemic chemical), biological control: introduction, biological control of insects and pests, use of resistant varieties, integrated management for disease control, quarantine.
2. Brief account, structure, importance, disease cycle and control of the following:
(i) Damping off, (ii) Wilt, (iii) Root rot, stem rot and fruit rot, (iv) Mildews (powdery and downy), (v) Rusts, (vi) Smuts, (vii) Leaf spots and leaf blights.
3. General characteristics, importance, disease cycle and control of the following:
(i) Bacterial disease, (ii) viral disease, (iii) mycoplasma disease, (iv) phytoplasma diesease.

SUGGESTED READINGS:

1. Ainsworth, G.C. 1971. Ainsworth and Bisby's Dictionary of Genera of Fungi. Central Myco. Inst. Kew, Surrey.UK.
2. Alexopoulus, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. John Willey & Sons Inc.
3. Bilgrami, K.S. 1982. Physiology of Fungi. Bishen Singh Mahendrapal Singh, Dehradun.
4. Clifton, A. 1958. Introduction to the Bacteria. McGraw-Hill book Co., New York.
5. Mandahar, C.L. 1978. Introduction to Plant Viruses. Chand & Co. Ltd., Delhi.
6. Mehrotra, R.S. and Aneja, R.S. 1998. An Introduction to Mycology. New Age Intermediate Press.
7. Webster, J. 1985. Introduction to Fungi. Cambridge University Press.

Paper III (BOT103): Phycology and Bryology

PHYCOLOGY

Unit 1

1. Algal habitats.
2. Thallus organization, cell structure and reproduction (vegetative, asexual and sexual).
3. Algal Classification, Criteria for classification of algae: pigments, reserve food and flagella.
4. Phylogeny and interrelationships of algae.

Unit 2

1. Classification and salient features of Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta and Cyanophyta.
2. A knowledge of algal life cycles; alternation of generations in algae; cytology and sexuality; physiology and biochemistry of algae; nitrogen fixation; parasitic algae.

3. Economic importance of Algae, Algal blooms, algal biofertilizers, algae as food and feed; uses of algae in industry.

BRYOLOGY

Unit 3

1. Morphology, structure reproduction and life history.
2. Classification and Phylogeny of various groups.
3. General account of Marchantiales, Jungermanniales, Calobryales, Sphaerocarpales, and Anthocerotales.

Unit 4

1. General account of Sphagnales, Andreales, Funariales, and Polytrichales.
2. Knowledge of the distribution of bryophytes in the Himalaya.
3. Ecology of bryophytes, their association with other organisms.
4. Fossil bryophytes: General account.

SUGGESTED READINGS:

1. Cavers, F. 1979. The Interrelationships of the Bryophytes Reprint. Bishen Singh Mahendrapal Singh, Dehradun.
2. Fritsch, F.E. 1979. The Structure and Reproduction of Algae. Reprint. Bishen Singh Mahendrapal Singh, Dehradun.
3. Kashyap, S.R. 1968. Liverworts of the Western Himalayas and Punjab Plains. The Chronica Botanic Co. Delhi.
4. Kumar, H.D. 1988. Introductory Phycology. Affiliated East-West Press Ltd., New Delhi.
5. Morris, I. 1986. An Introduction to the Algae. Cambridge University Press, U.K.
6. Parihar, N.S.1991. Bryophyta. Central Book Depot, Allahabad.
7. Presscott, G.W. Algae: A Review. Bishen Singh Mahendrapal Singh.
8. Puri, P. 1980. Bryophytes. Atma Ram & Sons, Delhi.
9. Ram Udar. Fifty years of Bryology in India. Golden Jubilee Series. IBS, New Delhi
10. Round, F.E. 1986.The Biology of Algae. Cambridge University Press, Cambridge.
11. Smith, G.M. 1955. Cryptogamic Botany. Vol. I and II. Tata Mc Graw Hill, New Delhi.
12. Stewart, W.N. and Rathwell, G.W. 1993. Paleobotany and the Evolution of Plants. Cambridge University Press.

Paper IV (BOT104): Pteridophyta, Gymnosperms and Palaeobotany

PTERIDOPHYTA

Unit 1

1. History, origin, classification, present and past distribution, morphology and life history of the following types.

a. Psilophyta: Psilophytales (*Psilophyton*) and Psilotales (*Psilotum*).
b. Lycophyta: Lepidodendrales (*Lepidodendron*), Lycopodiales (*Phylloglossum*), Lepidospermales (*Lepidocarpon*) and Isoetales (*Isoetes*).
c. Sphenophyta: Salient features of order Hyeniales, Sphenophyllales and Calamitales
d. Pterophyta: A general account of Ophioglossales Osmundales Filicales,and Salviniales .

GYMNOSPERMS

Unit 2

1. Classification and distribution of Gymnosperms in India with special reference to Himalaya.
2. Study of morphology, structure and life-history as illustrated by the following and indicated in the practical work:

Pteridospermales: Palaeozoic and Mesozoic groups with references to Lyginopteridaceae (*Lyginopteris*) and Medullosaceae (*Trigonocarpus*), A general account of Glossopteridaceae.
3. Bennettitales: A general account of Cycadeoidaceae, Williamsoniaceae and Wielandiellaceae.

Unit 3

1. Cycadales: A detailed account including distribution of living Cycads.
2. A general account of Pentoxylales and Cordaitales.
3. Ginkgoales: *Ginkgo*.
4. A general account of fossil and living Coniferales and Taxales.
5. Ephedrales, Welwitschiales and Gnetales: A general account.
6. Economic importance of Gymnosperms.

PALAEOBOTANY

Unit 4

1. Definition of fossil, different types of plant fossils as per their mode of preservation, concept of form genus.
2. Indian Gondwana Sequence, a general account.
3. Introductory idea of Continental Drift Hypothesis.

SUGGESTED READINGS:

1. Andrews, HN. 1961. Studies in Palaeobotany. New York.
2. Baker, J.G. 1995. Handbook of the Fern Allies. Reprint. Bishen Singh Mahendra Pal Singh, Dehradun.
3. Bhatnagar, S.P. and Mitra, A. 1996. Gymnosperms. New Age International Pvt. Ltd., New Delhi.
4. Beddome, R.H. 1966. The Ferns of British India. 2 Vols. Oxford and IBH, New Delhi.
5. Chamberlain, C.J. 1955. Gymnosperms: Structure and Evolution. Chicago.
6. Eams, A.J. 1969. Morphology of Lower Vascular Plants.
7. Parihar, N.S. 1996. Biology & Morphology of Pteridophytes. Central Book Depot Allahabad.
8. Raizada, M.B and Sahni, K.C. 1958. Living Indian Gymnosperms.
9. Sahni, K.C. 1996. Gymnosperms of India and Adjacent Countries. Bishen Singh Mahendrapal Singh, Dehradun.
10. Seward, A.C. 1919. Fossil Plants for Students of Botany and Geology. 4 Vols. Cambridge.
11. Sporne, K.R. 1991. The Morphology of Pteridophytes. Hutchinson Library Series London.

Lab Course (BOT10P):

1. Study of representative genera of Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.
2. Symptomatology of at least one diseased specimen of plant pathogens belonging to various fungal classes i.e. *Mastigomycotina*, Zygomycotina, acomycotina, basidiomycotina and deuteromycotina, bacteria and viruses.
3. Aseptic methods and demonstration of instruments viz., autoclave, hot air oven, incubator, laminar air flow.
4. Direct examination of root nodule bacteria under microscope and isolation of *Rhizobium* in root nodules.
5. Isolation and enumeration of microbes from natural samples (soil and water) by agar plate technique.
6. Morphological study of representative members of algae: *Microcystis, Lyngbya,*

Cylindrospermum, Gloeotrichia, Scytonema, Pandorina, Eudorina, Scendesmus, Pediastrum, Hydrodictyon, Ulva, Enteromorpha, Drapernaldiopsis, Stigeoclonium, Fritschiella, Coleochaete, Bulbochaete, Cosmarium, Caulerpa, Nitella, Dictyota, Gelidium, Gracillaria, Batrachospermum and *Polysiphonia.*

7. Study and identification with suitable preparations of *Ricciocarpus, Targionia, Cyathodium, Plagiochasma, Asterella (Fimbriaria), Dumortiera, Sewardiella, Pellia, Fossombronia, Porella, Calobryum, Notothylas, Sphagnum, Polytrichum* and *Funaria.*

8. Psilotum, Isoetes, Ophioglossum, , Osmunda,, Polypodium, Azolla, Salvinia and important fossil types.

9. Cycas, Ginkgo, Abies, Cedrus, Cryptomeria, Cupressus, Podocarpus, Cephalotaxus, Araucaria, Taxus, and *Gnetum*

10. Study of available fossil flora through specimens and slides, etc.

SEMESTER II

Paper 1 (BOT201): Taxonomy of Anglosperms

Unit 1

1. Origin of intra-population variation: Population and the environment; ecads and ecotypes; evolution and differentiation of species- various models.

2. The species concepts; taxonomic hierarchy, species, genus, family and other categories; principles used in assessing relationship, delimitation of taxa and attribution of rank.

Unit 2

3. Salient features of the International Code of Nomenclature for Algae, Fungi and Plants (ICN)

4. Taxonomic evidences and Taxonomic tools: anatomy, palynology, embryology, phytochemistry, histological, cytological, phytochemical, serological, biochemical and molecular techniques.

Unit 3

5. Systems of angiosperm classification: Phenetic versus phylogenetic systems; cladistics in taxonomy; major systems of classification (Bentham and Hooker, Hutchinson, Cronquist) and their relative merits and demerits.

6. Herbaria and Botanical gardens: General account.

7. Plant exploration in India with reference to North-West Himalaya.

8. Status of flowering plant diversity in Garhwal Himalaya.

Unit 4

Distinguishing features and economic importance of Dicot families of

(i) Polypetalae- Magnoliaceae, Violaceae, Linaceae, Rutaceae, Rhamnaceae, Sapindaceae, Anacardiaceae, Myrtaceae.

(ii) Gamopetalae- Dipterocarpaceae, Ericaceae, Oleaceae, Rubiaceae, Asteraceae, Acanthaceae.

(iii) Monochlamydeae- Chenopodiaceae, Amaranthaceae, Urticaceae.

(iv) Monocots- Orchidaceae , Arecaceae, Liliaceae, Amaryllidaceae, Zingiberaceae, Dioscoreaceae, Cyperaceae, Poaceae.

SUGGESTED READINGS

1. Babu, C.R. 1976. Herbaceous Flora of Dehradun. CSIR, New Delhi.

2. Cole, A.J. 1969. Numerical Taxonomy, Academic Press, London.

3. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New york.
4. Davis, P.H. and Heyhood, V.H. 1973. Principles of angiosperms Taxonomy. Robert E. Kreiger
Pub. Co., New York.
5. Gaur, R.D. 1999. Flora of District Garhwal: NW Himalaya. Transmedia, Srinagar, Garhwal.
6. Grant, V. 1971. Plant Speciation. Columbia University Press, New York.
7. Grant, W.F. 1984. Plant Biosystematics. Academic Press, London.
8. Harrison, H.J. 1971. New Concepts in Flowering Plant Taxonomy. Hieman Educationnal Books Ltd., London.
9. Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London
10. Hutchinson, J. 1973. The Families of Flowering Plants. 2 Vols. Oxford University Press, Oxford.
11. Jain, S.K. and Rao, R.R. 1977. A handbook of Field and Herbarium methods. Today and Tomorrow, New Delhi.
12. Jones, A.D. and Wilbins, A.D. 1971. Variations and Adaptations in Plant Species. Hieman & Co. Educational Books Ltd., London.
13. Jones, S.B., Jr. and Luchsinger, A.E. 1986. Plant Systematic (2nd edition). McGraw- Hill Book Co., New York.
14. Lawrence, H.W. 1951. Taxonomy of Vascular Plants. Reprint Oxford and IBH, New Delhi.
15. Naithani, B.D. 1985. Flora of Chamoli. 2 Vols, BSI, Calcutta.Nordenstam, B., El Gazaly, G. and Kassas, M. 2000. Plant Systematic for 21st Century. Portlant Press Ltd., London.
16. Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
17. Singh, H. 1978. Embryology of Gymnosperms. Encyclopaedia of Plant Anatomy X. Gebruder Bortraeger, Berlin.

Paper II (BOT202): Cytogenetics and Molecular Biology

Unit 1

1. The dynamic cell: Structural organization of the plant cell; specialized plant cell.
2. Cell wall: structure and functions; biogenesis, growth.
3. Plasma membrane: structure, models and functions; sites for ATPases, ion carriers, channels and pumps, receptors.
4. Mitochondria and chloroplast: Structure, genome organization, gene expression.

Unit 2

1. Nucleus: structure, nuclear pores, nucleosome organization.
2. Ribosomes: Structure, cytoprotein synthesis.
3. Chromatin organization: Chromosome structure and packaging of DNA, molecular organization of centromere and telomere, euchromatin and heterochromatin, specialized types of chromosomes; polytene, lampbrush, B-chromosomes and sex chromosomes.

Unit 3

1. Principles of inheritance: Mendelian laws along with molecular explanations, Exceptions to Mendelian laws, lethal alleles and Gene Interactions.
2. Structural and numerical alterations in chromosomes: Origin, occurrence, production and meiosis of haploids, aneuploids and euploids, induction and characterization of trisomics and monosomics.

3. Genetics of prokaryotes and eukaryotic organelles: genetic recombination of phage; genetic transportation, conjugation ant transduction in bacteria, cytoplasmic male sterility.

Unit 4

1. Gene structure and expression: Genetic fine structure, cis-trans test; fine structure analysis of eukaryotes. introns and their significance, regulation of gene expression in prokaryotes and eukaryotes. DNA damage and repair mechanism, defects in DNA repair; Initiation of cancer at cellular level, proto-oncogenes and oncogenes.
2. Genetic recombination and genetic mapping: Recombination; independent assortment and crossing over, linkage groups, genetic markers, construction of molecular maps.
3. Mutations: Spontaneous and induced mutations; physical and chemical mutation, molecular basis of gene mutation; mutations induced by transposons.
4. Nuclear DNA content; C-value paradox; Cot curves.

SUGGESTED READINGS:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1989. Molecular
2. Biology of the Cell (2nd edition). Garland Publishing Inc., New York.
3. Atherly, A.G., Girton, J.R. and McDonald, J.F. 1999. The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
4. Burnham, C.R. 1962. Discussions in Cytogenetics. Burgess Publishing Co., Minnesota.
5. Busch, H. and Rothblum, L. 1982. Volume X. The Cell Nucleus rDNA Part A. Academic Press.
6. Barry, J.M. and Barry, B.M. 1973. Molecular Biology, Prentice Hall Of India New Delhi.
7. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
8. De, D.N. 2000. Plant Cell Vacuoles: An Introduction. CSIRO Publication, Collingwood, Australia.
9. Gupta, P.K. 1998. Cytogenetics. Rastogi Publications. Meerut.
10. Hartl, D.L. and Jones, E.W. 1998. Genetics: Principles and Analysis (4th edition). Jones & Bartlett Publishers, Massachusetts, USA.
11. Kleinsmith, L.J. and Kish, V.M. 1995. Principles of cell and Molecular Biology (2nd Edition).
Harper Collins College Publishers, New York, USA.
12. Krishnamurthy, K.V. 2000. Methods in Cell wall Cytochemistry. CRC Press, Boca Raton, Florida.
13. Lewin, B. 2000. Genes VII. Oxford University Press, New York.
14. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. 2000. Molecular Cell Biology (4th Edition). W.H. Freeman and Co., New York, USA
15. Malacinski, G.M. and Freifelder, D. 1998. Essentials of Molecular Biology (3rd edition). Jones and Bartlet Publishers, Inc., London.

Paper III (BOT203): Economic Botany

ECONOMIC BOTANY

Unit 1

1. Plant resources: Concept, status, utilization and concerns.
2. World Centers of Primary Diversity of domesticated plants

3. Origin, evolution, botany, cultivation, cytotaxonomy and uses of (i) Cereals and millets (wheat,paddy, maize), (ii) Legumes (soybean, black gram and cowpeas), (iii) Sugar cane and starches(sugarcane, beetroot, potato, sweat potato, cassava), (iv) Forage and fodder crops.

Unit 2

1. Fiber crops, medicinal and aromatic.
2. Important firewood and timber yielding plants and non-wood forest products (NWFPs) such as bamboos, gums, tannins, dyes, resins, beverages.

INTELLECTUAL PROPERTY RIGHTS

Unit 3

1. Intellectual Property Rights, Concept, History, Protection of IPR;
2. Patent- requirements, procedures and limitations; International convention on Biological Diversity.

ETHNOBOTANY

Unit 4

1. Concept, linkage with other sciences, tools of ethnobotanical studies, world and Indian perspective with special reference to the Himalayas.
2. Green revolution: Benefits and adverse consequences.
3. Plants used as ornamentals and avenue trees.
4. Principles of conservation: Extinction; Status of plants based on International Union for Conservation of Nature (IUCN).

SUGGESTED READINGS:

1. Ayensu, E.S., Heywood, V.H. and Lucas G.I. 1984. Our green and living world: The wisdom to save it. Cambridge Univ. Press. Cambridge.
2. Baenzinger, S.P., Kleese, R.A. and Barns, R.F. 1993. Intellectual Property Rights, Protection of plant materials; executive summary and work group reports. CSSA Publication No. 21. Crop Science Soc. of America, Wisconsin, Madison.
3. Bellamy, R. 1993. Ethnobotany in Tropical forests: expedition in field techniques, Royal Geographic Society of London.
4. Berlin, B. 1992. Ethnobiological Classification: Principles and categorization of plants and animals in traditional societies. Princeton Univ. Press. Princeton.
5. Chandel, K.P.S., Shukla, G. and Sharma, N.1996. Biodiversity in Medicinal and Aromatic Plants in India: Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
6. Conway, G. and Barbier, E. 1994.Plants, Genes and Agriculture. Jones and Bartlett Publishers, Boston.
7. Council of Scientific & Industrial Research 1986. The Useful Plants of India. Publications and Information Directorate, CSIR, New Delhi.
8. Council of Scientific & Industrial Research (1948-1976). The Wealth of India. A Dictionary of Indian Raw Materials and Industrial Products. New Delhi. Raw Materials I-XII, Revised Volume I-III (1985-1992) Supplement (2000).
9. Densmore, F. 1974. How Indians use wild plants for food, medicine and crafts, Dover Publication Inc. New York.
10. WWF INDIA 1993. Directory of Indian Wetlands, New Delhi and AWB, Kuala Lumpur.
11. Falk, D.A., Olwell, M. and Millan, C. 1996. Restoring Diversity. Island Press, Columbia, USA.
12. Frankel, O.H., Brown, A.H.D. & Burdon, J.J. 1995. The Conservation of Plant Diversity.

Cambridge University Press, Cambridge, U.K.
13. Gadgil, M. and Guha, R. 1996. Ecology and Equity: Use and Abuse of Nature in Contemporary India. Penguin, New Delhi.
14. Gangulee, P. 1998. Gearing up for patents- the Indians Scenario. Univ. Press. Hyderabad.
15. Hill, A.F. 1952. Economic Botany. McGraw Hill., New York.
16. Kochar, S.L. 1998. Economic Botany in the Tropics. Mac Millan India Ltd. Delhi
17. Kothari, A. 1997. Understanding Biodiversity: Life Sustainability and Equity. Orient Longman.
18. Kohli, R., Arya, K.S., Singh, P.H. and Dhillon, H.S. 1994. Tree Directory of Chandigarh. Lovedale Educational, New Delhi.
19. Nair, M.N.B. *et al.* (Eds) 1998. Sustainable Management of Non-Wood forest Products. Faculty of Forestry, Universiti Putra Malaysia. 434004 PM Serdong, Selangor, Malaysia
20. Paroda, R.S. and Arora, R.K.1991. Plant Genetic resources conservation and Management. IPGRI (Publication) South Asia Office, C/o NBPGR, Pusa Campus, New Delhi.
21. Rodgers, N.A. and Panwar, H.S. 1988. Planning a Wildlife Protected Area Network in India. Vol. 1. The Report. Wildlife Institute of India, Dehradun.
22. Sahni, K.C. 2000. The Book of Indian Trees, 2nd edition. Oxford University Press Mumbai.
23. Sharma, O.P. 1996. Hill's economic Botany (Lata Dr. A.F. Hill, adapted by O.P. Sharma). Tata McGraw Hill Co. Ltd., new Delhi.
24. Swaminathan, M.S. and Kocchar, S.L. (Eds.) 1989. Plants and Society. Macmillan Publication Ltd., London.
25. Thakur, R.S., Puri, H.S. and Husain, A. 1989. Major Medicinal Plants of India. Central Institute of Medicinal and Aromatic Plants, CSIR, Lucknow.
26. Walter, K.S. and Gillet, H.J. 1998. IUCN Red List of Threatened Plants. IUCN The World Conservation Union. IUCN, Gland, Switzerland, and Cambridge, U.K.

Paper IV (BOT204): Plant Morphology, Anatomy and Embryology

PLANT MORPHOLOGY

Unit 1

1. Shoot Development: Organization of the shoot apical meristem (SAM); control of cell division and tissue differentiation especially xylem and phloem; secretary ducts and laticifers; wood development in relation to environmental factors and wood anatomy. Leaf growth and differentiation (structural development and classification of stomata and trichomes).
2. Root development: Organisation of root apical meristem (RAM); vascular tissue differentiation; lateral roots; root hairs.
3. Morphology of flower, stamen and carpel. Plant adaptations and their morphological nature.

EMBRYOLOGY

Unit 2

1. Male gametophyte: Structure of anther; microsporogenesis; pollen germination, pollen allergy; pollen embryos.
2. Female gametophyte: Ovule development; megasporogenesis; development and organization of the embryo sac.
3. Pollination, Pollen-pistil interaction and fertilization: Floral characteristics, pollination mechanism and vectors; commercial consideration; structure of the pistil; pollen stigma interactions, sporophytic and gametophytic self-incompatibility (cytological, biochemical and molecular aspects); double fertilization; in vitro fertilization.

Unit 3

1. Seed development and fruit growth: Endosperm development during early, maturation and desiccation stages; embryogenesis, cell lineages during late embryo development;
2. Polyembryony; apomixis, embryo culture.
3. Latent Life-dormancy: Importance and types of dormancy; bud dormancy.

ANATOMY

Unit 4

1. Tissue - General account
2. Stem anatomy - Dicot and Monocot
3. Root anatomy - Dicot and Monocot
4. Anamolous Secondary Growth - *Boerhaavia, Draceena, Nyctanthes, Mirabilis, Salvadora,* Periderm formation

Suggested Readings:

1. Bhojwani, S. S. and Bhatnagar, S. P. 2000. The embryology of Angiosperms. Vikas Publ. House, New Delhi.
2. Aghwan, V. 1997. Molecular embryology of flowering plants. Cambridge Univ. Press, Camp.
3. Shivanna, K. R. and Sawhney, V. K. 1997. Pollen biotechnology for crop production and improvement Cambridge Univ. Press.
4. Shivanna, K. R. and Sawhney, V. K. Pollen Biology.
5. Fonkot De. 1994. Plant growth and Development, A molecular approach, Academic Press, San Diego.
6. Howell, S. H. 1998. Molecular genetics of plant Development. Cambridge Univ. Press
7. Leins, P., Tucker, Sc & Endress, P. K. 1988. Aspects of floral development, J. Cramer. Germany.
8. Lyndon, R. F. 1990. Plant development: The cellular basis. Unnin Hyman, London.
9. Raghavan V. 1999. Developmental Biology of flowering plants. Springer velag, New York.
10. Singh, S.P. A Textbook of Plant Anatomy
11. Tayal, M.S. 1996. Plant Anatomy. Rastogi Publ. Meerut.

Lab Course (BOT20P):

1. Identification and description of locally available plants belonging to families included in the syllabus from fresh specimens, herbarium or preserved materials. After identification up to family level any suitable regional Flora may be provided for generic identification if required.
2. Description of a species based on various specimens to study intra specific variation.
3. Studies to find out the location of key characters and preparation of keys at generic level.
4. Field trips, compilation of field notes, the preparation of herbarium sheets and submission of herbarium and museum specimens and/or live potted specimens of taxonomic interest and submission of the excursion report.
5. Study of alternate and distichous, alternate and superposed, opposite and superposed opposite and decussate leaf arrangement. Examination of rosette plants (*Launaea, Mollugo, Raphanus, Hyoscyamus,* etc.) and induction of bolting under natural conditions as well as GA treatment.
6. Microscopical examination of vertical section of leaves, such as that of *Cannabis, Nicotiana, Zea mays* and *Triticum* to understand the internal structure of the tissue and trichomes, glands, etc. Also to study the anatomy of C_3 and C_4 plants.
7. Study of epidermal peels of leaves to study the development and final structure of stomata and

prepare stomatal index.
8. Study of microsporogenesis and gametogenesis in sections of anthers.
9. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, *Cannabis sativa, Crotolaria, Tradescantia, Brassica, Petunia, Solanum melongena,* and locally available flowers).
10. Tests for pollen viability using stains and *in vitro* germination. Pollen germination using hanging drop and sitting drop cultures.
11. Pollen storage, pollen–pistil interaction, self-incompatibility, *in vitro* pollination.
12. Food crops: wheat, rice, maize, chickpea, potato, tapioca, sweet potato, sugarcane; morphology, anatomy and micro chemical tests for stored food materials.
13. Forage/fodder plants: Study of ten important fodder crops of the locality.
14. Plant fibers: Textiles fibers (cotton, jute, sun hemp, cannabis, *Grewia*, etc.), Cordage fibers (coir), Stuffing fibers (silk cotton). Morphology, anatomy, microscopic study of whole fibers using appropriate, staining procedures.
15. Medicinal and aromatic plants including narcotics and antibiotics.
16. Vegetable oils: Mustard, groundnut, soybean, coconut, sunflower and castor. Morphology, microscopic structure of oil yielding tissues, test for oil and iodine number.
17. To prepare a water extract of vegetable tannins (*Acacia, Terminalia, Camellia, Cassia*) and dyes (*Curcuma longa, Bixa orellana, Indigofera, Butea monosperma, Lawsonia inermis, etc.).*
18. Study of mitotic chromosomes in root tips and leaf buds and meiotic chromosomes in floral buds.
19. Isolation of chloroplasts and SDS-PAGE profile of proteins to demarcate the two subunits of Rubisco.
20. Restrictioin digestion of plant DNA, its seperation by agarose gel electrophoresis and visualization by ethidium bromide staining.
21. Isolation of RNA and quantitation by spectrophotometric method.
22. Southern blot analysis using a gene specific probe.
23. Northern blot analysis using a gene specific probe.
24. Western blotting and ELISA.
25. Genetical problems on Mendelian and post-Mendelian ratios, gene interactions, sex-linked inheritance, chromosomal mapping, etc.

SEMESTER III

Paper I (BOT301): Plant Physiology and Biochemistry

Unit 1

1. Functional aspects of plant cell structure: colloidal systems, concept of water potential, diffusion, osmosis and imbibition. Life giving unique properties of water.
2. Energy flow: Principles of thermodynamics, free energy and chemical potential, redox reactions, structure and functions of ATP.

Unit 2

1. Biologically important molecules: Carbohydrates, Amino acids, Proteins and Lipids. Fundamentals of enzymology: General aspects of enzymes, allosteric mechanism, regulatory and active sites, isozymes, kinetic catalysis, Michaelis-Menton equation and its significance.

2. Membrane transport and translocation of water and solutes: Plant-water relations, mechanism of water transport through xylem and transport in cells. Absorption and transpiration of water.

Unit 3

1. Photophysiology and photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, photo oxidation of water, light reaction, Z scheme and photophosphorylation, mechanism of electron transport, carbon assimilation – the Calvin cycle, photorespiration and its significance, the C4 cycle, the CAM pathway, factors of photosynthesis.
2. Respiration and lipid metabolism: Overview of plant respiration, glycolysis, the TCA cycle, electron transport and ATP synthesis, pentose phosphate pathway, glyoxylate cycle, alternative oxidation system, photorespiration.

Unit 4

1. Nitrogen fixation, nitrogen and sulphur metabolism: Overview, biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and assimilation, sulfur uptake, transport and assimilation.
2. Phytohormones and Sensory photobiology: History of discovery of phytochromes and cryptochromes, and their photochemical and biochemical properties, photophysiology of light-induced responses, molecular mechanism of action of photomorphogenic receptors, signaling and gene expression.

SUGGESTED READINGS:

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, D.B. (eds) 1997. Plant Metabolism (Second edition). Longman, Essex, England.
3. Hooykaas, P.J.J., Hall, M.A. and Libbenga, K.R. (eds) 1999. Biochemistry and Molecular Biology of Plant Hormones. Elsevier, Amsterdam, The Netherlands.
4. Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.
5. Lodish, H., Berk, A., Zipursky, S.L., Maztsudaira, P., Baltimore, D. and Darnell, J.2000. Molecular Cell Biology (4th edition). W.H. Freeman and Company, New York, USA.
6. Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones (second edition). Springer-Verlag. New York USA.
7. Nobel, P.S. 1999. Physiochemical and Environmental Plant Physiology (Second edition). Academic Press, San Diego, USA.
8. Noggle, G.R and Fritz, G.F. 1977. Introductory Plant Physiology. Prentice Hall, New Delhi.
9. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4th edition). Wadsworth Publishing Co., California, USA.
10. Singhal, G.S., Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee 1999. Concepts in Photobiology: Photosynthesis and Photomorphogenesis. Narosa Publishing House, New Delhi.
11. Taiz, L. and Zeiger, E. 1998. Plant Physiology (2nd edition). Sinauer Associates, Inc., Publishers, Massachusetts, USA.
12. Thomas, B. and Vince-Prue, D. (1997) Photoperiodism in Plants (Second edition). Academic Press, San Diego, USA.

Paper II (BOT 302): Plant Ecology and Remote Sensing

PLANT ECOLOGY

Unit 1

1. Climate, soil and vegetation patterns of the world: Major biomes and vegetation types and environmental factors.
2. Population dynamics: Characters, r- and k- strategies.
3. Vegetation organization: Concepts of community and continuum; community characteristics, concept of ecological niche, ordination.
4. Ecological succession: Causes, mechanism and types, concepts of climax.

Unit 2

1. Ecosystem: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (Trophic organization, energy flow pathways, ecological efficiencies); litter fall and decomposition (mechanism, substrate quality and climatic factors);
2. Global biogeochemical cycles of C, N, P and S: (pathways, processes, in terrestrial and aquatic ecosystems; nutrient use efficiency, hydrological cycle.
3. Ecosystem stability: Concept (resistance and resilience); ecological perturbation (natural and anthropogenic) and their impact on plants and ecosystems; ecology of plant invasion; environmental impact assessment; ecosystem restoration.
4. Biological diversity: Concept and levels; species richness, diversity indices, concept of α and β diversity, phytogeographical regions of India, role and application of biodiversity in ecosystem function; speciation and extinction; IUCN categories of threat; distribution and global patterns of biodiversity, hot spots; inventory.

Environmental pollution: Kinds; sources, quality parameters; effects on plants and ecosystems and remedies.

Unit 3

1. Climate change: Greenhouse gases sources, trends and role; ozone layer and ozone hole; consequences of climate change (CO; sequestration, global warming, sea level rise, UV radiation).
2. Fire as an ecological factor: Types, role of fire, extent and causes of fire in forest, grasslands and in tropical savanna, fuel load, controlled burning, fire in different forest types in Uttaranchal; fire as management tool

REMOTE SENSING

Unit 4

1. Remote Sensing: Concepts and stages in the acquisition of remote sensing data; Spectral signature
2. Photographic and non-photographic sensors, Space Platforms.
3. Basic principles of Photogrammetry and Photo-interpretation.
4. Application of remote sensing in ecological research.

SUGGESTED READINGS:

1. Barbour, M.G., Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology. Benjamin/ Cummings Publication Company, California
2. Begon, M., Harpor, J.L. and Townsend, C.R. 1996. Ecology. Blackwell Science, Cambridge, U.S.A.
3. Chapman, J.L. and Reiss, M.J. 1988. Ecology: Principles and Applications. Cambridge University Press, Cambridge, U.K.

4. Heywood, V.H. and Watson, R.T.1995. Global Biodiversity Assesment. Cambridge University Press.
5. Kershaw, K.A. Quantitative and Dynamic Ecology. Oxford and IBH. Kormondy, E.J. 1996. Concepts of Ecology. Prentice-Hall of India Pvt. Ltd., New Delhi.
6. Odum, E.P. 1983.Basic Ecology. Saunders, Philadelphia
7. Smith, R.L. 1996. Ecology and Field Biology. Harper Collins, New York.

Paper III (BOT303): Plant Biotechnology

Unit 1

1. Biotechnology: Principle and scope, bio-safety guidelines.
2. Plant cell and tissue culture: Concept of cellular differentiation and totipotency, principle of root and shoot generation in vitro, applications of cell and tissue culture.
3. Callus culture, cell suspension culture, cryopreservation, clonal propagation, organ culture, protoplast culture, organogenesis, somatic embryogenesis, somatic hybridization, artificial seed, hybrids and cybrids; somaclonal variation.

Unit 2

1. Recombinant DNA technology: Tools of genetic engineering: enzyme, vectors; plasmids, cosmids, lamda phage vectors, shuttle vectors. BACs and YACs. Cloning strategies, genomic libraries, CDNA libraries, single gene cloning.
2. Detection and characterization of transformants: Screening and selection for transformants:

Unit 3

1. Hybridizations - colony, Southern, Northern, Western. DNA sequencing techniques, expression vectors in bacteria and eukaryotes; expression of industrially important products.
2. Genetic engineering of plants: Aims, tools, strategies for development of transgenic plant with suitable example, alien gene transfer and applications.

Unit 4

1. Elementary Knowledge of next generation sequencing, intellectual property rights, genomics and proteomics.
2. Biological databases (gene and protein). DNA restriction map analysis, DNA and protein sequence alignment. BLAST and FASTA.

Suggested Readings:

1. Bhojwani, S.S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Publisher, New York (U.S.A).
2. Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations. Elsevier Science Publisher, New York (U.S.A).
3. Collins, HA and Edwards, S. (1998). Plant Cell Culture. Bios Scentific Publisher, Oxford (UK).
4. Glazer, A.N. and Nikido, H. (1995). Microbial Biotechnology. W.H. Freeman and Company, New York (USA).
5. Shantharam, S. and Montgo Mery, J.F. (1999). Biotechnology, Biosafety and biodiversity. Oxford and IBH Publishing Company. Pvt. Ltd. New Delhi.
6. S.B. Primrose and R. M. Twyman. Principles of Gene Manipulation and Genomics.
7. Brown TA; Gene Cloning and DNA Analysis 5th Ed, 2006.
8. Sambrook & Russel Cold Spring Harbour Laboratory press N 2001. Molecular Cloning; 3rd Ed; D. W. Mount Bioinformatics; 2nd Ed; Cold Spring Harbor Laboratory Press; 2004.

9. Arthur Lesk. Introduction to Bioinformatics.

ELECTIVE PAPERS:

Paper IV (a) (BOT304/E1): Plant Health Management

Unit 1

1. Basic procedure in diagnosis of plant diseases: Significance of plant diseases.
2. Seed Pathology: Seed borne fungi. Disease transmitted through seeds. Bio-deterioration of seed in storage. Control of seed borne fungi.

Unit 2

1. Nursery disease: Important disease of nursery plants.
2. Plantation disease: Plantation disease of *Chir pine, Eucalyptus, Sal, Teak, Shisam, Populus, Acacia.*

Unit 3

1. Important disease of cash crops: Sugarcane, Potato and Ginger. How plants defend themselves against pathogen. Control of crop and forest disease. Treatment of wounds.
2. Introduction and various forms of Mycorrhiza. Role of Mycorrhiza in Forestry.

Unit 4

1. Diseases of cereals and Millets.
2. Diseases of vegetables and fruit trees.

Lab Course

1. Isolation and inoculation of mycorrhiza.
2. Study of seed borne pathogen. Description of pathogen, symptoms and section cutting.
3. Isolation of some important pathogens.
4. Procedure of equipments uses.
5. To establish a plant disease clinic in the department for advise to local people.

SUGGESTED READINGS:

1. Bilgrami, K.S. 1985. Text Book of Modern Plant Pathology. Bishen Singh Mahendra Pal
2. Singh Dehradun.
3. Butler, E.J. 1973. Fungi and Disease in Plants, Intern, Book Distributers. Dehradun.
4. Singh, R.S.1983. Plants Diseases. Oxford and IBH Publ. Co. New Delhi.
5. Singh, R.S. Principle of Plants Pathology. Oxford and IBH Publ. Co. New Delhi
6. Strobel, G.A. and D.E., Mathre 1970. Outlines of Plant Pathology. Van Nostrand
7. Reinhold Co. New York.
8. Tarr, S.A.J. 1972. The Principle of Plants Pathology. Winchester Press, New York.
9. Western, J.H. 1971. Diseases of Crop Plants. Mc Millan Press London

Paper IV (b) (BOT304/E2): Diversity and Cultivation of Mushrooms

Unit 1

1. General characteristics and life history: Reproduction, spore print, dissemination, growth size, colour and surface textures, odour, taste, Exudation and fairy rings; Bioluminescence and economic importance.
2. Biodiversity of Mushrooms.
3. Status of Mushroom research in India.
4. Ethnomycological approach of mushrooms, especially in Uttarakhand Himalaya.

5. Edible and poisonous mushrooms. Mushroom recipes, mushroom toxins, disease and pests of mushrooms.

Unit 2

1. Introduction to mushroom groups.
2. Taxonomic study of order Agaricales- Systematics of dark spored families viz., Boletaceae, Bolbitaceae, Boudarzewiaceae, Cortivariaceae, Coprinaceae, Crepidotaceae, Entomataceae, Gomphideaceae, Paxillaceae, Russulaceae; Systematics of light spored families. Agaricaceae, Amanitaceae, Hygrophoraceae, Pluteaceae, Tricholomataceae.
3. Order Aphyllophorales: Introduction and Systematics of Cantharelloid forms, Thelephoroid forms, Cupuloid forms, Clavarioid forms, hydnoid forms and poroid forms.
4. Gasteromycetes: Introduction and Systematics of order Hymenogastrales, Lycoperdales, Nidulariales, Phallales, Podaxales and Sclerodermatales.

Unit 3

1. DNA isolation, amplification and ITS; RELP, RAPD Analysis; DNA Primers and markers; PCR machine and working knowledge; Gel Electrophoresis, Use of Geldoc, Sequence and Phylogenetic data analysis.
2. Computer application in Mushroom Science, Formation of clade, dendrograms and sequence alignment; Knowledge to submit mushroom sequence data online, NCBI, MEGA4 and Muttalign.
3. Ecology of mushrooms. Role of mushrooms in forest ecosystem.
4. Mycorrhiza ; endomycorrhiza (arbuscular mycorrhiza), Ectendomycorrhiza (arbutoid mycorrhiza), Ericoid mycorrhiza, Monotropoid mycorrhiza and orchid mycorrhiza.

Unit 4

1. Tissue culture in wild mushrooms.
2. Preparation of compost- paddy straw, saw dust.
3. Cultivation of edible and medicinal mushrooms: *Agaricus, Calocybe, Flammulina, Ganoderma, Hericium, Lentinus, Pleurotus* .

Lab Course

1. Collection, preservation and identification of wild mushrooms
2. Morphological features: field notes, chemical spot tests, photography, sporeprint, colour change, smell, taste, etc.
3. Anatomical features: Microscopic studies, Mycorrhizal studies.
4. Ecological Observation.
5. Tissue culture techniques: Media preparation, solid and liquid culture media preparation. Pure culture techniques. Sub culturing, Lyophilization, Maintenance of mushroom culture.
6. Cultivation of *Agaricus, Calocybe, Flammulilna, Ganoderma, Lentinus* and *Volvariella.*
7. DNA Isolation, amplification and ITS, RELP, RAPD analysis, DNA primers and markers. PCR and Gel electrophoresis.

SUGGESTED READINGS:

1. Allen, M.F. 1991. The Ecology of Mycorrhiza. Cambridge Univ. Press, Cambridge.
2. Bakshi, B.K. 1974. Mycorrhiza and its role in forestry, FRI, Dehradun.
3. Chang, S.T. and W.A. Hayes. 1978. *The Biology and Cultivation of Edible Mushrooms*. Academic Press.
4. Hacskaylo, E. 1971. Mycorrhizae, USDA Forest Service Publ. No. 1189. US Govt. Printing Office. Washington, DC.

5. Hawksworth,DL; Sutton, B.C. and Ainsworth G.C. 1983. Dictionary of the Fungi. Kew, Surrey, England.
6. Krieger, LCC. 1967. The Mushroom Handbook. Dover Publications. INC New York.
7. Largent, D.L. 1977. How to identify Mushrooms to genus? I Macroscopic features. Mad River Press. Inc. Eureka.
8. Miller, O.K. Jr. 1981. Mushrooms of North America. EP Dutton, New York.
9. Singer, R. 1986. The Agaricales in Modern Taxonomy. BSMPS, Dehradun.
10. Stamets, P. and J.S. Chitton 1983. The Mushroom Cultivator, Agarikon Press, Olympia, Washington.

Paper IV (c) (BOT304/E3): Applied Plant Anatomy

Unit 1

1. Different types of microscopes, their principles, working and utility.
2. Sources of Timber. Importance of knowledge of wood structure.
3. How wood is formed: Cambium and its derivations, secondary growth, juvenile wood and mature wood.

Unit 2

1. Physical features of wood visible on the cross surface of log, sapwood and heart wood, growth rings and growth marks, colour, luster, odour and taste, weight, grain, texture.
2. Gross features of wood visible on longitudinal surface of wood.

Unit 3

1. Ultra structure of wood and techniques: Electron microscope, ultra structure of cell wall, microfibril angle.
2. Natural defects of wood: Reaction wood, Knots, Silica content and other defects due to stress.

Unit 4

1. Defects of timbers to utilization.
2. Wood structure in relation to properties and uses.
3. Criteria and methods of assessment of wood quality in plantation grown timbers, viz: *Eucalyptus* and *Populus* for pulp and timber.

Lab Course

1. Different types of Microscopes, their working and utility. Research, Polarized and Electron Microscopes.
2. Juvenile wood and mature wood: Maceration techniques.
3. Section cutting and mounting of different types soft and hard woods (locally available). Microscopic and anatomical features of wood viz: bamboo, canes and coconut.
4. Ultra structure of the wood and techniques. Study of cell wall, microfibril angle and proportion of tissues.
5. All physical features visible on cross surface of log.
6. Gross features of wood visible on longitudinal surface.

SUGGESTED READING

1. Wilson and Whyte Text Book of Wood Technology. HP Brown, McGraw Hill, New York.
2. Indian Forest Utilization. FRI Vol. I and II. Comparative Wood Anatomy. Sherwin Carlquist.
3. Ramesh Rao, K and Junija. Field Identification of 50 important timbers of India, FRI.
4. Tieman Pitman. Wood Technology, New York.
5. Foster, AS, Nostrand, D Van. Practical Plant Anatomy. New York.

6. Gupta, S. Atlas of Indian Heartwoods- their anatomical features and photomicrographs.
7. Fahn, A. Plant Anatomy. Pergamon Press.

Paper IV (d) (BOT304/E4): Ecosystem Analysis, GIS and Remote Sensing

Unit 1

Aerial Photography and Photogrammetry (AP&P):

1. Fundamentals of Aerial Photography, History, Aerial film processing, Procurement, and Security of Aerial photographs, Energy source and atmospheric effects in aerial photography. Principles of
Aerial Photos (flight planningon).
2. Introduction to Photogrammetry, Geometry of Aerial photos, Stereoscopic photography, Measurement of Height, Aerial Triangulation.
3. Principles and fundamentals of Aerial photo interpretation. Basics of Cartography.

Unit 2

Remote Sensing (RS):

1. Introduction to Remote Sensing. The electromagnetic spectrum, Energy instruction with atmosphere and earth surface, satellite and sensors, Remote sensing data acquisition.
2. Principles and basic concepts of Multispectral, Thermal and hyperspectral Scanning: Across-track and Along Track multispectral Scanning. History of Space Imaging
3. Image Interpretation: Type of Imagery, elements of Interpretation, Techniques of Visual Interpretation, Role of remote sensing in ecological research.

Unit 3

Digital Image Processing (DIP):

1. Fundamentals of digital image processing, Image rectification, Restoration and Enhancement.
2. Image classification: Supervised classification, unsupervised classification, Hybrid classification, Post-classification smoothing and Classification accuracy assessment.
3. Principles of microwave sensing, Geometric characteristics, Spatial resolution. Space-borne Radar System, Application of passive microwave sensing.

Unit 4

Geoinformatics (GIS):

1. Basics of Computer, Hardware and software,
2. Principles and basics of Geographic Information System: Raster and Vector GIS, Database creation and management. Network Analysis, Spatial data integration and Modelling.
3. Basics of Global Positioning System, GPS Satellites and GPS utility.

Lab Course

1. Stereo test and study of different types of aerial photos, Orientation of Stereo model for interpretation and mapping.
2. Determination of Scale, Determination of Height and Slope.
3. Visual interpretation of aerial photos and satellite data on different scales, Study of different types of satellite data products.
4. Study of Multispectral data, Study of Image Processing Systems, Display of raw data, Histogram analysis.
5. Digital classification and Enhancement of satellite data, Information extraction using DIP techniques.
6. Study of Geographic Information System, Geo-referencing, designing GIS database, Editing spatial and attribute, data output presentation.

Suggested Readings:

1. Lillesand & Kieffer, Remote Sensing and Image Interpretation. John Wiley & Sons, New York.
2. Sabins, F.F., Jr. Remote Sensing: Principles and interpretation.
3. Bhatia, S.C. Fundamentals of Remote Sensing.
4. Chanda, Datta, Majumdar. Digital Image Processing & Analysis.
5. Chang, K.T. Introduction to Geographic Information Systems.
6. Rao, et al., Geographic Information System.
7. Johnston C.A. Geographic Information Systems in ecology.
8. Ahmed, E. I & Rabbany. Introduction to Global Positioning System.
9. Aronoff, S. 1991. Geographic Information Systems: A Management Perspective. Ottawa WDL Publ.
10. Barrett, E.C. 1982. Introduction of Environmental Remote Sensing. Chapman and Hall.
11. Burrough, P.A. 1986. Principle of Geographic Information System for Land Resources Assessment. Oxford University Press.
12. Colwell, R.N. 1983. Manual of Remote Sensing. Vol. I.II American Society of Photogrammetry.
13. Curran, P.J. 1985. Principle of Remote Sensing. Longman Group.
14. Dury, S.A. 1990. A Guide to Sensing. Interpreting Image of Earth. Wiley and Sons.
15. Hord, R.M. 1986. Remote Sensing: Method and Application, John Wiley and Sons.
16. Jenson, J.R. 1996 Introductory Digital Image Processing, Prentice Hall. New Delhi.
17. Johnson, P.I. 1969. Remote Sensing in Ecology. Univ. Georgia Press, Athens.
18. Rampal, K.K. 1982. Text Book of Photogrammetry. Oxford and IBH Press.,
19. Rees, W.G. 1990. Physical Principles of Remote Sensing, Cambridge University Press.
20. Schander, E. 1976, Remote Sensing for Environmental Sciences. Springer Verlag.
21.Ulaby, F.T. Moor, R.K. and Fung, A.K. 1982. Microwave Remote Sensing Active and Passive. Vol. I and II Wesley Pub.

Paper IV (c) (BOT304/E5): Environment Management with Reference to Western Himalaya.

Unit 1

1. Introduction to the Environmental Management, Major Environmental Problems, Environmental ethics; Resource and conflicts, Environmental Laws; Stockholm Conference, The Earth summit, The Copenhagen Conference, Environmental Protection and Fundamental rights, Environmental Governance in India, Man and Environment, Trade and Environment; the WTO and GATS, Environment Concerns and WTO.
2. Introduction to the Environmental Impact Assessment; Planning and Significance, EIA practices and future trends in India; Legal frame work for EIA. Impact of forest fires, Forest Fire

Unit 2

1. Assessment and Risk Zonation. Thermal power stations, Power line and roads, River valley projects, Urbanization and Industrialization, Mining activities, GHGs, CFCs, fossil fuels etc., Flood monitoring, Snow melt and Glaciers, Ozone Layer Depletion. Principles of Environmental Analysis, Role of remote sensing in EIA.
2. Environmental Management and Natural Resources, Air Pollution, Water Pollution and its

Management, Environmental Pollution Act; Waste disposal and management, Integrated solid waste management, Recycling, Incineration, Sanitary landfill, Sewage disposal and sewage treatment; Hazardous wastes.

Unit 3

1. Environmental policy and environmental management system, Audit items and audit procedures, ISO Certification.
2. Watershed management: Definition and basic concepts, Aims and Principles, Importance of integrated watershed management, Principal watershed problems of India.

Unit 4

1. Basic concept of ecosystem and community, Biological populations and communities, Ecological niches, interaction among species, Key stone species, Species diversity and edge effects, Major terrestrial and aquatic biomes, Energy Flow, Food webs and trophic levels, Ecosystem diversity, Climate shifts, Species movements.
2. Biodiversity and conservation, *In-situ* and *ex-situ* conservation, Indigenous knowledge and biodiversity conservation, Loss of biodiversity- causes and its impact; Convention on biodiversity, Major Biodiversity resources. Global trends of invasive species, threats and managing invasive plants.
3. Biofuel plants- *Jatropha*, sugarcane and oil crops, Biofuel plantation, energy criteria for species selection, achievement of sustainable Biofuel production; Bioconversion, utilization of biomass sources, Incineration of organic wastes for energy. Alien invasive species and bioenergy production; Bioenergy and food production controversies. Carbon sequestration and carbon pools..

Lab Course

1. Field surveys to study various types of natural resources in Uttarakhand Himalaya.
2. Study on the pressures impinging on the natural resources.
3. Observations on the Environment Impact Assessment of Hydroelectric Power Project in Uttarakhand Himalaya.
3. Observations on Natural disasters viz., floods, landslides, forest fires frequent in Himalayas
4. Visits to National Parks, Wild life Sanctuaries and Biosphere Reserves.

SUGGESTED READINGS

1. FAO Conservation Guide Nos. 12, 13/1, 13/3, 13/4, 13/6, 14. Rome.
2. Heywood, H.V. 1995. Global Biodiversity Assessment.
3. Lochwood, M., Worboys, G.L. and Ashish, K. 2006. Managing Protected Areas: A Global Guide.
4. Ramakrishnan, P.S., Saxena, K.G. and Chandrashekara, U.M. 1998. Conserving the sacred for Biodiversity Management. Oxford and IBH Publ. Co. New Delhi
5. Richard, P.P. 1998. Essentials of Conservation Biology. Boston University.

Lab Course: BOT30P*

Plant Physiology and Biochemistry

1. To study the effect of temperature upon the permeability of the cytoplasmic membrane.
2. To determine the osmotic pressure (potential) of cell saps of living cells by plasmolytic method
and also by using KNO3 and sugar solution and to calculate the isotonic coefficient of sugar.

3. To determine the diffusion pressure deficit of plant cells.
4. To set up a Wilmott's bubbler and to study the effect of the following on the rate of photosynthesis
(a) varying CO2 concentration and (b) different wavelengths of light.
5. To extract the four pigments i.e. chlorophyll a & b, carotene and xanthophylls from the green leaves and preparation of their absorption spectrum.
6. To separate the four pigments i.e. chlorophyll a & b, carotene and xanthophylls from the green leaves by paper chromatography and column chromatography.
7. To separate the amino acids by paper chromatography.
8. Principles of colorimetry, spectrophotometry and flourimetry.

Plant Ecology and Remote Sensing

1. To determine the minimum size of the quadrat by species area curve method and minimum number of quadrats to be laid down in the field under study.
2. To determine the frequency, density and abundance of each species present in community.
3. To calculate relative frequency and relative density of each species in a given area.
4. To calculate mean basal cover and total basal cover of each species in a given area.
5. To compute the relative dominance and IVI (Importance Value Index) of each species in a given area.
6. To calculate the Alpha (α) diversity, Beta (β) diversity and total diversity of given community.
7. To calculate water holding capacity of three samples of various soil types and to find the percolation percentage of water in the given soil.
8. To find out the bulk density and porosity of different soil types
9. To test the pH and the buffering properties of soils.
10. Study of types of aerial photos and satellite data products.
11. Orientation of stereo model under mirror stereoscope.

Biotechnology:

1. Tissue culture activities
2. Growth characteristics of *E. coli* using plating and turbidimetric methods.
3. Isolation of plasmid of *E. coli* by alkaline lysis method and its quantitation spectro-photometrically.
4. Restriction digestion of plasmid and estimation of the size of different DNA fragments.
5. Cloning of a DNA fragment in a plasmid vector, transformation of the given bacterial population and selection of recombinants.
6. Demonstration of DNA sequencing by Sanger's dideoxy method.
7. Demonstration of protoplast fusion employing PEG.
8. Organogenesis and somatic embryogenesis using appropriate explants and preparation of artificial seed.
9. Co-cultivation of the plant material (e.g. leaf discs) with *Agro bacterium* and study GUS activity histo-chemically.

*Additional Lab course of selected elective paper.

SEMESTER IV

Paper I (BOT401): Plant Breeding and Biostatistics

PLANT BREEDING

Unit 1

1. The role of plant breeding – historical aspects and genetic basis: mode of reproduction in relation to breeding methods, breeding techniques; method of plant breeding in relation to self-pollinated and cross pollinated plants.
2. Hybridization: Interspecific and inter generic; pure line; back cross hybridization; self incompatibility system.
3. Heterosis: Its genetic and physiological basis.

Unit 2

1. Breeding for resistance to diseases, physiological races.
2. Role of mutation in crop improving and evolution.
3. Plant breeding work done in India with special reference to potato, paddy, wheat and sugarcane.
4. Maintenance of collection, registration of varieties, seed production, testing, certification and distribution.

BIOSTATISTICS

Unit 3

1. Biostatistics and its application in life sciences.
2. Methods of representation of statistical data and measurements of central tendencies.

Unit 4

1. Correlation, regression, curve fitting and ratio of variation.
2. Probability and use of binomial trials.
3. Test of significance, X^2, 't' and 'f' tests.

SUGGESTED READINGS:

Plant Breeding:

1. Harihar, Ram, 1997. Vegetable Breeding: Principles and Practices. Jagminder Book Agency. New Delhi
2. Hill, J. 1997. Quantitative and Ecological Aspects of Plant Breeding, Jagminder Book Agency. New Delhi.
3. Kapoor, R.L. 1997. Plant Breeding and Crop Improvement. 2 Vols
4. Mc Donald, M.B. 1997. Seed Production: Principles and Practices.
5. Poehlman, J.M and D. Borthakur, 1969. Asian Field Crops. Oxford and IBH Publ. New Delhi.
6. Poelhman, J.M and Sleeper, D.R. 1995. Breeding Field Crops. Panima Publ. House, New Delhi.
7. Sharma, J.R. 1994. Principles and Practice of Plant Breeding. Tata McGraw Hill Publ. Co. Ltd., New Delhi.
8. Singh, B.D. 2002. Plant Breeding Principles and Methods. Kalyani Publ. New Delhi.

Biostatistics:

1. Bliss, C.I. 1967. Statistics in Biology. 2 Vols. Mc Graw Hill, New York.
2. Downey, N.M and Heath, R.W. 1960. Basic Statistical Methods, Harper International.
3. Rayner, A.A. 1969. A first Course in Biometry for Agriculture Students. Peitermaritzburg. University of Natal Press.
4. Singh, R.K. 1994. Biometrical Techniques in Breeding and Genetics. Bishen Singh Mahendra

Pal Singh. Dehradun.
5. Watt, T. 1993. Introductory Statistics for Biology Students. Narosa, New Delhi.
6. Winer, B.J. 1962. Statistical Principles in Experimental Design. Mc Graw Hill,New York.

Paper II (BOT402): Conservation Biology

Unit 1

1. Conservation: The basic concept, History of conservation biology.
2. The origin and evolution of organism; genetic plasticity a factor in evolution; the invasion of unoccupied ecological niches.
3. Patterns of biodiversity: Global and regional patterns of biodiversity, Distribution, Gradients, Magnitude of biodiversity, Hotspots, keystone species, effects of species deletion and addition on maintenance of biodiversity.
4. Uses of biodiversity: food, fodder, timber, fibre, medicine, etc.; biodiversity based products and industries; wild relatives of cultivated plants; scientific role of biodiversity.

Unit 2

1. Threats to biodiversity: Habitat loss and fragmentation, Genetic drift, Inbreeding, Disturbance, Pollution, Climate Change, Overexploitation, Invasive Species, Disease,
2. Global environmental problems: Global warming, ozone depletion, desertification.
3. Extinction to species: Susceptibility to extinction causes of species extinction, endangered species, Red and Green Data Books.

Unit 3

1. Environmental Impact Assessment (EIA) origin and development, development in India, Purpose and aims of EIA, Core values and principles, EIA process, components of EIA, Participants in EIA process, Impact identification methods.
2. Conservation of Biological diversity: Genetic principles in conservation, biodiversity assessment and inventory.
3. Survey and monitoring of biological resources: sampling population for biological conservation; Collection and analysis of inventory data, criteria on choice of species for conservation. People participation, biodiversity registers and their maintenance.

Unit 4

1. Conservation of energy resources; conservation and maintenance of non-renewable fossil fuel resources; Conservation of biodiversity based renewable energy resources.
2. Protected Area Network, PAN with special reference to Uttarakhand and India.
3. Indian biodiversity and its conservation: International efforts for conserving biodiversity viz., CITES, CBD, IUCN, MAB, UNEP, UPOV (Union for the Protection of New Plant Varieties), WTO etc.). International treaty on Plant Genetic Resources, International Agreement for conserving marine biodiversity, Wetland conservation, Rangeland management.
4. Ecosystem restoration, Strategies and plans for restoration, Passive restoration (natural recovery) and active restoration.
5. Wildlife (Protection) act 1975, Forest (Conservation) Act 1980, Environment (Protection) Act 1986, Wildlife (Protection) Amendment Act 1991, Biodiversity Act 2003, etc.

SUGGESTED READINGS

1. Cain, M.L., Bowman, W.D. & Hacker, S.D. 2008. Ecology. Sinauer Associates, Inc.
2. Dhar, U. 1993 (Ed.). Himalayan Biodiversity: Conservation Straegies, Gyanodaya Prakashan, Nainital

3. Groombridge, B. and Jenkins, M.D. 2000. Global Biodiversity. Earth's living resources in the 21th century, UK. World conservation Monitoring Center. Pp 246.
4. Hunter, M.L.J. 1990. Wildlife, forest and forestry: Principals of Managing forests for biological diversity. Prentice Hall. Englewood. Cliffs. New Jersey. 370 pp.
5. Hunter, Jr, M.L. & Gibbs, J.P. 2006. Fundamentals of Conservation Biology. Wiley Blackwell.
6. Pullin, A Conservation Biology. Cambridge University Press, The Edinberg Building, Cambridge CB2ZRU, UK.
7. Primack, R.B. 2006. Essentials of Conservation Biology. Sinauer Associates, Inc.
8. Primack, R.B. 2008. A Primer of Conservation Biology. Sinauer Associates, Inc.
9. Singh, J.S., Singh, S.P. & Gupta, S.R. 2007. Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi.
10. Western, D. and Pearl, M.C. 1989. Conservation for twenty-first century. Oxford University Press, Oxford UK. Pp 109-120.

Paper III (BOT403): In-vitro technologies and industrial applications

Unit 1

1. Micropropagation (via organogenesis and embryogenesis) of floricultural, agricultural and pharmaceutical crops: Orchids, Chrysanthemum, Gerbera, Carnation, Anthurium, Bamboos, Spilanthes, Stevia, Psoralea, Chickpea and elite tree species of national importance.
2. Production of virus free plants through meristem culture in orchids and fruit trees.
3. Germplasm conservation in vitro.

Unit 2

1. Variations: Somaclonal and gametoclonal variations, spontaneous, genetic and epigenetic variations.
2. Culture systems: Differentiated, undifferentiated, physiological, biochemical and molecular role of minerals and growth regulators in understanding differentiation of organs under in vitro conditions.
3. Problems in Plant Tissue Culture: contamination, phenolics, recalcitrance.
4. Problems in establishment of regenerated plants in nature: hardening, association of mycorrhiza and rhizobia.

Unit 3

1. Factors responsible for in vitro and ex vitro hardening.
2. Use of bioreactors in secondary metabolite production and scale up automation of plant tissue culture.

Unit 4

1. Recent applications of tissue culture techniques and biotechnology in the introduction of economically important traits in horticultural, agricultural and medicinal plants.
2. Interactions, training and workshops in Biotech industries and placements.

SUGGESTED READINGS:

1. Herman EB (2008) Media and Techniques for Growth, Regeneration and Storage 2005-2008. Agritech Publications, New York, USA.
2. Pierik RLM (1999) In Vitro Culture of Higher Plants. Kluwer Academic Publishers.
3. Prakash J & Pierik RLM (1991) Horticulture - New Technologies and Applications (Current Plant Science and Biotechnology in Agriculture). Kluwer Academic Publishers.

4. George EF, Hall MA and Geert-Jan De Klerk (2008). Plant Propagation by Tissue Culture (3rdEdition), Springer, Netherlands.
5. Journals: Plant Cell, Tissue and Organ Culture, Plant Cell

Lab Course:

1. Development of regeneration protocols employing direct and indirect organogenesis / somatic embryogenesis in economically important horticultural and/or medicinal plants.
2. Control of phenolics in recalcitrant tissues under culture conditions.
3. Study of various physico-chemical factors (pH, light, hormones, etc.) on invitro growth and development of tissues or organs, rooting of regenerants, in vitro and ex vitro hardening, potting and acclimatization in natural conditions.
4. Shoot-tip meristem culture for raising virus-free plants in tomato / tobacco.
5. Agrobacterium rhizogenes mediated development of hairy root cultures.
6. Isolation of bioactive compounds from medicinal plants using column chromatography and TLC.
7. Preparation of synthetic seeds for germplasm conservation using somatic embryos or other propagules.

ELECTIVE PAPERS

Paper IV (a) (BOT404/E1): Forest Ecology

Unit 1

1 Forests, forestry and man: Definition, forests in geological ages, forests in prehistoric era, shifting cultivation, forests in historical time, scientific forestry, forest policy, natural forest policy, private forest policy, panned forest development, forestry education in India.
2. Essential elements of forest ecology: Extent and boundaries, physical features, geology, river system, soil, land-use pattern, role in country's economy, forests and wild land.

Unit 2

1. Forests and trees: Locality factors of the forests, forest influences, forest composition, stand structure, dynamics and growth, classification, forest types and their distribution, species diversity
2. Wild Life: Species and distribution, Sanctuaries, Biosphere reserves, wild life and recreation.
3. Forest conservancy and Potential Productivity: Soil, Water relation and nutrition, soil erosion and conservation, potential productivity of forests, site quality evaluation.

Unit 3

1. Forest Conservation and Management:
i) Impact of deforestation on soil and water, Role of fire: type, extent and cause of fire, fuel load, fire and different forest types of Himalaya.
ii) Forest resource management and forest resource information system.

Unit 4

1. Forest cover in India-State of Art, Ground inventory. Application of Remote Sensing and Geographic Information System (GIS) in Land cover mapping. Vegetation and forest type maps.
2. Environmental Impact Assessment: Maintenance and conservational policies such as Joint Forest Management (JFM) and Agroforestry in the region.

Lab Course:

1. To undertake studies on stand analysis, dominance, diversity and similarity coefficient.

2. To make studies on gradient analysis.
3. To identify different forest types of the locale.
4. Calculate the Pateron week index of any natural forest stand.
5. Study ordination and continuum of different forest stands.
6. Study interspecific Association in forest stands using Plot less technique.
7. Calculate analytical and synthetic characters of different forest stands.
8. Prepare profile diagram of forest stands using Single Plot Method.

SUGGESTED READINGS:

1. Bir, S.S. and Chatha, G.S. 1988. Forest Vegetation Characteristics of Indian Hills. Today and Tomorrow's Printers & Publ., New Delhi.
2. Dwivedi, A.P. Forestry in India. Jugal Kishor and Company, Dehradun.
3. Misra, R. Ecology Work Book. Oxford & IBH Publishing Co. New Delhi.
4. Mishra, R. and Gopal, B. Recent Advances in Tropical Ecology: Part I & II. International Society for Tropical ecology, Varanasi.
5. Negi, S.S. 1983. Forest Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.
6. Puri, G.S., Gupta, R.K., Meher-Homji, V.M. and Puri, S. 1989. Forest Ecology: PlantForm, Diversity, Communities and Succession. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
7. Puri, G.S., Meher-Homji, V.M., Gupta, R.K. and Puri, S. Forest Ecology: Vol I & II. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
8. Singh, G. 1987. Forest Ecology of India. Rawat Publications, Jaipur
9. Singh, J.S. and Singh, S.P. 1992. Forests of Himalaya. Consul Book Depot. Gyanodaya Prakashan, Nainital. India.
10. Singh, J.S. Singh, S.P. and Gupta, S.R. 2005. Ecology, Environment and Resource Conservation. Anamaya Publ., F-154/2 Ladosarai, New Delhi- 110 030
11. Singh, M.P. and Vishwakarma, V. 1997. Forest Environment and Biodiversity. Daya Publ. House, Delhi.
12. Wareing, R.H. and Schlesinger, W.H. 1985. Forest Ecosystems: Concepts and Management. Academic Press. New York.

Paper IV (b) (BOT404/E2): Industrial Microbiology

Unit 1

1. Introduction to industrial microbiology-Range of fermentation processes, microbial biomass, microbial enzymes, microbial metabolites and transformation processes.
2. Selection and strain improvement strategies - 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.

Unit 2

1. Types of fermentation - Solid state fermentation and submerged fermentation; batch, continuous and fed batch fermentation. Homo- and heterofermentation. Aerobic and anaerobic fermentation. Static and stirred fermentations.Media for microbial growth and fermentation - Typical media, media formulation; water, energy and carbon source, nitrogen sources, minerals and vitamins, buffers, precursors, metabolic regulators, oxygen requirement.
2. Bioreactors - Brief study on stirred tank fermenter, air-lift fermenter, packed tower fermenter, tray fermenter, rotary drum fermenter.Microbial fermentation- Sterilization -

media, fermenter, air. Inoculum preparation, inoculation.Aeration, agitation, pH control, temperature control, antifoam agents.Process parameter optimization: One factor at a time and statistical optimizations (brief study only).Scale up of fermentation (lab scale, pilot plant, industrial scale).

Unit 3

1. Downstream processing- Separation of microbial cells – Filtration, precipitation, centrifugation.
2. Cell disruption – liquid shear, freezing-thawing, ultrasonication, osmotic shock, enzyme treatment. Concentrating and purifying the products - ultrafiltration, crystallization, solvent precipitation, reverse osmosis, chromatography.Production of industrially important products

Unit 4

1. Antibiotics - Penicillin, Streptomycin.Amino acids - Lysine, Glutamic acid.Enzymes - Amylase, Cellulase, Pectinase. Organic acids - Lactic acid, Acetic acid, Gluconic acid.Biofuels – Bio-ethanol, Bio-butanol.Biopolymers - PHB, PLA.Alcoholic beverages - Wine, Beer.Microbial cells - SCP,
2. Baker's yeast. Immobilization of cells and enzymes- Methods of cell and enzyme immobilization. Applications of immobilized cells and enzymes.

Lab Course

1. Screening and isolation of microbes for production of organic acids and enzymes.
2. Preparation and maintenance of stock cultures (Bacteria and Fungi).
3. Preparation of bacterial inoculum by measuring OD and enumeration of bacterial cells by serial dilution and pour plate (or spread plate) method.
4. Solid state and Submerged fermentation for amylase (or any other enzyme) production and quantification of product by suitable assay methods.
5. Optimization of process parameters for enzyme production in submerged fermentation.
6. Partial purification of amylase (or any other enzyme) produced by microbial fermentation using acetone precipitation.
7. Immobilization of yeast cells and sugar fermentation using immobilized cells.

Suggested readings:

1. Madigan, M.T., J.M. Martink and J. Parker (1997). Brock Biology of Microorganism. Printice hall International, Inc., New, Jersey.

2. Prescott (2000). Microbiology.

3. Cruezer, W. and A. Cruezer (1990). A Textbook of Industrial Microbiology.

4. Alexander, M. (1977). Soil Microbiology. John Wiley and Sons, New York.

5. Dubey, R.C. and D.K. Maheshwari (2010). A Textbook of Microbiology. S. Chand and Co. Pvt. Ltd. New Delhi.

Paper IV (c) (BOT404/E3): Ethnobotany

Unit 1

1. Introduction, concept, scope and objectives. Linkage of Ethnobotany with other sciences and disciplines in biology – food and nutrition, medicine, sociological and cultural practices, religions and social costumes and economic relations.
2. Ethnic groups and Ethnobotany: Major and minor ethnic groups of Uttarakhand and their life styles. Forest v/s Ethnic groups.

Unit 2

1. Methodology of Ethnobotanical studies: Field work, Herbarium, Ancient Literature , Archaeological findings , Temples and sacred places. Protocols. Plants and Tribal medicine: Significance of *Curculigo orchioides, Costus speciosus, Gloriosa superba, Butea monosperma, Wrightia tinctoria* and *Pongamia pinnata* in Ethno-medical practices along with a brief note on their habitat and morphology.
2. Medico-ethnobotanical research in Uttarakhand.

Unit 3

1. Different systems of indigenous medicine (Traditional medicine, Ayurveda, Siddha, Unani), Homeopathy and Allopathy. Role of Phytomedicine in modern systems of medicine.
2. Classification of drugs; analytical methods – drug adulteration, drug evaluation, anatomical and phytochemical analysis of crude drugs; preliminary screening, fractionation and separation of different groups of biodynamic compounds and biological evaluation.

Unit 4

1. Phytopharmaceuticals: Drugs of alkaloids, coumarins, volatile oils, tannins, resins and gums. Natural pesticides, antibiotics, allergens and poisonous plants. Economic potential of phytomedicine; potential drug yielding plants and their marketing avenues. IPR and patenting of active principles.
2. Ethnobotany and conservation of plants with special reference to Uttarakhand – mythology and conservation of ecosystems, conservation of selected plant species: sacred groves, forestry and unique ecosystems and their ethnobiolgical values, plants and animals in art, tradition and ethnography: methodologies in ethno-botanical research

Lab Course:

1. Preparation of the herbarium specimen medicinally important plants.
2. Listing of plants used by villagers and on the basis of their local use to place them in the field of the study of ethnobotanical research.
3. Study of Economic potential of Phytomedicine and role of phytomedicine in modern system of medicine.

Suggested Readings:

1. S.K. Jain, Manual of ethnobotany, scientific publishers, Jodhpur, 1995.
2. S.K. Jain (ed.) Glimpses of Indian Ethnobotany, Oxford and I B H, New Delhi, 1981.
3. S.K. Jain, (ed.) Methods and approaches in ethnobotany. Society of Ethnobotanists, Lucknow, India, 1989.
4. S.K. Jain, Contributions of Indian ethnobotany. Scientific Publishers, Jodhpur, 1990.
5. Colton C.M. Ethnobotany-Priciples and applications. John Wiley and sons-Chichester, 1997.
6. Rama R. N. and A.N. Henry, The ethnobotany of Eastern Ghats in Andhra Pradesh, India. Botanical Survey of India, Howrah, 1996.
7. Rajiv K. Sinha, Ethnobotany-the renaissance of traditional Herbal Medicine-I N A- Shree publishers, Jaipur, 1996.

Paper IV (d) (BOT404/E4): PALYNOLOGY AND POLLINATION BIOLOGY

Unit 1

1. General Introduction, microsporogenesis, microspore tetrads and polarity of spores and pollen grains.
2. Pollen wall development and pollen chemistry, Chemical nature of sporopollenin, development of pollen wall, Ubisch body, pollen wall proteins, origin and formation exineless pollen grains; pollen expressed and pollen specific genes.

Unit 2

1. Spore-pollen morphology: Symmetry, shape, size, aperture patterns, NPC System for numerical expression of apertural details, exine stratification, surface structures and sculptures of sporoderm; LO-analysis and edge-analysis.
2. Paynotaxonomy: Systematic palynology, identification key and evolutionary trends among pollen grains based on palynotaxonomical works.
3. Aeropalynology with reference to allergy: Aeroallergens, introductory idea of Immune System with special reference to IgE. Study of airspora, identification of allergic taxa by *invivo* and *in-vitro* tests with spore-pollen extracts, chemical nature of exine-borne allergens, allergic taxa of North-West Himalaya.

Unit 3

1. **Melissopalynology:** Indian species of honey bees, importance of pollen grains as constituent of bee-bread, pollen-collecting mechanism of honey bees, analysis of pollen load and honey sample in understanding bee forage, objectives of melissopalynological studies, important bee plants of North- West Himalaya.
2. **Palaeopalynology:** Introductory idea about palaeopalynological remains, significance of palaeopalynology.

Unit 4

1. Forensic palynology: Definition and significance, a few well-known case studies.
2. Pollination Biology: Pollen dispersal units; pollination types, contrivances for cross- and self-pollination; pollen vectors, pollination modes and flora organization, Pollen viability and storage, evolutionary trends in pollination modes. Breeding systems, incompatibility and compatibility control with reference to pollen-pistil interactions and pollen biotechnology.

Lab Course

1. Pollen morphological studies of some pterodophytes, gymnosperms, and angiosperms representing different morphological types using acetolysis / alkali maceration method.
2. Extraction of pollen grains from honey sample and study of the frequency of different morpho-types.
3. Study of in vivo and in vitro germination of pollen grains.
4. Morpho-anatomical study of stigma and style.
5. Study of the growth of pollen tube through stigma and style.
6. Study of allergy producing pollen morpho-types.

SUGGESTED READINGS:

1. Crane, Eva; Walker, Penelope and Day Rosemany.1984. Directory of Important World Honey Sources: International Bee Research Association, London.
2. Erdtman, G. 1952. Pollen Morphology and Plant Taxonomy, Angiosperms; Almquist and Wiksell, Stockholm.

3. Knut Segril. Johnson Iverson. 1975. Text book of pollen analysis 3rd edition. Blackwell Publ.
4. Nair, P.K.K. 1966. Essentails of Palynology; Asia Publication House Lucknow.
5. Woodhouse, R.P. 1935. Pollen Grains: Hafner Publication Co.

Paper IV (e) (BOT404/E5): Seed Pathology

Unit 1

1. Introduction, terminology and historical development, seed health and its importance.
2. Kinds of seed borne pathogens: fungi, bacteria, viruses, viroides and nematodes.
3. Types of damage caused by the seed borne fungi to seeds and crops.

Unit 2

1. Nature of seed infection. Systemic infection through flower, fruit and seed stock. Penetration through seed coat, natural openings and inflicted openings.
2. Longevity of seed borne pathogens. Factors influencing longevity.

Unit 3

1. Epiphytology of seed borne diseases, monocyclic and polycyclic diseases
2. Detection of seed borne pathogens, objectives of seed health testing. Testing methods for seed borne fungi, seed borne bacteria, seed borne viruses and seed borne nematodes.

Unit 4

1. Study of seed borne diseases of certain specific crops, cereals, millets, pulses, oil crops, fibre crops, and vegetable and timber crops
2. Control of seed borne pathogens: selection of seed production areas, crop management, seed treatment, certification, plant quarantine and disease resistance.

Lab Course

1. Isolation and inoculation of mycorrhiza.
2. Study of seed borne pathogen. Description of pathogen, symptoms and section cutting.
3. Isolation of some important pathogens.
4. Procedure of equipments uses.
5. To establish a plant disease clinic in the department for advise to local people.

SUGGESTED READINGS

1. Neegard P. 1977. Seed Pathology Vol I and II. MacMillan Press, London
2. Suryanarayan, D. 1978. Seed Pathology. Vikas Publ. House. Pvt. Ltd. New Delhi.
3. Jha, D.K. 1995. A Text Book of Seed Pathology. Vikas Publ. House. Pvt. Ltd. New Delhi.
4. Agarwal, V.K. 1978. Principles of Seed Pathology. In (ed.) James B.S. Sindair.CRC Press. II Edition.
5. Desai, B.B. Seed Handbook. CRC Press.
6. Singh, Gurnam, Seed Pathology. Pointer Publisher, Jaipur.
7. Singh, T. Seed Technology and Seed Pathology. Pointer Publisher, Jaipur.
8. Nene, Y.L. and Agarwal, V.K. 1978. Some seed borne diseases and their control. ICAR, New Delhi

Lab Course : BOT40P*

1. Emasculation, bagging and hand pollination techniques to study pollen germination. Application of common plant breeding techniques
2. Floral biology of local food, pulse, vegetable and horticultural crop
3. To test the goodness of fit and independent assortment using Chi-square method.
4. To study the pattern of regional biodiversity.
5. To study the Hot spots and key stone species.
6. Survey of biological resources.
7. Study of habitat loss with respect to plant species. To observe factors expediting habitat loss viz., floods, forest fires, landslides, natural and anthropological activities.
8. Visits to national parks, sanctuaries and biosphere reserves of Uttarakhand.
9. Visit to ecosystem restoration sites in mined areas in Uttarakhand Himalayas.
10. PTC – Laboratory organization, different sterilization/aseptic technique.
11. Preparation and sterilization of media
12. Callus culture (morphological and internal structure) and suspension cultures (growth curve)
13. Shoot tip, axillary bud, nodal explant culture.
14. Root tip and leaf culture.
15. Protoplast isolation and fusion
16. Somatic embryogenesis and production of artificial seeds.
17. Anther, pollen, ovule culture.

*Additional lab course of selected elective paper.

04.07.2018

OBJECTIVE OF THE COURSE

To teach the fundamental concepts of Chemistry and their applications, the syllabus pertaining to M.Sc. (2 Year Degree Course) in the subject of Chemistry has been prepared as per provision of the UGC module and demand of the academic environment. The syllabus contents are duly arranged unit wise and contents are included in such a manner that due importance is given to requisite intellectual and laboratory skills. This M.Sc course of chemistry consist of 2 year - course with semester system-in all 4 semesters (two semester in a year)
Total marks: 2000 (1000 per year and 500 per semester) of core and elective disciplines

MSc SEM I

S. No.	Paper	Paper Code	Max Marks (100)	
			Ext.	Int.
1	Inorganic Chemistry	CHC101	80	20
2	Organic Chemistry	CHC102	80	20
3	Physical Chemistry	CHC103	80	20
4	Group Theory and Instrumentation Techniques	CHC104	80	20
5	Lab Course (Inorganic Organic and physical))	CHC10P	80	20

MSc SEM II

S. No.	Paper	Paper Code	Max Marks (100)	
			Ext	Int.
1	Inorganic Chemistry	CHC201	80	20
2	Organic Chemistry	CHC202	80	20
3	Physical Chemistry	CHC203	80	20
4	Spectroscopy and analytical methods	CHC204	80	20
5	Lab Course (Inorganic ,Organic and Physical)	CHC20P	80	20

MSc SEM III [SPECIALIZATION IN INORGANIC CHEMISTRY]

S. No.	Paper	Paper Code	Max Marks	
			Ext.	Int.
1	Organometallic Chemistry	CHC301	80	20
2	Spectroscopy	CHC302	80	20
3	Analytical Chemistry	CHC303	80	20
4(i)	Chemistry of Biological System I (Bioinorganic)	CHE301	80	20
(ii)	Bioinorganic & Supramolecular Chemistry	CHE302	80	20
5	Lab Course (Inorganic)	ICHC30P	80	20

MSc SEM III [SPECIALIZATION IN ORGANIC CHEMISTRY]

S. No.	Paper	Paper Code	Max Marks	
			Ext.	Int.
1	Reagents in Organic Synthesis and Organometallics	CHC304	80	20

2	Spectroscopy	CHC302	80	20
3	Organic Photochemistry	CHC305	80	20
4(i)	Chemistry of Biological System I (Bioorganic)	CHE303	80	20
(ii)	Chemistry of Natural Products	CHE304	80	20
5	Lab Course (Organic)	OCHC30P	80	20

MSc SEM III [SPECIALIZATION IN PHYSICAL CHEMISTRY]

S. No.	Paper	Paper Code	Max Marks	
			Ext.	Int.
1	Advanced Quantum Chemistry	CHC306	80	20
2	Spectroscopy	CHC302	80	20
3	Analytical Chemistry	CHC307	80	20
4(i)	Chemistry of Biological System I (Biophysical)	CHE305	80	20
(ii)	Nuclear Chemistry	CHE306	80	20
5	Lab Course (Physical)	PCHC30P	80	20

MSc SEM IV [SPECIALIZATION IN INORGANIC CHEMISTRY]

S. No.	Paper	Paper Code	Max Marks	
			Ext.	Int.
1	Spectroscopy & Diffraction method	CHC401	80	20
2	Photo Inorganic Chemistry	CHC402	80	20
3	Inorganic Polymers	CHC403	80	20
4(i)	Nuclear Chemistry	CHE306	80	20
(ii)	Environmental Chemistry	CHE401	80	20
(iii)	Project work / Dissertation	CHE402	80	20
5	Lab Course (Inorganic)	ICHC40P	80	20

MSc SEM IV [SPECIALIZATION IN ORGANIC CHEMISTRY]

S. No.	Paper	Paper Code	Max Marks	
			Ext.	Int.
1	Organic Synthesis	CHC404	80	20
2	Organic Spectroscopy	CHC405	80	20
3	Heterocyclic Compounds	CHC406	80	20
4(i)	Medicinal Chemistry	CHE403	80	20
(ii)	Environmental Chemistry	CHE401	80	20
(iii)	Project work / Dissertation	CHE404	80	20
5	Lab Course (Organic)	OCHC40P	80	20

MSc SEM IV [SPECIALIZATION IN PHYSICAL CHEMISTRY]

S. No.	Paper	Paper Code	Max Marks	
			Ext.	Int.
1	Advanced Chemical Dynamics	CHC407	80	20
2	Advanced Spectroscopy	CHC408	80	20
3	Solid State Chemistry	CHC409	80	20
4(i)	Chemistry of Materials	CHE405	80	20

(ii)	Environmental Chemistry	CHE401	80	20
(iii)	Project work / Dissertation	CHE406	80	20
5	Lab Course (Physical)	PCHC40P	80	20

Abbreviation:

CHC = Chemistry Core course CHE = Chemistry Elective Course

Note:

In III and IV semesters, the candidate shall have to opt for one elective papers of a particular specialization (Inorganic/Organic/Physical). The candidate shall not be allowed to opt elective papers from different specializations. Five lab experiments from the list of experiments given in the syllabus is the minimum requirement. He/ She can opt for Project/dissertation as an elective paper. The topic of the project will be decided by the Project Supervisor. Marks awarded for the project work shall be based on the novelty/quality of project work; it's presentation/viva-voice and social applicability. He/She will have to submit the project/dissertation not later than the date of his/her practical examination.

SEM I

(I) Inorganic Chemistry (CHC101)

1. **Stereochemistry and Bonding of**
   a) Main Group Compounds

   Origin of VSEPR theory and its significance in main group structural chemistry, structure of SF_4,TeF_5^- ,BrF_3^-, ICl_2^-, ICl_4^-, OF_2, OSF_4, XeF_6 and IF_7, $d\pi$-$p\pi$ bonds, Bent rule and energetic of hybridization, some simple reactions of covalently bonded molecules.

   b) Metal Borides, metal carbides and metal nitrides
   Metal borides, carbides and nitrides: preparation, properties, structures and application.

2. **Metal-Ligand bonding in Coordination Chemistry**

   Crystal field theory, factors affecting the magnitude of $\Delta 0$. Consequences of crystal field splitting. Merits and limitations of CFT Jahn-Teller distortion and its consequences on complex formation. Evidence of covalent character in Metal-Ligand bonding. Molecular orbital theory as applied to octahedral, tetrahedral and square planar complexes.

3. **Metal Ligand Equilibria in Solution**

   Concept of thermodynamic and kinetic stabilities of metal complexes. Stepwise and overall formation constants and their correlations, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH-metry and spectrophotometry

4. **Reaction Mechanism of Transition metal Complexes**

   Energy profile of a reaction and reactivity of metal complexes. Inert and labile complexes. Ligand substitution reactions in octahedral complexes i.e. SN1,SN2 and SN1CB mechanism. Anation reactions without metal ligand bond cleavage. Electron transfer reactions(Redox reactions). Outer and inner sphere mechanism (OSM and ISM).Reactions of coordinated ligands. Substitution reactions in square-planer complexes.

Books Recommended:

1. F. A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann, Advance Inorganic Chemistry, John Wiley & Sons , New York.
2. J. D. Lee, Concise Inorganic Chemistry, Oxford University Press.
3. Atkins, Overton, Rourke, Weller and Armstrong, Inorganic Chemistry, Oxford University Press.
4. J. E. Huheey, E. A Keiter and R. L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, Pearson Education.
5. W. W. Porterfield, Inorganic Chemistry: A Unified Approach, Elsevier.
6. G. Wulfsberg, Inorganic Chemistry, Viva Books.
7. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, Pearson Education.

(II) Organic Chemistry (CHC102)

1. **Nature of Bonding in Organic Molecules**
   Delocalized chemical bonding conjugation, cross conjugation, resonance, hyperconjugation, bonding in fullerenes, tautomerism. Aromatcity in benzenoid and non-benzenoid compounds, alternant and nonalternant hydrocarbons, Hückel's rule, energy level of π -molecular orbitals,

annulenes, antiaromaticity, ψ-aromaticity, homo-aromaticity, PMO approach. Bond weaker than covalent bond, addition compounds, crown ether complexes andcryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes.

2. **Stereochemistry of Organic compounds**

Molecular symmetry and chirality: symmetry operations and symmetry elements, point group classification and symmetry number. Stereoisomerism: Classification, racemic modification, molecules with one, two or more chiral centres. Configuration, nomenclature, D, L, R, S and E, Z nomenclature. Axial and planar chirality and helicity (P & M); stereochemistry and configurations of allenes, spiranes, alkylidene, cycloalkanes, adamantanes, catenanes, biphenyls (atropisomerism), bridged biphenyls, ansa compounds and cyclophanes. Topicity and prostereoisomerism: Topicity of ligands and faces and their nomenclature, stereogenicity, cyclostereoisomerism: configurations, conformations and stability of cyclohexanes, (mono-, di- and tri-substituted), cyclohexenes, cyclohexanones, halocyclohexanones, decalines, decalols, decalones.. Assymetric induction; Cram's, Prelog's and Horeaus rules. Dynamic stereochemistry (cyclic and acyclic). Stereochemistry of compounds containing N, S and P. chirogenicity, pseudo asymmetry and stereogenic centre. Stereoselectivity, stereospecificity, regioselectivity and chemoselectivity. Enantiomeric and diasteriomeric excess.

3. **Reaction Mechanism: structure and reactivity**

Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects. Effect of structure on reactivity – resonance and field effects, steric effect, quantitative treatments. Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation.

4. **Aliphatic and Aromatic Nucleophilic Substitution and Mechanism of Carbocationic rearrangement reactions**

The SN^2, SN^1, mixed SN^1 and SN^2, SN^i and SET mechanisms. Nucleophilic substitution at and allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity. Neighbouring group mechanism, neighbouring group participation by □ and □ bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl system.

Pinacol-Pinacolone rearrangement, Wagner-Meerwein rearrangement, Benzilic acid rearrangement, Allylic rearrangement, Hofman reaction, Schmidt reaction, Baeyer- Villiger oxidation, Cumene-Hydroperoxide rearrangement, Curtius rearrangements, Lossen rearrangement, Dakin reaction. Application of NMR Spectroscopy in detection of carbocations.

BOOKS SUGGESTED:

1. Jerry March, Advanced Organic Chemistry Reactions, Mechanism and Structure, John Wiley.
2. R. T. Morrison and R. N. Boyd, Organic Chemistry, Prentice Hall.
3. C. K. Ingold, Structure and Mechanism in Organic Chemistry, Cornell University Press.
4. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Macmillan.
5. D. Nasipuri, Stereochemistry of Organic Compounds, New Age International
6. P. S. Kalsi, Stereochemistry of Organic Compounds, New Age International.
7. S. M. Mukherjee, Pericyclic Reactions, Macmillan, India.
8. F. A. Carey and R. J.Sundberg Advanced Organic Chemistry, Plenum.
9. Benjamin, Modern Organic Reactions, HO House.
10. Ernest L. Eliel andSamuel H. Wilen, Stereochemistry of Organic Compounds, Wiley

11. India
12. Ernest L.Eliel, Stereochemistry of Carbon Compounds. Tata McGraw Hill.

(III) Physical Chemistry (CHC103)

1. **Quantum Chemistry**

Introduction: De Broglie's equation and its physical significance. Time independent and dependent forms of Schrodinger equation. Operator and their algebra. Postulates of Quantum mechanics. Particle in one, two and three dimensional box. Harmonic oscillator. Rigid rotator. Hydrogen atom and shapes of orbitals.

Approximate Methods: Approximate methods of quantum mechanics: Variational method and Perturbation theory upto second order in energy and applications (Helium atom).

Angular Momentum and eigen function. Ladder operator. Addition of angular and spin momentum. Pauli exclusion principle. Fermions and bosons.

Chemical Bonding: Valence bond (VB) and molecular orbital (MO) approaches. VB treatment of Hydrogen molecule. Bonding and antibonding MO according to LCAO method. Huckel molecular orbital (HMO) theory and its application to ethene, butadiene etc.

2. **Chemical Thermodynamics**

Basics of thermodynamics (laws of thermodynamics). Partial molar properties: Chemical potential and its determination and applications.

Concept of fugacity and its determination. Activity and activity coefficient. Debye-Huckel theory for activity coefficient of electrolytic solutions. Ionic strength.

3. **Chemical Dynamics**

Arrhenius equation. Kinetics of bimolecular reactions: Collision theory of reaction rates. Activated complex theory. Kinetics of unimolecular reactions: Lindemann-Hinshelwood theory, RRKM treatment.

Kinetics of Chain Reactions: Hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane.

Kinetics of photochemical reactions: Hydrogen-bromine and hydrogen-chlorine photochemical reactions.

Oscillatory reactions: Belousov-Zhabotinsky reaction

4. **Surface Chemistry and Micelles**

Adsorption: Thermodynamics and kinetics of adsorption. BET method and it's applications for estimation of surface area. Heterogeneous catalysis.

Micelles: Concept of Micellization. Critical micellar concentration (CMC). Factors affecting micelles formation. Thermodynamics of micellization. Soluilization. Reverse micelles.

BOOKS SUGGESTED:

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
3. Quantum Chemistry, Ira N. Levine, Prentice Hall. Coulson's Valence, R. McWeeny, ELBS.
4. B. R. Puri, L. R. Sharma and M. S. Pathnia, Physical Chemistry, Milestone Publisher & Distributors, New Delhi.
5. K. L. Kapoor, Physical Chemistry, Macmillan Publishers India Limited.
6. K. J. Laidler,Kinetics, Pearson Education India.

(IV) Group Theory and Analytical Techniques (CHC104)

1. **Symmetry and Group Theory in chemistry**

Symmetry elements and symmetry operation. Defination of group, subgroup. Point symmetry group. Matrix representation of groups (C_n, C_{nv}, C_{nh}, D_{nh} only). Character table. Character representation of (case of H_2O and NH_3). Great orthogonality theorem (without derivation) and its applications. Applications of group theory in IR and Raman spectroscopy.

2. **Chromatographic and Radio Analytical Methods**

Basic principle and types of chromatography. Principle, instrumentation and applications of GC, LC, HPLC and Ion-exchange chromatography. Van-Deemter equation (without derivation).

Nuclear reactions and radiations. Measurement and detection of radiation. Principle of Isotopic dilution method and Neutron activation analysis (NAA).

3. **Microwave, Infrared, Raman Spectroscopy**

Classification of molecules. Principle of rotational spectroscopy. Energy, selection rule and spectroscopic frequency of rigid and non-rigid diatomic rotator. Population of states. Stark effect. Application of MW spectroscopy. Effect of isotopic substitution.

Principle of vibrational spectroscopy. Morse function and diagram. Vibrational energies, selection rules for diatomic harmonic and anharmonic oscillator. Overtones, hot bands, P-Q-R branch lines. Fundamental modes of vibrations, fundamental frequency and factors affecting it. Applications of IR, FTIR and its advantages.

Classical and Quantum theories of Raman effect. Pure rotational, vibrational and rotational-vibrational Raman spectroscopy. Stokes and antistokes lines. Mutual exclusion principle. Applications.

4. **Atomic and Molecular Spectroscopy**

Energies of atomic orbitals. Spin and angular vector coupling for p^2 and d^2 system. Spectra of hydrogen atom and alkali metal atoms. Frank Condone principle. Electronic spectrum of diatomic molecules: Vibrational (coarse) progressions and Rotational fine structures. Einstein's coefficients. Fluorescence, Phosphorescence and Stimulated emission.

Books Suggested:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
3. Chemical Applications of Group Theory, F.A. Cotton.
4. Introduction of Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
5. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
6. Symmetry and Spectroscopy of Molecules, K. Veera Reddy, New Age International.

(V) Lab Course (Inorganic, Organic and Physical) SEM I (CHC10P) (2×6 hours)

I(a). Qualitative Analysis

Qualitative analysis of mixtures by semi-micro methods containing not more than six cations and anions including:

(i). Rare-earth elements
(ii). Anions, which have not been done in under graduate practicals. 1×20 marks
(iii). Insolubles.

(b). Chromatography
Separation of cations and anions by- Paper Chromatography, Thin Layer Chromatography
Ion Exchange Chromatography

2(a). Qualitative Analysis
Separation, purification and identification of compounds of binary mixture (solid-solid or liquid and solid) using TLC and Paper Chromatography, Chemical tests and spectroscopic analysis.

(b). Organic Synthesis **1×20 marks**
Acetylation: Acetylation
Oxidation: Adipic acid by chromic acid oxidation of cyclohexanol.
Grignard reaction: Synthesis of triphenylmethanol from benzoic acid.
Sandmeyer reaction: p-Chlorotoluene from p-toluene

3(a). Chemical Kinetics

i. Determination of the effect of (a) Change of temperature (b) Change of concentration of reactants and catalyst and (c) ionic strength of the media on the velocity constant of Hydrolysis of an ester/ionic reactions.
ii. Determination of the velocity constant of hydrolysis of an ester.
iii. Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide studying the kinetics of the reaction.
iv. Flowing clock reactions (Ref: Experiments in Physical Chemistry by Showmaker).
v. Determination of the primary salt effect on the kinetics of ionic reactions and testing of the Bronsted relationship (iodide ion is oxidized by persulphate ion).

(b). Electrochemistry **1×15 marks**
Conductometry

i. Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometrically.
ii. Determination of solubility and solubility product of sparingly soluble salts (e.g., $PbSO_4$, $BaSO_4$) conductometrically.
iii. Determination of the strength of strong and weak acids in a given mixture conductometrically.
iv. To study the effect of solvent on the conductance of $AgNO_3/CH_3COOH$ and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Huckel-Onsager theory.
v. Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Huckel's limiting law.
vi.

4. Viva **10 marks**

5. Record **15 marks**

SEM II

(I) Inorganic Chemistry (CHC201)

1. Electronic Spectra & Magnetic Properties of Transition Metal Complexes

Spectroscopic ground states correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), calculations of Dq, B and β parameters, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, magnetic properties of complexes of various geometries based on CFT, spin free- spin paired equilibrium in octahedral stereochemistry, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

2. Metal –π Acid Complexes and Organometallic compounds

Metal carbonyl complexes. Preparation, properties and uses. Nature of bonding in metal carbonyls and carbon monoxide analogs i.e. nitrosyls and dinitrogen complexes. Evidence for back bonding in complexes. Nature of M-C bond Synthesis, bonding and uses of organometallic compounds, two electron ligands (olefinic and acetylenic complexes), three electron ligands (allylic complexes), four electron ligand (butadiene and cyclobutadiene complexes), five electron ligand (ferrocene complexes.

3. **Metal Clusters, Polyoxometalates and silicates**

Higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyl and metalhalide clusters. Clusterswith metal-metal multiple bonds. Isopoly and heteropoly acids and salts (or anions) with special reference to vanadium, molybdenum and tungsten. Nomenclature, classification, preparation and structural aspects of poly acids and polyanions.

4. **Silicates**

Principles of silicates. Structure and classification of silicates. Asbestos, Zeolites and Ultramarines as silicate materials. Silicates in technology.

Books Recommended:

1. F. A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann, Advance Inorganic Chemistry, John Wiley & Sons , New York.
2. J. D. Lee, Concise Inorganic Chemistry, Oxford University Press.
3. Atkins, Overton, Rourke, Weller and Armstrong, Inorganic Chemistry, Oxford University Press.
4. J. E. Huheey, E. A Keiter and R. L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, Pearson Education.
5. W. W. Porterfield, Inorganic Chemistry: A Unified Approach, Elsevier.
6. G. Wulfsberg, Inorganic Chemistry, Viva Books.
7. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, Pearson Education.

(II) Organic Chemistry (CHC202)

1. **Free Radical Reactions**

Types of free radical reactions, free radical substitution mechanism, mechanism of an aromatic substrate, neighboring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

2. **Electrophilic substitution reactions of**

a) Aliphatic Organic Compounds

Biomolecular mechanisms-SE2 and SE1. The SE1 mechanism, electrophilic substitution accompanied by double bonds shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity

b) Aromatic Organic Compounds

Orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrate and electrophiles. Diazonium coupling, Vilsmeir Haak reaction, Gattermann-Koch reaction.

3. **Addition Reactions and Elimination Reactions**

(a) Addition reactions of carbon-carbon multiple bonds

Mechanism and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation.

(b) Addition reactions of c-hetero multiple bonds

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Wittig reaction. Mechanism of condensation reactions involving enolates-Knoevenagel, Claisen, Mannich Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

(c) Elimination Reactions

The E2, E1 and E1cB mechanisms and their spectrum. Orientation of the double bond. Reactivity-effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

4. **Pericyclic Reactions**

Molecular orbital symmetry, Frontier orbitals of ethylene, 1, 3-butadiene, 1, 3, 5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann. Correlation diagrams. FMO and PMO approach. Electrocyclic reactions-conrotatory and suprafacial additions, 4n, and 4n+2 systems. Cycloadditions-antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1, 3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic

rearrangements- suprafacial and antarafacial shiffs of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5- sigmatropic rearrangements. Claisen, Cope and aza- Cope rearrangements. Fluxional tautomerism. Ene reaction.

BOOKS SUGGESTED:

1. Jerry March, Advanced Organic Chemistry Reactions, Mechanism and Structure, John Wiley.
2. R. T. Morrison and R. N. Boyd, Organic Chemistry, Prentice Hall.
3. C. K.Ingold, Structure and Mechanism in Organic Chemistry, Cornell University Press.
4. S. M.Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Macmillan.
5. D.Nasipuri, Stereochemistry of Organic Compounds, New Age International
6. P. S.Kalsi, Stereochemistry of Organic Compounds, New Age International.
7. S. M. Mukherjee, Pericyclic Reactions, Macmillan, India.
8. F. A. Carey and R. J.Sundberg,Advanced Organic Chemistry, Plenum.
9. Benjamin ,Modern Organic Reactions, HO House.
10. Ernest L. Eliel andSamuel H.Wilen, Stereochemistry of Organic Compounds, Wiley
11. India
12. Ernest L.Eliel, Stereochemistry of Carbon Compounds. Tata McGraw Hill.

(III) Physical Chemistry (CHC203)

1. **Statistical Thermodynamics**

Most probable distribution. Ensemble averaging. Canonical, grand canonical and microcanonical ensembles. Partition functions. Translational, rotational and vibrational partition functions. Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac Statistics. Thermodynamic properties and partition functions. Applications of partition functions.

2. **Non-equilibrium Thermodynamics**

Thermodynamical criteria for non-equilibrium states. Entropy production and entropy flow. Entropy balance equations for different irreversible processes (e.g. heat flow, chemical reaction etc.) transformations of the generalized fluxes and forces, non-equilibrium stationar states. Phenomenological equations, microscopic reversibility and Onsager's reciprocity relations. Electrokinetic phenomena, diffusion, electric conduction. Irreversible thermodynamic for biological systems, coupled reactions.

3. Electrochemistry

Basics of electrochemistry. Debye-Huckel-Onsagar treatment for ion-solvent interactions. Structure of electrified interfaces: Gouy, Chapman and Stern.
Over voltage and potential. Theories of over voltage. Exchange current density. Derivation of Butler-Volmer equation. Tafel plot.
Polarography theoretical aspect. Ilkovic equation. Half potential and its significance. Applications. Corrosion. Theory of corrosion. Forms of corrosion. Monitoring and prevention of corrosion.

4. Macromolecules-Polymers

Classification. Kinetics of polymerisation. Number and mass average molecular mass. Molecular mass determination (osmometry, viscometry, diffusion and light scattering method). Chain configuration of macromolecules. Calculation of average dimensions of various chain structures.

BOOKS SUGGESTED:

1. Physical Chemistry, P.W. Atkins, ELBS.
2. B. R. Puri, L. R. Sharma and M. S. Pathnia, Physical Chemistry, Milestone Publisher & Distributors, New Delhi.
3. K. L. Kapoor, Physical Chemistry, Macmillan Publishers India Limited.
4. K. J. Laidler,Kinetics, Pearson Education India

(IV) Spectroscopy and Analytical Methods (CHC204)

1. Thermal Analytical methods and XRD

Methods of thermal analysis. Principle and instrumentation of TGA, DTA and DSC. Applications. X-ray diffraction and Bragg's equation. Principle of XRD and its application in crystal structure determinations. Principle of Auger emission spectroscopy (AES).

2. Electron Spin Resonance (ESR) and Nuclear Magnetic Resonance Spectroscopy (NMR)

Principle of ESR. Lande's g factor. Hyperfine splitting. Application to hydrogen atom, methyl free radical etc.
ENDOR and ELDOR. Applications.Principle of NMR. Nuclear spin, Population of states. Saturation, Chemical shift and its measurement. Factor affecting chemical shift, Spin-spin interaction, factors influencing coupling constant 'J'. Spin decoupling. NMR studies of nuclei other than proton-^{13}C, ^{19}F and ^{31}P. FT NMR, advantages of FT NMR. Instrumentation of NMR. Applications.

3. Mass Spectrometry

Principle of Mass spectrometry. Mass instrumentation. Ionisation methods: EI, CI, ESI & Desorption methods. Analyser: Magnetic sector, Quadrupole & Time-of Flight analyser.

4. Electroanalytical Methods

Principle of Potentiometry, Voltametry, Conductometry and pH-metry. Applications.

BOOKS SUGGESTED:

1. Pavia, Lampman, Kriz, Spectroscopy, Books/Cole: Vyvyan
2. PS KalsiSpectroscopy of Organic Compounds, New Age International Publishers;
3. Silverstein, Robert M.; Webster, Francis X.; Kiemle,Spectrometric Identification of Organic Compounds, John Wiley;
4. ML Martin, JJDelpeach and GJ Martin, Heyden, Practical NMR Spectroscopy,
5. Colin N. Banwell and Elaine M. Mc Cash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.
6. RJ Abraham, J Fischer and P Loftus, Introduction to NMR Spectroscopy, Wiley.
7. DH Williams, I Fleming, Spectroscopic Method in Organic Chemistry: Tata MacGraw Hill.
8. Willard Merritt, Dean, Settle,Instrumental Method of Analysis: Seventh Edition, CBS, Publication.

(V) Lab Course (Inorganic, Organic and Physical) SEM II (CHC20P) (2×6 hours)

1. Quantitative Analysis

Quantitative Analysis of mixtures of two metal ions involving Volumetric (by omplexometric titration using masking and demasking agents) and gravimetric analysis.

2(a). Organic Synthesis **20 marks**

Acetoacetic ester Condensation: Synthesis of ethyl-n-butylacetoacetate by A.E.E. condensation. Cannizzaro reaction: 4-Chlorobenzaldehyde as substrate. Aromatic electrophilic Substitutions: Synthesis of p-nitroaniline and p-bromoaniline. The products may be characterized by Spectral Techniques where possible.

(b). Quantitative Analysis **1×20 marks**

Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method. Estimation of amines/phenols using bromate bromide solution/or acetylation method. Determination of Iodine and Saponification values of an oil sample. Determination of DO, COD and BOD of water sample.

3(a).Potentiometry/pH-metry

i. Determination of strengths of halides in a mixtures potentiometrically.
ii. Determination of the valency of mercurous ions potentiometrically.
iii. Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter.
iv. Determination of temperature dependence of EMF of a cell.
v. Determination of the formation constant of silver-ammonia complex and stiochiometry of the complex potentiometrically.
vi. Acid-base titration in a non-aqueous media using a pH meter.
vii. Determination of activity and activity coefficient of electrolytes.
viii. Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by
ix. titrating it with KOH.
x. Determination of the dissociation constant of monobasic/dibasic by Albert-Serjeant method.

1×15 marks

(b). Spectrophotometric (UV/VIS) Estimations

(i) Amino acids
(ii) Ascorbic acid
(iii) Proteins
(iv) Aspirin
(v) Carbohydrates
(vi) Caffeine
(vii) Cholesterol

4. Viva **10 marks**

5. Record **15 marks**

SEM III

Specialization Inorganic Chemistry

(I) Organometallic Chemistry (CHC301)

1. **Transition Metal π-Complexes and metal compounds with bonds to hydrogen**
   Transition Metal π-Complexes with unsaturated organic molecules. Alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes; preparation, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis. Compounds of Metal-Carbon Multiple Bonds and Metal Compounds with Bonds to Hydrogen

2. **Organic Derivatives of Metals and Alkyls, Aryls and Acyls of Metals:**
   Metal beta-diketonates and thio-betadiketonates: general chemistry, structural aspects and applications. Metal Alkoxides: general methods of preparation, reactivity, structure and applications Alkyls, aryls and acyls of transition metals, nature of metal carbon bond, routes of synthesis, stability and decomposition pathways and structure, alkyls, aryls and acyls of s-block and p-block elements. Comparison of such transition and non-transition element derivates. Organocopper in organic synthesis.

3. **Homogeneous Catalysis and types of reactions**:
   Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), oxopalladation reactions. Activation of C-H bond. Oxidative-Addition and Migration (Inseration) Reactions, activation of small molecules by coordination

4. **Fluxional Organometallic Compounds** Fluxionality and dynamic equilibria in compounds such as ɳ3- allyl and dienyl complexes, their characterization.

Books Suggested:

1. Principle and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.P. Norton and R.G. Finke. University Science Books.
2. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley.
3. Metallo-organic Chemistry, A.J. Pearson, Wiley.
4. Organometallic Chemistry, R.C. Mehrotra and A. Singh; New Age International.
5. Organometallic Compounds, N.H Green, Chapman & Hall, U.K.
6. Principles of Organometallic Chemistry, G.E. Coates, M.L.H Green, P. Powell, Chapman & Hall, U.K.

(II) Spectroscopy (CHC302)

1. **Photo-Electron Spectroscopy (PES) and Fluorometry and Phophometry**

   Photoelectric effect. Principle of PES. Ionization process. Koopman's Theorem. Photoelectron spectra of simple molecules. ESCA. Chemical information from ESCA. Applications.

   Principles. Factors affecting fluorescence and phosphorescence. Total Luminescence spectroscopy. Applications

2. **Nuclear Quadrupole Resonance (NQR)**
   Quadrupole nuclei. Quadrupole moment. Principle of NQR. Splitting of NQR spectra. Instrumentation.

3. **Mossbauer Spectroscopy**

Principle of Mossbauer technique. Parameters in Mossbauer spectroscopy. Instrumentation. Applocations.

4. **Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD)**

Principles of ORD and CD. Cotton effect. Octant rule for ketones. Applications

Books Suggested:

1. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
2. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S.
3. Cradock, ELBS.
4. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto,
5. Wiley.
6. Inorganic Electronic Spectroscopy, A.P.B. Lever, Elsevier.
7. Symmetry and Spectroscopy, K. Veera Reddy, New Age International, 1998.
8. Instrumental Methods of Analysis, Willard et al., 7th Edn., CBS Publishers.

(III) Analytical Chemistry(CHC303)

1. **Introduction**

Role of analytical chemistry. Classification of analytical methods-classical and instrumental. Types of instrumental analysis. Selecting an analytical method. Neatness and cleanliness. Laboratory operations and practices. Analytical balance. Techniques of weighing, errors. Volumetric glassware-cleaning and calibration of glassware. Sample preparations-dissolution and decompositions. Gravimetric techniques. Selecting and handling of reagents. Laboratory notebooks. Safety in the analytical laboratory.

2. **Errors**

Determinate and indeterminate errors, minimization of determinate errors, random distribution of indeterminate errors.

3. **Statistical data analysis**

Accuracy and precision, significant figures and computations, mean and standard deviation, distribution of random errors, reliability of results, confidence interval, comparison of results, comparison of means of two samples, paired t-test, number of replicate determinations and its use, correlation and regression, linear regression, analysis of variance, rejection of data.

4. **Application of Analytical Chemistry**

Application of analytical chemistry in the study of water and soil pollutions, analysis of fuel, body fluids and drugs

Books Suggested:

1. Analytical Chemistry, G.D. Christian, J. Wiley.
2. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler, W.B. Saunders.
3. Analytical Chemistry-Principles, J.H. Kennedy, W.B. Saunders.
4. Analytical Chemistry-Principles and Techniques, L.G. Hargis, Prentice Hall.
5. Principles of Instrumental Analysis, D.A. Skoog and J.L. Loary, W.B. Saunders.
6. Quantitative Analysis, R.A. Day, Jr. and A.L. Underwood, Prentice Hall.
7. Environmental Solution Analysis, S.M. Khopkar, Wiley Eastern.
8. Basic Concepts of Analytical Chemistry, S.M. Khopkar, Wiley Eastern.
9. Handbook of Instrumental Techniques for Analytical Chemistry, F. Settle, Prentice Hall.

IV (i) Chemistry of Biological System I (Bioinorganic) (CHE301)

1. **Metal Ions in Biological Systems, Na+/K+ Pump**

Essential and trace metals. Role of metal ions in biological processes. Na+/K+ Pump.

2. **Bioenergetics and ATP Cycles**
   DNA polymerization, glucose storage, metal complexes in transmission of energy; chlorophylls, photo system I and photo system II in cleavage of water. Model systems.
3. **Transport and Storage of Dioxygen**
   Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerythrin, model synthetic complexes of iron, cobalt and copper.
4. **Electron Transfer in Biology and Nitrogenase**
   Structure and function of metalloproteins in electron transport processes-cytochromes and ionsulphur proteins, synthetic models.
   Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

BOOKS SUGGESTED

1. P.S. Kalsi, Bioorganic, Bioinorganic and Supramolecular Chemistry, New Age International.
2. I Berteni, H.B. Gray, S.J. Lippard and J.S. Valentine,Bioinorganic Chemistry, University Science Books.
3. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
4. Bioinorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag.

IV(ii) Bioinorganic & Supramolecular Chemistry (CHE302)

1. **Metal Storage Transport and Biomineralization**
   Ferritin, transferring and siderophores.

2. **Calcium in Biology**
   Calcium in living cells, transport and regulation, molecular aspects of intramolecular processes, extracellular binding proteins.

3. **Metalloenzymes and Metal – Nucleic Acid Interactions**

   Zinc enzymes– carboxypeptidase and carbonic anhydrase. Iron enzymes –catalase, peroxidase and cytochrome P-450. Copper enzymes– superoxide dismutase. Molybdenum oxatransferase enzymes – xanthine oxidase. Coenzyme vitamin B12.
   Metal ions and metal complex interactions, Metal complexes –nucleic acids

4. **Supramolecular Chemistry**
   Concepts and language. Molecular recognition: Molecular receptors for different types of molecules including arisonic substrates, design and synthesis of coreceptor molecules and multiple recognition. Supramolecular reactivity and catalysis. Transport processes and carrier design. Supramolecular devices. Supramolecular photochemistry. Supramolecular electronic, ionic and switching devices. Some example of self-assembly in supramolecular chemistry.

BOOKS SUGGESTED

1. P.S. Kalsi, Bioorganic, Bioinorganic and Supramolecular Chemistry, New Age International.
2. Understanding Enzymes, Trevor Palmer, Prentice Hall.
3. Enzyme Chemistry: Impact and Applications, Ed. Colliins J Sucking, Chapman and Hall.
4. Enzymes Mechanism Ed, M.I. Page and A. Williams, Royal Society of Chemistry.
5. Fundamentals of Enzymology, N.C. Price and L. Stevens, Oxford University Press.
6. I Berteni, H.B. Gray, S.J. Lippard and J.S. Valentine,Bioinorganic Chemistry, University Science Books.
7. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.

8. Immobilized Enzymes: An Introduction and Applications in Biotechnology, Michael D. Trevan, John Wiley.
9. Enzymatic Reaction Mechanism, C. Walsh, W.H. Freeman.
10. Enzymatic Structure and Mechanism, W.H. Freeman.
11. Supramolecular Chemistry, J.M. Lehn, VCH.

(V) Lab Course (Inorganic) SEM III (ICHC30P) (2×6 hours)

1. Analysis of the given sample (Ores)/Both Qualitative and Quantitative Dolomite, Pyrolusite, Galena. **20 marks**

2. Analysis of the given alloys: Coin, Gunmetal, Brass and Bronze. **20 marks**

3. Preparations

Preparation of selected inorganic compounds:

(i) $VO(acac)_2$
(ii) $TiO(C_9H_8NO)_2.2H_2O$
(iii) cis-$K[Cr(C_2O_4)_2(H_2O)_2]$ **1×20 marks**
(iv) $Na[Cr(NH_3)_2(SCN)_4]$
(v) $Mn(acac)_3$
(vi) $K_3[Fe(C_2O_4)_3]\ 3H_2O$
(vii) $Co[(NH_3)_6]Cl_3$
(viii) $[Cu(en)_2(H_2O)_2]I_2$
(ix) $[Co(Py)_2Cl_2]$
(x) Tris-(thiourea) copper (I) sulphate $[Cu(tu)_3]SO_4.2H_2O$

And their characterization by following techniques

i) Elemental analysis
ii) Molar conductance values
iii) I.R. Spectral interpretation
iv) Thermal analysis
v) UV-Visible Spectra

4.Viva **10 marks**

5. Record **10 marks**

Specialization Organic Chemistry

(I) Reagents in Organic Synthesis and Organometallics (CHC304)

1. **Determination of Reaction Mechanism**

Classification, rate constants and life times of reactive energy states-determination of rate constants of reactions. Effect of light intensity on the rate of photochemical reactions. Types of photochemical reactions, photo-dissociation, gas-phase photolysis.

2. **Oxidation: Reduction and Reaction**

Introductino. Different oxidative processes. Hydrocarbons-alkenes, aromatic rings, saturated C-H groups (activated &unactivated). Alcohols, diols, aldehydes, ketones, ketals and carbosylic acids. Amines, hydrazines and sulphides. Oxidation with ruthenium tetraoxide, iodobenzenediacetate and thallium (III) nitrate.

Introduction. Different reductive processes.
Reduction of hydrocarbons- alkenes, alkynes and aromatic rings.
Reduction of carbonyl compounds (aldehydes, ketones, acids and their derivatives). Epoxides.
Reduction of nitro, nitroso, azo and oxime groups.

Hydrogenolysis.

3. **Organometellics in Synthesis:**
Principle, preparations, properties and applications of the following in organic synthesis:
Group I and II metal organic compounds Li, Mg, Hg and Zn compounds.
Transition metals: Pd, Ni, Fe, Ti, Cu, Rh and Cr compounds; Other elements :S, Si and B compounds.

4. **Metallocenes, Nonbenzenoid Aromatics and Polycyclic Aromatic Compounds:**
General considerations, synthesis and reactions of some representative compounds.

Books suggested

1. Modern Synthetic Reactions, H.O. House, W.A. Benjamin.
2. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.
3. Advanced Organic Chemistry, Reactions Mechanisms and Structure, J. March, John Wiley.
4. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.
5. Advanced Organic Chemistry Part B, F.A. Carey and R.J. Sundberg, Plenum Press.
6. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
7. W. Carruthers, Some Modern Methods of Organic Synthesis, Cambridges Univ. Press.
8. J. Fuhrhop and G. Penzillin,Organic Synthesis- Concept, Methods and Starting Materials Verlage VCH.

(II) Spectroscopy (CHC302)

1. **Photo-Electron Spectroscopy (PES) and Fluorometry , Phophometry**

Photoelectric effect. Principle of PES. Ionization process. Koopman's Theorem. Photoelectron spectra of simple molecules. ESCA. Chemical information from ESCA. Applications.
Principles. Factors affecting fluorescence and phosphorescence. Total Luminescence spectroscopy. Applications.

2. **Nuclear Quadrupole Resonance (NQR)**
Quadrupole nuclei. Quadrupole moment. Principle of NQR. Splitting of NQR spectra. Instrumentation.

3. **Mossbauer Spectroscopy**
Principle of Mossbauer technique. Parameters in Mossbauer spectroscopy. Instrumentation. Applocations.

4. **Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD)**
Principles of ORD and CD. Cotton effect. Octant rule for ketones. Applications.

Books Suggested:

1. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
2. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S.
3. Cradock, ELBS.
4. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto,
5. Wiley.
6. Inorganic Electronic Spectroscopy, A.P.B. Lever, Elsevier.
7. Symmetry and Spectroscopy, K. Veera Reddy, New Age International, 1998.
8. Instrumental Methods of Analysis, Willard et al., 7th Edn., CBS Publishers.

(III) Organic Photochemistry(CHC305)

1. **Basics of Photochemistry:**
   Absorption, excitation, photochemical laws, electronically excited states-life times, measurements of the times. Flash photolysis, Stopped flow techniques. Energy dissipation by radiative and non-radiative processes, absorption spectra, Franck-Condon principle, Photochemical stages- primary and secondary processes. Photo physical reactions, Jablonskii diagram, photosensitization, quantum yield and its determination, reactions of high and low quantum yields with suitable examples, fluorescence, phosphorescence and chemiluminiscence with suitable examples

2. **Photochemistry of Organic Compounds:**
   Photochemistry of alkenes; cis-trans isomerization, non-vertical energy transfer; photochemical additions; reactions of 1,3- and 1,4-dienes; dimerisation.

3. **Photochemistry of Carbonyl Compounds:**
   Norrish type I & II reactions (cyclic and acyclic); α,β-unsaturated ketones; β,γ-unsaturated ketones; cyclohexenones (conjugated); cyclohexadienons (cross-conjugated & conjugated); Paterno-Buchi reactions; photoreductions.

4. **Photochemistry of Aromatic Compounds:**
   Isomerisation, skeletal isomerisations, Dewar and prismanes in isomerisations. Singlet oxygens reactions; Photo Fries rearrangement of ethers and anilides; Barton reaction, Hoffmann-Loefller-Freytag reaction.

Books Suggested:

1. Fundamentals of Photochemistry, K.K. Rohtagi-Mukherji, New Age International
2. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication
3. Molecular Photochemistry, N.J. Turro, W.A. Benjamin
4. Introductory Photochemistry, A. Cox and T. Camp, McGraw Hill
5. Photochemistry, R.P. Kundall and A. Gilbert, Thomson Nelson
6. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press
7. W. M. Horspool, Aspects of Organic Photochemistry,Academic Press.

IV (i) Chemistry of Biological System I (Bioorganic (CHE303)

1. **Enzymes**
   Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Nomenclature and classification, extraction and purification. Fischer's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Enzyme kinetics, Michaelis - Menten and Lineweaver-Burk plots, reversible and irreversible inhibition.

2. **Mechanism of Enzyme Action and Kinds of Reactions Catalysed by Enzymes**
   Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A.
   Nucleophilic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP cleavage to endergonic processes. Transfer of sulphate, addition and elimination reactions, enolic intermediates in isomerization reactions, α-cleavage and condensation, some isomerization and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation.

3. **Enzyme Models and Co-Enzyme Chemistry**

Host-guest chemistry, chiral recognition and catalysis, molecular recognition, molecular asymmetry and prochirality. Biomimetic chemistry, crown ethers, cryptates. Cyclodextrins, cyclodextrin- based enzyme models, calixarenes, ionophores, micelles, synthetic enzymes or synzymes.

Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD+, NADP+, FMN, FAD, lipoic acid, vitamin B12. Mechanisms of reactions catalyzed by the above cofactors.

4. **Applications of Enzymes**

Large-scale production and purification of enzymes, techniques and methods of immobilization of enzymes, effect of immobilization on enzyme activity, application of immobilized enzymes, use of enzymes in food and drink industry-brewing and cheese-making, syrups from corn starch, enzymes as targets for drug design. Clinical uses of enzymes, enzyme therapy, enzymes and recombinant DNA technology.

BOOKS SUGGESTED

5. P.S. Kalsi, Bioorganic, Bioinorganic and Supramolecular Chemistry, New Age International.
6. Understanding Enzymes, Trevor Palmer, Prentice Hall.
7. Enzyme Chemistry: Impact and Applications, Ed. Colliins J Sucking, Chapman and Hall.
8. Enzymes Mechanism Ed, M.I. Page and A. Williams, Royal Society of Chemistry.
12. Fundamentals of Enzymology, N.C. Price and L. Stevens, Oxford University Press.
13. I Berteni, H.B. Gray, S.J. Lippard and J.S. Valentine,Bioinorganic Chemistry, University Science Books.
14. Immobilized Enzymes: An Introduction and Applications in Biotechnology, Michael D. Trevan, John Wiley.
15. Enzymatic Reaction Mechanism, C. Walsh, W.H. Freeman.
16. Enzymatic Structure and Mechanism, W.H. Freeman.
17. Supramolecular Chemistry, J.M. Lehn, VCH.

IV(ii)Chemistry of Natural Products (CHE304)

1. **Terpenoids and Carotenoids**

Classification, occurrence, isolation, general methods of structure determination, U.V., IR., NMR and Mass Spectra. Biosynthesis and synthesis of citral, geraniol, -terpineol, menthol, farnesol, zingiberene, santonine, longifolene, phytol, abietic acid, -carotene and vitamin A.

Plant Pigments:

Occurrence, nomenclature, synthesis of Quercetin myrcetin cyanidine hirsutidin Biosynthesis of plant pigments flov onoids, flovone, flavonol.

2. **Steroids**

Occurrence, physiological action, basic skeleton, stereochemistry, structure determination of cholesterol by degradation experiments, synthesis and biosynthesis of cholesterol, bile acids, and rosterone, testosterone, estrone, progestrone, cortisone.

3. **Alkaloids**

Occurrence, isolation, physilogical action, general method structure elucidtion, degradation, classification based on nitrogen heterocyclic ring structure, stereochemistry, synthesis and biosynthesis of ephedrine, coniine, Nicotine, atropine, quinine, morphine, chloroquin and prima quin, uses of strychnine brucin etc. in organic synthesis.

4. **Vitamins**

Occurrence, deficiency, physiological effects and synthesis of B complex, E and K. Chemotherapy; Sulpha drugs, antibiotics Cell wall biosynthesis, inhibitors, β-lactam rings synthesis of penicillin G, V, ampicillin, amoxycillin, chloramphenicol, cephalosporin, tetracyclin and streptomycin. Postaglandins Biosynthesis, Synthesis of PGE2 and PGF22.

Books Suggested

1. Natural Products: Chemistry and Biological Significance, J.Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J.B. Harborne, Longman, Essex.
2. Organic Chemistry, Vol 2, I.L. Finar, ELBS.
3. Stereoselective Synthesis: A Practical Approach, M. Nogradi, VCH.
4. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
5. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the mericas, Ed. Kurt. Hostettmann, M.P. Gupta and A. Marston, Harwood Academic Publishers.
6. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers.
7. New Trends in Natural product Chemistry, Atta-ur-Rahman and M.I. Chaudhary, Harwood Academic Publishers

(V) Lab Course (Organic) SEM III (OCHC30P) (2×6 hours)

1. Qualitative Analysis

Separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid, two solids and one liquid), using TLC for checking the purity of the separated compounds. Preparation of derivatives and spectral analysis.

2. Multi-step Synthesis of Organic Compounds

The exercise should illustrate the use of organic reagents and may involve purification of the products by chromatographic techniques. **2×30 marks**

3. Photochemical conversions

Benzophenone to Benzpinacol to Benzpinacolone
Beckmann rearrangement: Benzanilide from benzene
Benzene to Benzophenone to Benzophenone oxime to Benzanilide
Benzilic acid rearrangement: Benzilic acid from benzoin
Benzoin to Benzil to Benzilic acid

4. Enzymatic Synthesis

Enzymatic reduction: Reduction of ethyl acetoacetate using Baker's yeast to yield enantiomeric excess of S (+) ethyl-3-hydroxybutanoate and determine its optical purity.
Biosynthesis of ethanol from sucrose

5. Viva **10 marks**

6. Record **10 marks**

Specialization Physical Chemistry

(I) Advanced Quantum Chemistry (CHC306)

1. **Theoretical and Computational (optional) Treatment of Atoms and Molecules, Hartree-Fock Theory**

   Review of the principles of quantum mechanics. Born-Oppenheimer approximation. Slater-Condon rules. Hartree-Fock equation. Koopmans and Brillouin theories. Roothan equation, Gaussian basis sets.

2. **Configuration Interaction and MC-SCF**

   Introduction to CI; full and truncated CI theories. Size consistency. Introductory treatment of coupled cluster and MC-SCF methods.

3. **Semi-Empirical Theories**

A review of the Huckel, EHT and PPP treatments, ZDO approximation. Detailed treatment of CNDO and INDO theories. A discussion of electronic energies and properties.

4. **Density Functional Theory**
Derivation of Hohenberg-Kohn theorem, Kohn-Sham formulation, N- and V- representabilities; review of the performance of the existing local (e.g. Slater Xa and other methods) and non-local functionals, treatment of chemical concepts with the density functional theory.

Books Suggested

1. Modern Quantum Chemistry, N.S. Ostlund and a. Szabo, McGraw Hill.
2. Methods of Molecular Quantum Mechanics, R. Mcweeny and B.T. Sutcliffe, Academic Press
3. Density Functional Theory of Atoms and Molecules, R.G. Parr and W. Yang, Oxford.
4. Exploring Chemistry with Electron Structure Methods, J.B. Foresman and e. Frish, Goussian Inc.
5. Semi-empirical MO Theory, J. Pople and D.L. Beveridge.

(II) Spectroscopy (CHC302)

1. **Photo-Electron Spectroscopy (PES) and Fluorometry , Phosphometry**
Photoelectric effect. Principle of PES. Ionization process. Koopman's Theorem. Photoelectron spectra of simple molecules. ESCA. Chemical information from ESCA. Applications.

Principles. Factors affecting fluorescence and phosphorescence. Total Luminescence spectroscopy. Applications.

2. **Nuclear Quadrupole Resonance (NQR)**
Quadrupole nuclei. Quadrupole moment. Principle of NQR. Splitting of NQR spectra. Instrumentation.

3. **Mossbauer Spectroscopy**
Principle of Mossbauer technique. Parameters in Mossbauer spectroscopy. Instrumentation. Applocations.

4. **Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD)**
Principles of ORD and CD. Cotton effect. Octant rule for ketones. Applications.

Books Suggested:

1. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
2. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S.
3. Cradock, ELBS.
4. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto,
5. Wiley.
6. Inorganic Electronic Spectroscopy, A.P.B. Lever, Elsevier.
7. Symmetry and Spectroscopy, K. Veera Reddy, New Age International, 1998.
Instrumental Methods of Analysis, Willard et al., 7th Edn., CBS Publishers.

(III) Analytical Chemistry(CHC307)

1. **Introduction**
Role of analytical chemistry. Classification of analytical methods-classical and instrumental. Types of instrumental analysis. Selecting an analytical method. Neatness and cleanliness. Laboratory operations and practices. Analytical balance. Techniques of weighing, errors. Volumetric glassware-cleaning and calibration of glassware. Sample preparations-dissolution and decompositions. Gravimetric techniques. Selecting and handling of reagents. Laboratory notebooks. Safety in the analytical laboratory.

2. **Errors**

Determinate and indeterminate errors, minimization of determinate errors, random distribution of indeterminate errors.

3. **Statistical data analysis**

Accuracy and precision, significant figures and computations, mean and standard deviation, distribution of random errors, reliability of results, confidence interval, comparison of results, comparison of means of two samples, paired t-test, number of replicate determinations and its use, correlation and regression, linear regression, analysis of variance, rejection of data.

4. **Application of Analytical Chemistry**

Application of analytical chemistry in the study of water and soil pollutions, analysis of fuel, body fluids and drugs

Books Suggested:

1. Analytical Chemistry, G.D. Christian, J. Wiley.
2. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler, W.B. Saunders.
3. Analytical Chemistry-Principles, J.H. Kennedy, W.B. Saunders.
4. Analytical Chemistry-Principles and Techniques, L.G. Hargis, Prentice Hall.
5. Principles of Instrumental Analysis, D.A. Skoog and J.L. Loary, W.B. Saunders.
6. Quantitative Analysis, R.A. Day, Jr. and A.L. Underwood, Prentice Hall.
7. Environmental Solution Analysis, S.M. Khopkar, Wiley Eastern.
8. Basic Concepts of Analytical Chemistry, S.M. Khopkar, Wiley Eastern.
9. Handbook of Instrumental Techniques for Analytical Chemistry, F. Settle, Prentice Hall.

IV(i)Chemistry of Biological System I (Biophysical)(CHE305)

1. **Biological Cell and its Constituents, Cell Membrane and Transport of Ions**

Biological cell, structure and functions of proteins. Enzymes, DNA and RNA in living systems. Helix coil transition. Structure and functions of cell membrane. Ion transport through cell membrane.

2. **Bioenergetics and Statistical Mechanism in Biopolymers**

Standard free energy change in biological reactions. Exergonic, endergonic. Hydrolysis of ATP. Synthesis of ATP from ADP

Chain configuration of macromolecules. Statistical distribution. End-to-end dimensions. Calculation of average dimensions for various chain structures. Polypeptide and protein structures. Introduction to protein folding problem.

3. **Biopolymer Interactions, Thermodynamics of Biopolymer Solutions**

Forces involved in biopolymer interactions. Electrostatic charge and molecular expansion, hydrophobic forces, dispersion force interactions. Multiple equilibria and various types of binding processes in biological systems. Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical system.

4. **Biopolymers and their Molecular Weights**

Evaluation of size, shape, molecular weight and extent of hydration of biopolymers by various experimental techniques. Sedimentation equilibrium, hydrodynamic methods, diffusion, sedimentation velocity, viscosity, electrophoresis and rotational motions.

IV (ii) Nuclear Chemistry (CHE306)

1. **Atomic Nucleus and Nuclear Models**
   Basics of atomic structure. Classification of nuclides. Nuclear stability. Mechanical effects due to orbiting and spinning nucleons. Magnetic quantum number. Total magnetic nuclear quantum number. NMR. Mossbauer effect. Parity. Quarks and Gluons.
   Shell model. Liquid drop model. Fermi gas model. Collective model. Optical model.
2. **Radioactivity and Nuclear reactions**
   Radioactive decay. Kinetics. Alpha, beta decay. Nuclear deexcitation. Artificial radioactivity. Bethe's notation. Types. Reaction cross-section. Compound nucleus theory. Photonuclear reactions. Thermonuclear reactions. Nuclear Fission, fission energy, cross-section and threshold. Neutron evaporation and spallation.
3. **Detection and Measurement of Activity**
   Electrometer. Ionization chamber. Electron pulse counter. Scintillation detector. Semiconductors detectors. Thermoluminescence and neutron detector.
4. **Radiation Chemistry**
   Interaction of radiation with matter. Interaction of neutrons and gamma radiations with matter. Units. Dosimetry. Radiolysis. Radiochemical and radiometric analysis in chemistry.

Book Suggested:

1. Essential of nuclear chemistry by H.J. Arnikal (Wiley Publication)
2. Morden nuclear chemistry by Walter Loveland and Water D. Loveland (Wiley Publication)
3. Radio chemistry and nuclear chemistry by Gregory and Choppin (Wiley Publication)

(IV) Lab Course (Physical) SEM III((6×2 hours)

1. (a) Determination of transport number.
   (b)Determination of liquid junction potential.
   (c)Determination of the charge on colloidal particle.
   (d)Determination of partial molar volume of solute.
   (e)Determination of CMC of surfactants
   (f) Determination of solubility of sparingly soluble salts by the following methods: Electrical Conductivity or E.M.F
2. (a)Beer's law verification. **3×20 marks**
   (b) Decomposition of potential determination.
   (c)Validity of Freundlich's adsorption isotherm.
   (d)Dissociation constants of polybasic acids.
3. Study of complex formation by the following methods and determination of stability constant wherever practicable:
   (a). Cryoscopic
   (b). Electrical Methods.
   (c). E.M.F.
4. Polarography.
5. Viva 10 marks
6. Record 10 marks

MSc SEM IV

Specialization Inorganic Chemistry

(I) Spectroscopy & Diffraction method (CHC401)

1. **UV-Visible Spectroscopy**
   Electronic states in complexes. Selection rules. Orgel Diagram. Electronic spectrum of inorganic compounds.

2. **IR Spectroscopy**

Vibrational frequencies of metal carbonyls, nitrosyls and phosphine derivatives. Effect of substitution and conjugation. IR spectrum of other inorganic compounds.

3. **Diffraction methods**

I. X-Ray Diffraction

Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in diffraction pattern. Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules, Ramchandran diagram.

II. Electron Diffraction

Scattering intensity vs. scattering angle, Wire equation, measurement technique, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surfaces.

III. Neutron Diffraction

Scattering of neutrons by solids and liquids, magnetic scattering, measuring techniques. Elucidation of structure of magnetically ordered unit cell.

4. **Atomic Absorption Spectroscopy (AAS) and Atomic Emission Spectroscopy (AES)**

Principle of AAS. Interference. Applications. Principle of AES. ICP method of elemental analysis.

Books Suggested

1. Physical Method for Chemistry, R.S. Drago, Saunders Company.
2. Structural Method in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS
3. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Horwood. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
4. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley.
5. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley.
6. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill. Introduction to Spectroscopy, D.L. Pavia, G.M. Lampman, G.S. Kritz, Thompson Asia Pvt. Ltd.,Singapore.
7. Electronic spectroscopy, D.N. Sathyanarayan, Universities Press.
8. Interpretation of Mass Spectra, F.W. McLafferty, University Science Books,California.

(II) Photo Inorganic Chemistry (CHC402)

1. **Basics of Photochemistry and Photochemical Reactions**

Absorption, excitation, photochemical laws, electronically excited states-life times, measurements of the times. Flash photolysis, stopped flow techniques. Energy dissipation by radiative and non-radiative processes, absorption spectra, Franck-Condon principle, photochemical stages- primary and secondary processes.

Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry. Singlet molecular oxygen reactions. Photochemical formation of smog. Photo-degradation of polymers. Photochemistry of vision.

2. **Excited States of Metal Complexes and Ligand Field Photochemistry:**

Structure, dipole moment, acid-base strengths, reactivity. Photochemical kinetics-calculation of rates of radiative processes. Biomolecular deactivation-quenching. Excited states of metal complexes: comparison with organic compounds, electronically excited states of metal complexes. Charge-transfer spectra, charge transfer excitations, methods for obtaining charge-transfer spectra.

Photosubsitution, photooxidation and photoreduction, lability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero-zero spectroscopic energy, development of the equations for redox potentials of the excited states.

3. **Redox Reacitons by Excited Metal Complexes:**
   Energy transfer under conditions of weak interaction and strong interactionexciplex formation, conditions of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates (2,2'-bipyridine and 1,10-phenenthroline complexes), illustration of reducing and oxidizing character of Ru2+bipyridal complex (comparison with [Fe(bipy)3]); role of spinorbit coupling-life time of these complexes. Application of redox processes of electronically excited states for catalytic purpose, transformation of low energy reactants into high energy products, chemical energy into light.
4. **Metal Complex Sensitizers and Determination of Reaction Mechanism :**
   Metal complex sensitizer, electron relay, metal colloid system, semiconductor supported metal or oxide systems, water photolysis, nitrogen fixation and coarbon dioxide reduction. Classification, rate constants and life times of reactive energy states-determination of rate constants of reactions. Effects of light intensity on the rate of photochemical reactions. Types of photochemical reactions; photo-dissociation, gas-phase photolysis

Books Suggested:

1. Concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fleischauer, Wiley. Inorganic Photochemistry, J. Chem. Educ., vol. 60, no. 10, 1983.
2. Progress in Inorganic Chemistry, vol. 30, ed. S.J. Lippard, Wiley.
3. Co-ordination Chem. Revs., 1975, 15, 321; 1981, vol. 39, 121, 131; 1990, 97, 313.
4. Photochemistry of Co-ordination Compounds, V. Balzari and V. Carassiti, Academic Press.
5. Elements of Inorganic Photochemistry, G.J. Ferraudi, Wiley..
6. Fundamentals of Photochemistry, K.K. Rohtagi-Mukherji, Wiley-Eastern.
7. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
8. Molecular Photochemistry, N.J. Turro, W.A. Benjamin.
9. Introductory Photochemistry, A. Cox

(III) Inorganic Polymers (CHC403)

1. **Introduction of Inorganic Polymers:**
   Importance of polymers, basic concepts: monomers, repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers, polymerization: condensation, addition, radical chain-ionic and co-ordination and co-polymerization. Polymerization conditions and polymer reactions Kinetics of polymerization. Stererochemistry and mechanism of polymerization. Polymerization in homogeneous and heterogeneous systems. Comparison with organic polymers.
2. **Polymer Characterization:**
   Polydispersion, average 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 weight: end-group, viscosity, light scattering, osmotic and ultacentrifugation 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 abrasion resistance.
3. **Structure, Propertiesand Polymer Processing**
   Morphology and order in crystalline polymers-configurations of polymer chains: Crystal structures of polymers. Morphology of crystalline polymers, strain-induced morphology, crystallization and melting. Polymer structure and physical properties-crystalline melting point(TM); melting points

of homogeneous series, effect of chain, flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature(Tg), relationship between Tm and Tg, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking. Property requirements and polymer utilization.

Plastics, elastomers and fibres. Compounding. Processing techniques: calendering, die casting, rotational casting, film casting, injection moulding, extrusion moudling, thermoforming, foaming, reinforcing and fibre spinning.

4. **Boron Based Polymers, Silicon Based Polymers, Phosphorous Based Polymers and Coordination Polymers:**

Borazine, substituted borazines, boron nitride. Boron-oxygen-silicon and boron-oxygen-phosphorus polymers. Ployhedralborane anions. Silica, feldspars and ultramarines, silicones, silicone fluids, silicone rubbers, silicone greases, silicone resins and metallosiloxanes. Silicon-nitrogen polymers and silazenes. Metaphosphates, polyphosphates, cross-linked phosphates. Phosphonitrilic halides and related polymers. Phosphorous-sulphur polymers. Factors affecting formation of coordination polymers. Types of coordination polymers. Metal halides. Metal pseudohalides, metal alkoxides, metal carboxylates and metal chelates

Books Suggested

1. Textbook of Polymer Science, F.W. Billmeyer Jr, Wiley.
2. Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern.
3. Functional Monomers and Polymers, K. Takemoto, Y. inaki and R.M. Ottanbrite.
4. Contemporary Polymer Chemistry, H.R. Alcock and F.W. Lambe, Prentice Hall.
5. Physics and Chemistry of Polymers, J.M.G. Cowie, Blackie Academic and Professional.
6. F.W. Bilimever Jr.,Text Book of Polymer Science, Wiley.
7. N.H. Ray, Inorganic Polymers, Academic Press, N. York.
8. J.M. Lehn, Supramolecular Chemistry, VCH.

IV (i) Nuclear Chemistry (CHE306)

1. **Atomic Nucleus and Nuclear Models**

Basics of atomic structure. Classification of nuclides. Nuclear stability. Mechanical effects due to orbiting and spinning nucleons. Magnetic quantum number. Total magnetic nuclear quantum number. NMR. Mossbauer effect. Parity. Quarks and Gluons.

Shell model. Liquid drop model. Fermi gas model. Collective model. Optical model.

2. **Radioactivity and Nuclear reactions**

Radioactive decay. Kinetics. Alpha, beta decay. Nuclear deexcitation. Artificial radioactivity.

Bethe's notation. Types. Reaction cross-section. Compound nucleus theory. Photonuclear reactions. Thermonuclear reactions. Nuclear Fission, fission energy, cross-section and threshold. Neutron evaporation and spallation.

3. **Detection and Measurement of Activity**

Electrometer. Ionization chamber. Electron pulse counter. Scintillation detector. Semiconductors detectors. Thermoluminescence and neutron detector.

4. **Radiation Chemistry**

Interaction of radiation with matter. Interaction of neutrons and gamma radiations with matter. Units. Dosimetry. Radiolysis. Radiochemical and radiometric analysis in chemistry.

Book Suggested:

7. Essential of nuclear chemistry by H.J. Arnikal (Wiley Publication)
8. Morden nuclear chemistry by Walter Loveland and Water D. Loveland (Wiley Publication)
9. Radio chemistry and nuclear chemistry by Gregory and Choppin (Wiley Publication)

(IV) Environmental Chemistry(CHE401)

1. Introduction to Environmental Chemistry and Description of Atmosphere

Concept and scope of environmental chemistry.Environmental terminology and nomenclatures. Environmental segments. The natural cycles of environment (Hydrological, Oxygen, Nitrogen).
Atmosphere, environmental segments, composition of the atmosphere, earth's radiation balance, particulates, ions and radicals and their formation, chemical and photochemical reactions in the atmosphere, air pollution, oxides of C,N,S and their effects, acid-rain, smog formation, Green house effects (global warming and ozone depletion, air pollution controls and introduction to analytical methods for monitoring air pollution.

2. Hydrosphere and Lithosphere:

Chemical composition of water bodies-lakes, streams, rivers, sea etc, hydrological cycle, complexation in natural and waste water and microbially mediated redox reactions. Water pollution-inorganic, organic, pesticides, industrial and radioactive materials, oil spills and oil pollutants, eutrophication, acid-mine drainage, waste water treatment, domestic waste water(aerobic and anaerobic treatment), and industrial waste water treatment.
Inorganic and organic components in soil, acid-base and ion-exchange reactions in soil, micro and macro nutrients, nitrogen pathways and NPK in soil.

3. Water quality parameters and standards:

Analytical methods for measuring DO, BOD, COD, fluoride, oils and grease and metals (As, Cd, Hg, Pb, Zn,Cu,Cr), Biochemical effects of As, Cd, Hg, Pb, Cr, CN and pesticides.

4. Air Pollution and Water Pollution:

Particulates, aerosols, SOx, NOx, COx and hydrocarbon. Photochemical smog, air-quality standards.

Books suggested

1. Environmental Chemistry, S.E. Manahan, Lewis Publishers.
2. Environmental Chemistry, Sharma and Kaur, Krishna Publishers.
3. Environmental Chemistry, A.K. De, Wiley Eastern.
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern.
5. Standard Method of Chemical Analysis, F.J. Welcher Vol. III, Van Nostrand Reinhold Co.
6. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
7. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creatchman, Gordon And Breach Science Publication.
8. Environmental Chemistry, C. Baird, W.H. Freeman.

IV (iii Project Work /Dissertation (CHE402)

(V) Lab Course (Inorganic) SEM IV (ICHC40P) (2×6 hours)

1. Spectrophotometric Determinations

(a). Manganese/chromium/vanadium in steel sample.
(b). Nickle/molybdenum/tungsten/vanadium/uranium by extractive Spectrophotometric method.
(c). Fluoride/nitrite/phosphate.
(d). Iron-phenanthroline complex: Job's Method of continuous variation.
(e). Zirconium-alizarin Red-S complex: Mole-ratio method.
(f). Copper-ethylene diamine complex: Slope –ratio method.

2. Flame Photometric Determinations

(a). Sodium and Potassium when present together.
(b). Lithium/Calcium/barium/strontium. **3×20marks**
(c). Cadmium and magnesium in tap water.

3. Nephelometric Determinations

(a). Sulphate
(b). Phosphate
(c). Silver

4. Chromatographic separations: Paper or TLC and determination of Rf values:

(a). Cadmium and Zinc.
(b). Silver, Lead and Mercury.
(c). Nickel, Magnesium, Cobalt and Zinc.

5. Viva 10 marks
6. Record 10 marks

Specialization Organic Chemistry

Organic Synthesis (CHC404)

(I)

1. Disconnection Approach

An introduction to synthons and synthetic equivalents disconnection approach, functional group
interconversions, the importance of order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions and amine synthesis.

2. One Group and Two Group C-C Disconnections

Alcohols and carbonyl compounds regioselectivity. Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis. Diels-Alder reaction, 1,3-difunctional compounds, α,β-unsaturated carbonyl compounds, control in carbonyl condensations. Micheal addition and Robinson annelation.

3. Ring Synthesis and Protecting Groups

Saturated hetercycles, synthesis of 3-,4-,5- and 6-membered rings, aromatic heterocycles in organic synthesis.
Principles of protection of alcohol, amine, carbonyl and carboxyl groups

4. Synthesis of Some Complex molecules

Application of the above in the synthesis of following compounds: Camphor, Longifoline, Cortisone, Reserpine, Vitamin D, Juvabione, Aphidicolin and Fredericamysin A.

Books Suggested

1. Modern Synthetic Reactions, H.O. House, W.A. Benjamin.
2. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.
3. Advanced Organic Chemistry, Reactions Mechanisms and Structure, J. March, John Wiley.
4. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.
5. Advanced Organic Chemistry Part B, F.A. Carey and R.J. Sundberg, Plenum Press.
6. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
7. Designing Organic Synthesis, S. Warren, Wiley.
8. Organic Synthesis-Concept, Methods and Starting Materials, J. Fuhrhop and G. Penzillin, Verlag VCH.

(II) Organic Spectroscopy(CHC405)

1. UV-Visible Spectroscopy

Electronic transitions in organic compounds. Factors affecting absorption maximum and molar extinction coefficient. Solvent effects. Woodward Fieser rules for conjugated dienes and carbonyl

compounds. UV-Visible spectrum of alkenes, carbonyl compounds, alcohol/phenol. Aromatic compounds (characteristic features).

2. IR Spectroscopy

Effect of Hydrogen Bonding and solvent polarity of IR spectrum of organic compounds. Characteristic features of IR spectrum of aliphatic/aromatic hydrocarbons, alcohols/phenols, amines, carbonyl compounds, carboxylic acid and derivatives. Effect of conjugation on vibrational frequencies.

3. Nuclear magnetic resonance

Proton-NMR Spectroscopy

Chemical shift values for protons bonded to carbon (aliphatic, olelinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, carboxylic acids, amines, amides). Chemical exchange. Effects of deuteration. Karplus curve-variation of coupling constant with dihedral angle.

Carbon-13 NMR Spectroscopy

Characteristics of CMR. Chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl compound). Coupling constants. Advantages and disadvantages.

Fluorine -19 NMR Spectroscopy

Characteristic features of F19-NMR. Chemical shifts and Coupling constants.

Introduction of DEPT, COSY and 2D NMR spectroscopy.

4. Mass Spectrometry

Fragmentation Pattern. Isotopic studies. Characteristics of Mass spectrum of aliphatic, olelinic, aromatic, carbonyl compounds, alcohols, phenols, carboxylic acids, amines and amides.

Books Suggested

1. Pavia, Lampman, Kriz and VyvyanSpectroscopy, Books/Cole
2. P. S.Kalsi,Spectroscopy of Organic Compounds, New Age International Publishers.
3. Robert M.Silverstein, Francis X.Webster, and D. J. KiemleSpectrometric Identification
4. of Organic Compounds, John Wiley
5. M. L. Martin, J. J.Delpeach G. J. Martin and Heyden,Practical NMR Spectroscopy.
6. Colin N. Banwell and Elaine M. McCash,Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.
7. R. J. Abraham, J. Fischer and P. Loftus,Introduction to NMR Spectroscopy, Wiley.
8. D. H. Williams and I. Fleming, Spectroscopic Method in Organic Chemistry, Tata Mac Graw Hill.
9. H. H. Willard,Jr. L. L. Merritt, J. A. Dean and Jr F. A. Settle.CBSPublication.Instrumental Method of Analysis: Seventh Edition,

(III) Heterocyclic Compounds (CHC406)

1. Aromatic and Non-aromatic Heterocycles

Replacement and Systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused and bridged heterocycles

General chemical behaviour of aromatic heterocycles, classification (structural type), Heteroaromatic reactivity and tautomerism in aromatic heterocycles Strain –bond angle and torsional strains and their consequences in small ring heterocycles. Conformation of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interactions. Stereo-electronic effects, aromatic and related effects. Attractive interactions - hydrogen bonding and intermolecular nucleophilic, electrophilic interactions.

2. Small Ring and Benzo-Fused Five-Membered Heterocycles

Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes

Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes

3. **Six-Membered Heterocycles with One, Two or More Heteroatoms**
Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium & thiopyrylium salts and pyridines Synthesis and reactions of quinolizinium and benzopyrylium salts, coumarins and chromones Synthesis and reactions of diazines, triazines, tetrazines and thiazines

4. **Seven-and Large-Membered Heterocycles**
Synthesis and reactions of azepines, oxepines, thiepines, diazepines thiazepines, azocines, diazocines, dioxocines and dithiocines

Books Suggested:

1. Heterocyclic Chemistry Vol. 1 & 2, R.R. Gupta, M. Kumar and V. Gupta, Springer Verlag
2. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.
3. Heterocyclic Chemistry, J.A. Joule, K. Mills and G.F. Smith, Chapman and Hall.
4. Heterocyclic Chemistry, T.L. Gilchrist, Longman Scietific Technical
5. Contemporary Heterocyclic Chemistry, G.R. Newkome and W.W. Paudler, Wiley-Inter Science.
6. An introduction to the Heterocyclic Compounds, R.M. Acheson, John Wiley
7. Comprehensive Heterocyclic Chemistry, A.R. Katritzky and C.W. Rees, eds. Pergamon
8. Natural Products: Chemistry and Biological Significance, J.Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J.B. Harborne, Longman, Essex.
9. Organic Chemistry, Vol 2, I.L. Finar, ELBS.
10. Stereoselective Synthesis: A Practical Approach, M. Nogradi, VCH

(IV) Medicinal Chemistry (CHE403)

1. **Drug Design**
Development of new drugs, procedures followed in drug design, concepts of lead compound and lead modification, concepts of prodrugs and soft drugs, structure-activity relationship (SAR) factors affecting bioactivity, resonance, inductive effect, isosterism, bio-isosterism, spatial considerations. Theories of drug activity: occupancy theory, rate theory, induced fit theory. Quantitative structure activity relationship. History and development of QSAR. Concepts of drug receptors. Elementary treatment of drug receptor interactions. Physico-chemical parameters: lipophilicity, partition coefficient, electronic ionization constant, steric, Shelton and surface activity parameters and redox potentials. Free Wilson analysis, Hansch analysis, relationships between Free-Wilson and Hansch analysis. LD-50, ED-50 (Mathematical derivations of equations excluded).

2. **Pharmacokinetics**
Introduction to drug absorption, disposition, elimination using pharmacokinetics, important pharmacokinetic parameters in defining drug disposition and in therapeutics. Mention of uses of pharmacokinetics in drug development process.

3. **Pharmacodynamics**
Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, sulphonamides, membrane active drugs, drug metabolism, xenobiotic, biotransformation, significance of drug metabolism in medicinal chemistry.

4. **Antineoplastic Agents and Antibiotics**
Introduction, cancer chemotherapy, special problems, role of alkylating agents and antimetabolites in treatment of cancer. Mention of carcinolytic antibiotics and mitotic inhibitors. Synthesis of mechlorethamine, cyclophosphamide, melphalan, uracil, mustards, and 6-mercaptopurine. Recent development in cancer chemotherapy. Hormone and natural products.
Cell wall biosynthesis inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis. Synthesis of penicillin G, penicillin V, ampicillin, amoxycillin, chloramphenicol, cephalosporin, tetracycline and streptomycin.

Books suggested

1. Introduction to Medicinal Chemistry, A. Gringuage, Wiley-VCH.
2. Wilson and Gisvold's: Text Book of Organic Medicinal and Pharmaceutical Chemistry, Ed. Robert F. Dorge.
3. An Introduction to Drug Design, S.S. Pandeya and J.R. Dimmock, New Age International.
4. Burger's Medicinal Chemistry and Drug Discovery, Vol-I, Ed. M.E. Wolff, John Wiley.
5. Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill.
6. The Organic Chemistry of Drug Design and Drug Action, R.B. Silverman, Academic Press.
7. Strategies for Organic Drug Synthesis and Design, D. Lednicer, John Wiley.

IV(ii)Environmental Chemistry(CHE401)

1- Introduction to Environmental Chemistry and Description of Atmosphere

Concept and scope of environmental chemistry.Environmental terminology and nomenclatures. Environmental segments. The natural cycles of environment (Hydrological, Oxygen, Nitrogen).

Atmosphere, environmental segments, composition of the atmosphere, earth's radiation balance, particulates, ions and radicals and their formation, chemical and photochemical reactions in the atmosphere, air pollution, oxides of C,N,S and their effects, acid-rain, smog formation, Green house effects (global warming and ozone depletion, air pollution controls and introduction to analytical methods for monitoring air pollution.

2-Hydrosphere and Lithosphere:

Chemical composition of water bodies-lakes, streams, rivers, sea etc, hydrological cycle, complexation in natural and waste water and microbially mediated redox reactions. Water pollution-inorganic, organic, pesticides, industrial and radioactive materials, oil spills and oil pollutants, eutrophication, acid-mine drainage, waste water treatment, domestic waste water(aerobic and anaerobic treatment), and industrial waste water treatment.

Inorganic and organic components in soil, acid-base and ion-exchange reactions in soil, micro and macro nutrients, nitrogen pathways and NPK in soil.

3-Water quality parameters and standards:

Analytical methods for measuring DO, BOD, COD, fluoride, oils and grease and metals (As, Cd, Hg, Ph, Zn,Cu,Cr), Biochemical effects of As, Cd, Hg, Pb, Cr, CN and pesticides.

4-Air Pollution and Water Pollution:

Particulates, aerosols, SOx, NOx, COx and hydrocarbon. Photochemical smog, air-quality standards.

Books suggested

1. Environmental Chemistry, S.E. Manahan, Lewis Publishers.
2. Environmental Chemistry, Sharma and Kaur, Krishna Publishers.
3. Environmental Chemistry, A.K. De, Wiley Eastern.
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern.
5. Standard Method of Chemical Analysis, F.J. Welcher Vol. III, Van Nostrand Reinhold Co.
6. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
7. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creatchman, Gordon And Breach Science Publication.
8. Environmental Chemistry, C. Baird, W.H. Freeman.

IV (iii) Project Work /Dissertation (CHE404)

(V) Lab Course (Organic) SEM IV (OCHC40P) (2×6 hours)

1. Spectroscopy

Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR & MS) (Compulsory) **20 marks**

2(a). Extraction of Organic Compounds from Natural Sources

i. Isolation of caffeine from tea leaves.
ii. Isolation of casein from milk (the students are required to try some typical colour reactions of proteins).
iii. Isolation of lactose from milk (purity of sugar should be checked by TLC and PC and Rf value reported).
iv. Isolation of nicotine dipicrate from tobacco.
v. Isolation of cinchonine from cinchona bark. **2×20 marks**
vi. Isolation of piperine from black pepper.
vii. Isolation of lycopene from tomatoes.
viii. Isolation of β-carotene from carrots.
ix. Isolation of oleic acid from olive oil (involving the preparation of complex with urea and separation of linoleic acid).
x. Isolation of eugenol from cloves.
xi. Isolation of limonene from citrus fruits.

(b).Synthesis of heterocyclic compounds

Skraup synthesis: Preparation of quinoline from aniline. Fisher-Indole synthesis: Preparation of 2-phenyl indole from phenylhydrazine.

(c).Spectrophotometric (UV/VIS) Estimations

i. Amino acids
ii. Proteins
iii. Carbohydrates
iv. Cholesterol
v. Ascorbic acid
vi. Aspirin
vii. Caffeine

3. Viva **10 marks**

4. Record **10 marks**

Specialization Physical Chemistry

(I) Advanced Chemical Dynamics(CHC407)

1. Thermodynamics

Thermodynamical properties of Solids: Crystal symmetry and Macroscopic properties. Microscopic theory of thermal properties. Contribution of Anharmonicity. Properties of Complex Solids and imperfect solids.

Phase rule: Phase diagram of CO_2, H_2O and He. Thermodynamical aspects of phase transitions. Liquid-Solid phase diagrams, Eutectics, Incongruent melting. Ternary systems, partially miscible liquids.

2. Kinetics

Interactions between reacting molecules (Quantum mechanical aspect). Methods of determinations of rate of fast reactions. Fluctuations in chemical kinetics. Symmetry rules.
Electron transfer in homogeneous systems, role of electron tunnelling, reorganization energy. Kinetics of electrode reactions. Rates of adsorption and desorption.

3. Liquids

Thermodynamical properties of Liquids: Bulk properties. Relation between structure and thermodynamic properties of simple liquids. Molecular theory of monoatomic liquids.
Molecular interactions in liquids, radial distribution. Liquid-surface interface, surface tension, curved surface and capillary action. Thermodynamics of surface layers. Condensation.

4. Non-equilibrium phenomena

Transport parameters in gases, diffusion coefficient, thermal conductivity, viscosity and effusion.

Liquid viscosity, Mobility of ions, drift speed, mobility and conductivity, Einstein relations.

Thermodynamical and statistical view of diffusion.

Book Suggested

i. Chemical Kinetics and Reaction Dynamics –Upadhyay ,Santosh K. (Springer)
ii. Chemical Kinetics and Dynamics – Jeffrey I. Stein Felf's Books
iii. C.M Guldberg and P.Waage- Studies concerning affinity.
iv. Atkins P.and de Paula J.-Physical Chemistry
v. Stainfeld J.I ., Francisco J.S. and Hase W.L.- Chemical Kinetics and Dynamics (Prentice –Hall)

vi. Advanced Spectroscopy(CHC408)

1. Molecular Spectroscopy

Anharmonicity, convergence of energy levels. Resonance Raman spectroscopy, Coherent anti-Stokes Raman spectroscopy.

LASER, Pulsed LASER, Time-resolved spectroscopy. Examples of LASER. Applications. Instrumentation of IR and UV-Visible spectrometers.

2. Magnetic Resonance

Nuclear Overhauser effect. Pulse Sequence, Magnetization vectors. DEPT, Two-dimensional NMR. Solid state NMR.

3. X-Ray Diffraction

Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in diffraction pattern. Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules, Ramchandran diagram.

4. Electron Diffraction and Neutron Diffraction

Scattering intensity vs. scattering angle, Wire equation, measurement technique, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surfaces. Scattering of neutrons by solids and liquids, magnetic scattering, measuring techniques. Elucidation of structure of magnetically ordered unit cell.

Books Suggested

1. Physical Method for Chemistry, R.S. Drago, Saunders Company.
2. Structural Method in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS
3. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Horwood.
4. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
5. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C.
6. Morrill, John Wiley.
7. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley.
8. Inorganic Electronic Spectroscopy, A.P.B. Lever, Elsevier.
9. Solid State Chemistry and its Applications, A.R. West, Plenum.
10. Solid State Chemistry, D.K. Chakrabarty, New Age International.
11. Symmetry and Spectroscopy, K. Veera Reddy, New Age International, 1998. Instrumental Methods of Analysis, Willard et al., 7th Edn., CBS Publishers.

III Solid State Chemistry(CHC409)

1. **Crystalline solids and Solid preparations**
   Basics of solids. Crystalline solids. Crystal systems. Defects in solids. Methods of crystallization. Doping. Intercalation compounds. Deposition methods. Preparation of thin films and monolayers.
2. **Advanced solid materials**
   Fullerenes. Nanomaterials-definition and classification. Carbon nanomaterials. Ceramics and their uses. Intercalation compounds of transition elements.
3. **Solid State Reactions**
   General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions.
4. **Electrical and magnetic properties of solids**
   Electrically conducting solids, Electrical properties of fullerenes and doped fullerenes carbon nanotubes. Magnetism in inorganic and organic materials. Superconductivity in inorganic and organic compounds. Solids used in rectifiers, transistors, switches and sensors.

Books Recommended

1. G.W. Castellan, Physical Chemistry, 4th Ed. Narosa.
2. R.G. Mortimer, Physical Chemistry, 3rd Ed. Elsevier. NOIDA, UP.
3. Solid State Chemistry and its Applications, A.R. West, Plenum.
4. Solid State Chemistry, D.K. Chakrabarty, New Age International.

IV (i) Chemistry of Materials (CHE405)

1. **Glasses, Ceramics, Composites and Nanomaterials**

   Glassy state, glass formers and glass modifiers, applications. Ceramic structures, mechanical properties, clay products. Refractories, characterizations, properties and applications.

   Microscopic composites; dispersion-strengthened and particle-reinforced, firbe-reinforced composites, macroscopic composites. Nanocrystalline phase, preparation procedures, special properties, applications.

2. **Thin Films ,Langmuir-Blodgett Films and Liquid Crystals**
   Preparation techniques; evaporation/sputtering, chemical processes, MOCVD, sol-gel etc.

   Langmuiur-Blodgett (LB) film, growth techniques, photolithography, properties and applications of thin and LB films.

   Mesomorphic ehavior, thermotropic liquid crystals, positional order, bond orientational order, nematic and smectic mesophases; smectic-nematic transition and clearing temperature-homeotropic, planar and schlieren textures, twisted nematics, chiral nematics, molecular arrangement in smectic C phases, optical properties of liquid crystals. Dielectric susceptibility and dielectric constants. Lyotropic phases and their description of ordering in liquid crystals.

3. **Ionic Conductors**

   Types of ionic conductors, mechanism of ionic conductors, interstitial jumps (Frenkel); vacancy mechanism, diffusion superionic conductors; phase transitions and mechanism of conduction in superionic conductors, examples and applications of ionic conductors.

4. High Tc Materials

Defect perovskites, high Tc superconductivity in cuprates, preparation and characterization of 1-2-3 and 2-1-4 materials, normal state properties; anisotropy; temperature dependence of electrical resistance; optical phonon modes, superconducting state; heat capacity; coherence length, elastic constants, position lifetimes, microwave absorption-pairing and multigap structure in high Tc materials, applications of high Tc materials.

Books Suggested

1. Solid State Physics, N.W. Ashcroft and N.D. Mermin, Saunders College.
2. Material Science and Engineering, An Introduction, W.D. Callister, Wiley.
3. Principles of the Solid State, H.V. Keer, Wiley Eastern.
4. Materials Science, J.C. Anderson, K.D. Leaver, J.M. Alexander and R.D. Rawlings, ELBS.
5. Thermotropic Liquid Crystals, Ed., G.W. Gray, John Wiley.
6. Handbook of Liquid Crystals, Kelker and Hatz, Chemie Verlag.
7. Inorganic Materials:Recent Advances,Editors D.Bahadur *et al*.,Narosa
8. Ion Conducting Materials: Theory and Applications, Editor A. R. Kulkarni, Narosa.

IV(ii) Environmental Chemistry(401)

1-Introduction to Environmental Chemistry and Description of Atmosphere

Concept and scope of environmental chemistry.Environmental terminology and nomenclatures. Environmental segments. The natural cycles of environment (Hydrological, Oxygen, Nitrogen).
Atmosphere, environmental segments, composition of the atmosphere, earth's radiation balance, particulates, ions and radicals and their formation, chemical and photochemical reactions in the atmosphere, air pollution, oxides of C,N,S and their effects, acid-rain, smog formation, Green house effects (global warming and ozone depletion, air pollution controls and introduction to analytical methods for monitoring air pollution.

2-Hydrosphere and Lithosphere:

Chemical composition of water bodies-lakes, streams, rivers, sea etc, hydrological cycle, complexation in natural and waste water and microbially mediated redox reactions. Water pollution-inorganic, organic, pesticides, industrial and radioactive materials, oil spills and oil pollutants, eutrophication, acid-mine drainage, waste water treatment, domestic waste water(aerobic and anaerobic treatment), and industrial waste water treatment.
Inorganic and organic components in soil, acid-base and ion-exchange reactions in soil, micro and macro nutrients, nitrogen pathways and NPK in soil.

3-Water quality parameters and standards:

Analytical methods for measuring DO, BOD, COD, fluoride, oils and grease and metals (As, Cd, Hg, Pb, Zn,Cu,Cr), Biochemical effects of As, Cd, Hg, Pb, Cr, CN and pesticides.

4-Air Pollution and Water Pollution:

Particulates, aerosols, SOx, NOx, COx and hydrocarbon. Photochemical smog, air-quality standards.

Books suggested

1. Environmental Chemistry, S.E. Manahan, Lewis Publishers.
2. Environmental Chemistry, Sharma and Kaur, Krishna Publishers.

3. Environmental Chemistry, A.K. De, Wiley Eastern.
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern.
5. Standard Method of Chemical Analysis, F.J. Welcher Vol. III, Van Nostrand Reinhold Co.
6. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
7. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creatchman, Gordon And Breach Science Publication.
8. Environmental Chemistry, C. Baird, W.H. Freeman.

IV (iii) Project Work / Dissertation (CHE406)

(V) Lab Course (Physical) SEM IV (PCHC40P) (2×6 hours)

1. Verification of the law of photochemical equivalence.

2. Order of reaction by:
   (a). Isolation Method.
   (b). Half life period method
   (c). Integration method **3×20 marks**
   (d)Temperature coefficient of a reaction.
   (e)Energy of activation of a reaction.
   (f)Entropy of a reaction..
3. Determination of pH by following methods:
   (a). Electrical Conductivity.
   (b). E.M.F.
   (c). Polarography
4. Hydrolysis of the salts by following methods:
   (a). Cryoscopic
   (b). Electrical Conductivity.
   (c). E.M.F.

5. **Viva** **10 marks**
6. **Record** **10 marks**

Prof. (S.S. Jangwan)

Sridev Suman University

Details of PG courses & Syllabus (Physics)
(M. Sc. Two year course, Semester system)

Marks Distribution

Theory : External =80, Internal assessment =20 (80+20= 100) each paper
Practical: (80+ 20=100) each semester, 80 marks Practical + 20 Internal

M Sc I Year

Semester I:

Paper I: Classical Mechanics
Paper II: Mathematical Physics
Paper III: Astrophysics
Paper IV: Electrodynamics
Lab Course: Practical

Semester II:

Paper I: Atomic and Molecular Physics
Paper II: Solid State Physics
Paper III: Statistical Mechanics
Paper IV: Quantum Mechanics
Lab Course: Practical

M Sc II Year

Semester III:

Paper I: Advanced Quantum mechanics
Paper II: Nuclear Physics
Paper III: Particle Physics
Paper IV: Elective: (any one of the followings)

i. Condensed Matter Physics -A
ii. Electronics –A

Lab Course: Practical

Semester IV:

Paper I: Computational Physics
Paper II: Environmental Physics
Paper III: Laser and Fiber Optics
Paper IV: Elective: (any one of the following)

i. Condensed Matter Physics –B
ii. Electronics –B

Lab Course: Practical/ Dissertation (or Project)

M. Sc. I Semester

CLASSICAL MECHANICS

Lagrangian formulation and Variational Principle: Mechanics of particles and system of particles, conversion law, constraints, degree of freedom, generalized coordinates, D'Alembert's Principle, Lagrange's equations of motion from D'Alembert's principle, application of Lagrange's equation of motion to a particle and system of particles, conservation theorem, Hamilton's Variational principle, Euler- Lagrange's differential equation.

Hamilton's formalism: Need of Hamilton's procedure , Legendre's transformation and Hamilton's equation of motion, physical significance of H cyclic coordinates, Hamilton's equation in cylindrical and spherical coordinates and applications, applications of Hamilton's equation of motion to a particle and system of particles.

Principle of least action (no proof): Canonical or contrast transformation, their advantages and examples, condition for a transformation to be canonical, infinitesimal contact transformation (ICT), Poisson brackets : Definition and properties, Invariance with respect to Cnonical transformation, equation of motion in Poission's Bracket form, Jacobian's form.

Mechanics of Rigid Bodies and Theory of Small Oscillations: Coordinates of rigid body motion, Euler's angle, angular momentum of a rigid body moments and products of inertia, principle axis transformation, Euler's equation of motion of a rigid body, stable and unstable equilibriums. Lagrange's equation of motion for small oscillators, normal coordinates and normal mode frequency of vibrations, free vibration of linear triatomic molecules.

Reference Books :

1. N C Rama and P S Joag: Classical Mechanics (Tata McGrawHil, 1991)
2. H Goldstein: Classical Mechanics (Addition Wesley, 1980)
3. A Sommerfield: Mechanics (Academic Press, 1952)
4. I Peiceivel and D Richards: Introduction to Dynamics (Cambridge University Press)

MATHEMATICAL PHYSICS

Differential Equations: Special equations of Mathematical Physics, Legendre and Associated Legendre equations.Hermite equation, Laguerre equation, Bessel's equation, Beta and Gamma functions. Fourier and Laplace Transforms, Laplace equation and its solution, Poission, Diffusion and Wave equations, Vibrating membrane.

Group Theory: Definition, Classification of groups, subgroup, cyclic group, isomorphism and homomorphism, classes, vector spaces, representation theory of finite groups, Reducible and Ir-reducible representations, Schur's Lemmas and orthogonality theorem, Characters of representaions.

Complex Variable: Function of complex variable, Analytic functions, Cauchy's integral theorem and Cauchy's integral formula , Taylor and Laurent's expressions, theorem of residues, Contour intergration.

Matrix and Tensors: Inverse and Trace of Matrix, Unitary Matrices, Orthogonality, Eigen values-Eigen vectors and Diagonalistaion of matrices, Coordinate transformation, Covarient and contravarient Tensors, addition, multiplication and contration of tensors, Associated tensors.

Reference Books :

1. G Arfken: Mathematical Methods for Physicist (Academic Press)
2. Pipes and Harvil: Mathematical Methods for Engineers and Physicist
3. C Harper: Introduction to Mathematical Physics (Prentice Hall of India)
4. A W Joshi: Element of Group Theory for Physicists (Wiley Eastern)
5. Mathematical Physics: Satya Prakash, Pragati Prakashan, Meerut
6. Mathematical Physics: Dass and Verma, S Chand & company
7. Mathematical physics: B S Rajput

ASTROPHYSICS

The universe and Solar System: Basic idea of universe and galaxies, Astronomical telescopes. The solar system, Classification of the Planets, Orbits, Laws of planetary motion, Physical features, surface features, Internal Structure, Atmosphere, Satellites and Rings. Asteroids, Meteors and Meteorites their types, Orbits: physical nature and composition, Origin of the minor planets, Observation of meteor showers and sporadic meteors Meteorite craters. Origin of Comets, Periodic comets, Physical nature, Spectra, Brightness variation, Gas production rates, dust and ion tails.

Stellar System: Sun As a Star: History of Sun, Sun's interior, the photosphere, the solar atmosphere (chromosphere & corona). Salient features of sunspots, sun's rotation & solar magnetic field, explanation for observed features of sunspots. Distances of stars from the trigonometric. Secular and moving cluster parallaxes. Stellar motions, Magnitude scale and magnitude systems. Atmospheric extinction. Absolute magnitudes and distance modulus, color index. The Hertzberg- Russell Diagram:The colour, Brightness or luminosity, the population of star. Elementary idea of Binary & Variable Stars. Nuclear fission, Nuclear fusion, condition for nuclear reaction in stars.Types of galaxies, Structure and features of the Milky Way Galaxy.

Physics of the Stars: Apparent and Mean Position of stars. Effects of atmospheric refraction, aberration, parallax, precession, nutation and proper motion on the coordinates of stars. Reduction from apparent to mean places and vice versa. Spectra of Stars. Distribution of stars in space. Statistical parallaxes. Local standard of rest. Solar motion and its determination. Peculiar velocities. Single and Two star stream hypothesis. Velocity ellipsoid. Comparison with solar neighbourhood. Bottlinger's diagram. HR diagram, HD and MK spectral classification of stellar spectra. Radiation laws and basic ideas on spectral line formation. Explanation of stellar spectra in terms of Boltzmann and Saha equations. Spectroscopic parallax.

Fundamental Equations: Equation of mass distribution. Equation of hydrostatic equilibrium. Equation of energy transport by radiative and convective processes. Equation of thermal equilibrium. Equation of state. Stellar opacity. Stellar energy sources. Stellar models: The overall problem and boundary conditions. Russell-Voigt theorem. Dimensional discussions of mass-luminosity law. Polytropic configurations. Homology transformations.

Reference Books:

1. Principles of Stellar Dynamics, S.Chandrasekhar
2. The Great Universe, G K Sudarshan, S chand Publications.
3. Our Solar System, Joshi and Rana, New Age Publicatiopns
4. Galaxies and Universe , K.C.Freeman:
5 The Origin and Evolution of Galaxies , S.D.M.White:
6. Lecture notes on "Dynamics of Stellar Systems", S.M.Alladin:
7. Stars and Galaxies: K.D.Abhyankar (Tata McGraw Hill Publication)
8. Exploration of the Universe: G.Abell
9. The Structure of Universe:JayantNaralikar
10.Physics of Comets: K.S. Krishnaswamy
11. Our solar system: A.W. Joshi & N. Rana
12.Introduction to Astrophysics: Baidyanath Basu
13.Astrophysics of the Sun:Harold Zirin
14. The Quiet Sun: Gibson
15. Stellar Evolution: M. Schwarzschild
16. S.Chandrasekhar:Stellar Structure: S. Chandrasekhar
17.Principles of Stellar Interiors - Vol.I and II: Cox and Guili
18. White Dwarfs, Neutron Stars and Black Holes:Shapiro and Tevkolsky

ELECTRODYNAMICS

Maxwell's equations and Electromagnetic Wave: Equation of Continuity, Displacement current, Maxwell's equations, Poynting theorem, Electromagnetic Wave equation, Propagation of Plane Electromagnetic Wave in free space, conducting and non-conducting medium and ionised gases.

Interaction of Electromagnetic Waves with Matter: Boundary Conditions for the Electromagnetic field vectors, Reflection and Refraction at the boundary of two conducting and non-conducting media, Propagation of Electromagnetic wave between parallel con2ucting plates, Basic concept of Wave Guides, Scattering by a free and bound electron

Electromagnetic Radiation: Electromagnetic vector and scalar potential, Lorentz and Coulomb Gauge, Lienard-Wichert potential, Electric and magnetic fields of a charge in uniform motion and concept of virtual photon, Radiation from an Accelerated Charge. Larmor's formula and its relativistic Generalization, Bremstrahlung, Cerenkov radiation.

Relativistic Electrodynamics: Minkowski space, Four vectors, Lorentz transformation of space and time in four-vector form, Transformation of electromagnetic potential, Invariance of Maxwell's field equations in terms of four-vectors, Electromagnetic field tensor, Maxwell's equations in covariance four tensor form, Lorentz force, Invariants of the electromagnetic field.

Reference Books :

1. Electrodynamics –D.J. Grifiths
2. Classical Electrodynamics – J.D.Jackson, Wiley Eastern, New Delhi
3. Classical theory of fields – Landau and Lifshitz, Pergameon Press
4. Elecrodynamic wave and fields, R N Singh
5. Classical Electricity and Magnetism- Panofsky and Phillips
6. Electrodynamics of Continuous Media - Landau &Lifshitz
7. Electromagnetic Theory and Electrodynamics – SatyaPrakash

List of Experiments : At least 10 experiments are to be performed

1. Study of LCR circuit
2. Transistorized LCR bridge
3. Study of UJT
4. Study of MOSFET
5. Study of NPN and PNP transistor characteristics
6. Study of DIAC
7. Study of TRIAC
8. Study of FET
9. R.C. Coupled amplifier
10. T.C. Coupled amplifier
11. Study of feedback amplifier
12. Study of Hartley Oscillator
13. Study of Colpit's Oscillator
14. Study of Wien Bridge oscillator
15. Design and study of different Network theorems
16. Study of Hubble's law (from given data)
17. Study of constant density neutron star
18. Study of the static parameters of a Neutron Star model with inverse square density distribution
19. Study of star cluster from a given data
20. Study of Extinction coefficients
21. Study of variability of stars

M.Sc. II Semester
ATOMIC AND MOLECULAR PHYSICS

Atomic Spectroscopy: Fine structure of Hydrogen lines, alkali atom Spectra, penetrating and non penetrating orbits, electron spin orbit interaction, L-S and J-J coupling schemes, Hunde's rule Spectra of two valence electron atoms, (Helium, Magnesium), selection rules for atomic transitions, multielectron spectra, Central field approximation Hartreesself consistent field theory, Thomas Fermi statistical model, Pauli's exclusion principle and determination of ground state. Zeeman Effect, Paschen Back Effect, Hyper fine structure, Stark effect, width of spectral lines, lamb shift.

Molecular Spectroscopy: Rotational spectra of diatomic molecules, non rigid rotator, vibrational spectra enharmonic oscillator explanation of rotational vibrational spectra in infrared, molecular dissociation and calculation of dissociation energy, Raman effect and intensity alternation of the rotational bands, Applications of infrared and Raman spectroscopy.

Born- Openheimer approximation: Molecular orbital theory, Heitler-Loudon treatment of Hydrogen molecule ion and Hydrogen molecule, Electronic spectra of molecules, Fortrait Parabola, Deslandres table, vibrational structure of electronic bands, Intensities of electronic transitions, Franek Condon principle, Condon parabola.

Lasers: Einstein's quantum theory of radiation, Life time. Theory of some simple optical processes, Kinetics of optical absorption, Stimulated emission, laser pumping, three and four level scheme, Threshold condition, different types of lasers, gas lasers: He-Ne, N_2 and CO_2 , dye lasers, solid state lasers, semiconductor lasers. Holography and its applications.

Reference Books:

1. Atomic Spectra- H.E white Cambridge University Press, Newyork, 1935)
2. Principle of Atomic Spectra - Shore and Menzel
3. Spectra of Diatomic Molecules - G. Herzberg
4. C.B.Banewell: fundamentals of Molecular Spectroscopy
5. Molecular Spectroscopy – Arul Das.
6. Elements opf spectroscopy, Gupta, Kumar & Sharma, Pragati Prakasan, Meerut
7. Laser and applications : Thyagrajan & Ghatak

SOLID STATE PHYSICS

Crystal Binding and Elastic Constants: Ionic Crystal, Covalent Crystal, Metals, Hydrogen bonds, analysis of elastic springs, elastic stress and strain, work done by elastic forces, elastic energy density, stress –strain relations, elastic compliance and stiffness constants, Reduction in number of elastic constants in cubic systems. Elastic waves and velocity in cubic crystals, Experimental determination of elastic constants,

Diffraction and Reciprocal lattice: Diffraction waves by crystals, Braggs diffraction of X-rays, , Different experimental methods, diffraction of electron and neutron, Inelastic neutron scattering, The atomic scattering factor, Atomic form factor, Structure factor for sc, fcc and bcc lattice, Scattered wave amplitude, Laue equations, Brillouin Zones, Bragg's diffraction condition in reciprocal space.

Phonons and Lattice Vibrations : Quantization of elastic waves, Normal modes of vibration, Concept of phonon, Phonon momentum, Inelastic scattering of photons by phonons, Vibrations of one dimensional monatomic lattice, First Brillouin Zone, Group Velocity, Long wavelength limit, Vibrations of one dimensional diatomic lattice, Infrared absorption and optical properties.

Thermal Properties of Solids: Specific heat of solids, Einstein Model of lattice specific heat, Debye theory of lattice specific heat, Debye approximation, Thermal expansion, lattice thermal conductivity, Electronic heat conduction,

Reference Books:

1. Introduction of Solid State Physics, C Kittel
2. Solid State Physics, Ashcroft & Mermin
3. Solid State Physics- Ajay Kumar Saxena
4. Solid State Physics, A J Dekker;
5. Solid State Physics, S O Pillai
6. Introduction to Solid State Physics, Peterson
7. Solid State Physics, Singhal
8. Solid State Physics, R Asokamani

STATISTICAL PHYSICS

Basic Postulates- Phase space, relation between eigen states and phase space volume, Liouville's theorem, ensembles, Microcanonical, Canonical and Grand canonical ensembles, Maxwell's Boltzmnn's distribution and Gibb's formulation for canonical and grand canonical ensembles, partition function, their thermodynamic properties, laws of thermodynamics.

Application of classical distribution to the ideal gases: Degrees of freedom, translational motion, Helmholtz free energy, Gibb's free energy, entropy and thermodynamic properties, Gibb's paradox, Sakur-tetrode equation. Imperfect gases: Difference between ideal and real gas, imperfect gases, Vander Waal's equation, virial coefficients, condensation of gases, general properties of liquids, Fermi theory, liquid Helium, phase rule.

Quantum Statistics: Drawbacks of M B distribution, Bose-Einstein's and Fermi-Dirac distribution, symmetric and antisymmetric particles, partition functions, non degenerate, weakly degenerate and strongly degenerate cases, B.E. condensation, application to He, pressure-energy relationship, electronic specific heat of solids and paramagnetism.

Black Body Radiation: Planck's distribution, pressure and energy relationship of photons, black body radiation, Rayleigh Jean's formula, Wein's law, Wein's displacement formula, absorption and emission of radiation, Stefan's law, high temperature measurements.

Reference Books:

1. E.S. Raj Gopal: Statistical Mechanics and Properties of Matter
2. Mayer And Mayer: Statistical Mechanics
3. Landau and Lifshitz: Statistical Physics
4. Pointon: Introduction to Statistical Physics
5. Huang: Statistical Mechanics
6. Wanier: Statistical Physics
7. Statistical Physics , Raj Kumar

QUANTUM MECHANICS

Introduction: A brief review of foundations of quantum mechanics, basic postulates of quantum mechanics, uncertainty relations, Schrodinger wave equation, expectation value and Ehrenfest theorem., Relationship between space and momentum representation.Schroedinger equation in spherically polar coordinates, Free particle in spherical coordinates, Applications: three dimensional squares well potential, three dimensional harmonic oscillator

Matrix Formulation of Quantum Mechanics: Vector representation of states, transformation of Hamiltonian with unitary matrix, representation of an operator, Hilbert Space. Dirac bra and ket notation, projection operators,Schrodinger, Heisenberg and interaction pictures. Relationship between Poisson brackets and commutation relations. Matrix theory of Harmonic oscillator.

Symmetry in Quantum Mechanics: Unitary operators for space and time translations.Symmetry and degeneracy.Rotation and angular momentum; Commutation relations, eigenvalue spectrum, angular momentum matrices of J_+, J_-, J_z, J^2.Concept of spin, Pauli spin matrices. Addition of angular momenta, Clebsch-Gordon coefficients and their properties, recurssion relations. Matrix elements for rotated state, irreducible tensor operator, Wigner-Eckart theorem.Rotation matrices and group aspects.

Approximation Methods for Bound State: Time independent perturbation theory for non-degenerate and degenerate systems upto second order perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogen atom, Zeeman effect with electron spin. Variation principle, application to ground state of helium atom, electron interaction energy and extension of variational principle to excited states. WKB approximation: energy levels of a potential well, quantization rules. Time-dependent perturbation theory; transition probability (Fermi Golden Rule), application to constant perturbation and harmonic perturbation.Semi-classical treatment of radiation.Einstein coefficients; radiative transitions.

Recommended Books:

1.L. I. Schiff, Quantum Mechanics (McGraw Hill).
2.V. K. Thankappan, Quantum Mechanics (Wiley Eastern).
3.P. M. Mathews and K. Venkatesan, A Text-Book of Quantum Mechanics (TMH)
4.C. Cohen-Tannoudji, Bernard Diu, Franck Loloe, Quantum Mechanics Vols-I&II (John Wiley).
5.J. J. Sakurai, Modern Quantum Mechanics (Addison-Wesley).
6.A. K. Ghatakh and S. Lokanathan, Quantum Mechanics 3rd ed. (MacMillan).

List of experiments: At least 10 experiments are to be performed

1. Multivibrator Bistable/Monostable/Astable
2. Study of different types of Oscillators
3. Ionisatin potential of Mercury using gas filled diodes
4. Michelson Interfermeter
5. Fabry Pert Interferometer
6. Fresnals law
7. Determination of absorption coeficient of iodine vapour
8. B-H curve
9. Lecher wire experiment
10. Determination of magnetic susceptibility
11. Study of CRO.
12. Velocity of Ultrasonic waves
13. Linear Air track
14. Determination of Planks constant
15. Wein's and Stefan's law

M.Sc. III Semester

ADVANCED QUANTUM MECHANICS

Scattering Theory: General considerations; kinematics, wave mechanical picture, scattering amplitude, differential and total cross-section.Green's function for scattering. Partial wave analysis: asymptotic behaviour of partial waves, phase shifts, scattering amplitude in terms of phase shifts, cross-sections, Optical theorem. Phase shifts and its relation to potential, effective range theory. Application to low energy scattering; resonant scattering, Breit-Wigner formula for one level and two levels, non-resonant scattering, s-wave and p-wave resonances. Born approximation

Identical Particles: The Schrodinger equation for a system consisting of identical particles, symmetric and anti-symmetric wave functions, elementary theory of the ground state of two electron atoms; ortho- and Para-helium. Spin and statistics connection, permutation symmetry and Young tableaux.Scattering of identical particles.

Relativistic Wave Equations:Generalization of the Schrodinger equation; Klein-Gordon equation, plane wave solutions, charge and current densities, interaction with electromagnetic fields, Hydrogen-like atom non-relativistic limit. Extension of Klein-Gordon equation to spin 1 particles. Dirac Equation; relativistic Hamiltonian, probability density, expectation values, Dirac gamma matrices, and their properties, non-relativistic limit of Dirac equation. Covariance of Dirac equation and bilinear covariance, plane wave solution, energy spectrum of hydrogen atom, electron spin and magnetic moment, negative energy sea, hole interpretation and the concept of positron. Spin-orbit coupling.

Quantization of wave fields: The quantization of wave fields, Classical and quantum field equations quantization of non-relativistic Schrodinger equation, Second quantization of Schroedinger field, K-G field and Dirac fields, quantization of electromagnetic fields, creation and annihilation operators.

Reference Books:

1. P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics (TMH)
2. A. S. Davydov, Quantum Mechanics (Pergamon).
3. L. I. Schiff, Quantum Mechanics (McGraw Hill).
4. J. D. Bjorken and S. D. Drell, Relativistic Quantum Mechanics (McGraw Hill).
5. J. J. Sakurai, Advanced Quantum Mechanics (Addison Wesley).
6. V. K. Thankappan, Quantum Mechanics (Wiley Eastern).
7. R.P Feynman and A.R.Hibbs; Quantum Mechanics and Path Integrals.
8. L.H. Ryder, Quantum field Theory (Academic Press).

NUCLEAR PHYSICS

General Properties & Models-: Nuclear size, nuclear angular momentum (Spin), Nuclear magnetic moments, statistics, Binding energy, Liquid drop model, Shell model, Collective model.

Nuclear Forces and Detectros – Ground state of deuteron, Low energy neutron-proton scattering and proton-proton scattering, Exchange and tensor forces, G.M. Counter, Electron & Proton Synchrotron.

Radioactive decay: Radioactive decay equation equilibrium units,Gamow's theory of alpha decay and Geiger Nuttal law, Fermi's theory of beta decay, parity violation in beta decay, electromagnetic decays.

Nuclear Reactions- Q-value of nuclear reaction, Bohr's Theory of compound nucleus, Scattering cross section of nuclear reaction (phase shift method), Breit Wigner single level resonance formula for scattering cross section.

References Books:

1- I. Kaplan: Nuclear Physics
2- H.A. Enge : Nuclear Physics
3- R.Roy & B.P. Nigam : Nuclear Physics
4- R.D. Evans: Nuclear Physics
5- E. Segre : Nuclei & Particles.
6- B.R. Martin : Nuclear & Particle Physics.
7- B.L. Cohen : Concepts of Nuclear Physics.
8- S.S.M. Wong : Introductory Nuclear Physics
9- S.B. Patel : Nuclear Physics
10- S.N. Ghoshal : Nuclear Physics.

PARTICLE PHYSICS

Classification and Properties of Elementary Particles : Elementary Particles,their classification on the basis of their mass and spins (Leptons, Mesons, Baryons) and field quanta.Their general properties (mass, spins, life time and their production and decay modes), Antiparticles.

Conservation Laws and Gauge Invariances: Conservation of Energy, Linear and Angular momentum, Spin, Charge, Lepton No., Baryon No.Isospin, Hypercharge, Parity, Strangeness, Charge conjugation, Time Reversal,CP, CPT theorem, Global and Local gauge invariances.

Fundamental Interaction: Qualitative ideas (Relative strengths, Ranges, Characteristic times and Mediators) of Gravitational, Electromagnetic, Strong and Weak Nuclear interactions.General idea of Electro-week and Grand unifications.

Quark Model: Eight fold way, Quarks as building blocks of hadrons, six quarks (u,d,s,c,t and b), Antiquarks, General properties of quarks (Charge, Mass, Colour - A new degree of freedom, quark confinement, Asymptotic freedom) Evidences for Quarks (Lepton scattering, Hadron Spectroscopy, Jet production), Quark compositions of Mesons and Baryons. General idea of Standard Model.Idea of Higgs Boson.

Reference Books:

1. Introduction to High Energy Physics-D.H.Perkins. (Addision – Wesley-1986)
2. Introduction to Nuclear & Particle Physics.Mittal, Verma &.Gupta (Prentice Hall of India, Pvt.Ltd., New Delhi,
3. Concepts of Modern Physics- Arthur Beiser (Tata McGraw Hill Edu.Pvt Ltd., New Delhi, Sixth Ed. 2009
4. Quarks and Leptons- An Introductory course in Modern Particle Physics-Francis Halzen & A D.Martin ,John Wiley & Cons,Inc.
5. Nuclear and Particle Physics, W.E. Burcham& M. Jobes (Essex,England ISE Reprint
6. Introduction to Particle Physics-M.P. Khanna, (Prentice Hall India)
7. Introduction to Elementary Particle Physics-D.Griffiths (John Wiley 4 sons,1987)
8. Elementary Particle Physics-Gasiorowicz (John Wiley & sons, 1966).
9. Nuclear & Particle Physics-B.R. Martin & G. Shaw(John wiley& sons, 1997)
10. A Modern Introduction to Particle Physics- Riyazuddin and Fayazuddin
11. Particle Physics- M.Leon
12. Principles of Physics- Resnick, Halliday& Walker (John wiley&sons,England) 9th

Extended edition, 2013, chapter 44)
13. Modern Elementary Particle Physics G. L. Kane (Addison- Wesley 1987).
14. Grand Unified theories, Graham Ross.
15. Gauge Theories of Strong, Weak and Electromagnetic Interactions, C. Quigg (Addison – Wesley)
16. Gauge Theory of Elementary Particle Physics , T.D. Cheng and Ling Fong Li (Clarendon Oxford)

Elective 1 :-CONDENSED MATTER PHYSICS- A

Defects in crystals: Point defects, Impuritics, Vacancies, Frenkel defects, Schottky defects, Intrinsic vacancies, Concentration of Schottky defects, Concentration of frankel defects, extrinsic vacancies, Diffusion, Colour centres, F-Centre, V-Centre, dislocation, Line defects, edge dislocation, screw dislocation, Burger vector.

Magnetism: Magnetic materials and their importance in solid state physics, Dia, Para and ferromagnetism, Langvin"s theory of paramagnetism, Ferromagnitiam, Weiss molecular theory, quantum theory of ferromagnetism, Bloch wall, Temperature dependence of spontaneous magnetism, Ferromagnetic domains, Antiferromagnitism, Neel"s theory, Two sublattice model, ferrites.

Energy Bands: Origin of energy gap, Magnitude of the energy gap, Brilloun Zone, Bloch function, Bloch theorem, velocity of electrons, Kronig penny model, Number of possible wave function in a band, crystal momentum, the concept of effective mass, concept of holes, hole band construction, distinction between metal, insulator and semiconductor, experimental evidence of band theory.

Dielectric and electrical properties of insulators: Polar and non polar dielectrics, Polarization, Internal Lorentz field static dielectric constant, measurement of dielectric constant, Macroscopic description of dielectric constants, electronic ionic and orientational polarizability of molecules, Complex dielectric constant, Dielectric loss and relaxation time, Optical absorption. Piezoelectric effect,,and its applications, piezoelectric crystals and uses, ferroelectricity, antiferroelectricity, uses of ferroclectric materials

Reference Books:

1. Introduction to solid state Physics: Kittel
2. Principles of theory of solids: Ziman
3. Quantum theory of solids: J. Callaway
4. Solid State Physics: A.J. Dekker
5. Intermediate Quantum theory of crystalline solids:Animalu
6. Solid State Physics: N W Ashcroft and N David Mermin
7. Solid State Physics: Ajay Kumar Saxena
8. Solid State Physics: Aschroft and Mermin
9. Solid State Physics: Saxena Gupta Saxena
10. Solid State Physics: R.L. Singhal
11. Solid state physics: S O Pillai

Elective-II: Eletronics A

Transistor Oscillators and Multivibrators: Tuned collector oscillator, tuned emmiter oscillator, tuned based oscillator, Hartly, phase shift, Colpit's, Clapp, Wein bridge, RC and crystal oscillator, frequency stability, Switcing charactristics of transistor, Astable, Mono and Bistable multivibrators, Schmitt trigger-bootstrap-sweep circuits.

Combinational digital circuits: Implementations of Logic Functions using gates, RTL, DTL, TTL, ECL MOS and CMOS Logic and their characteristics, 7400 Series. Adders, Subtractors, Serial adder/ Subtractor, Parallel adder/ Subtractor, Carry look ahead adder, BCD adder, Magnitude Comparator, Multiplexer, Demultiplexer, Encoder, Decoder, Parity-checker, Code converters

Sequential Circuits: Flip flops: SR, RS, JK, T, D and Master-Slave flip flops, Characteristic table and equation, Edge triggering, Level Triggering. Registers & Counters: Asynchronous/ Ripple counters, Synchronous counters, Modulo–n Counters, Shift registers, A/D and D/A converters, Universal shift register, Shift counters, Ring counters.

Memory Devices & IC-Technology: Classification of memories, RAM organization, Write/Read operations, Memory cycle, Timing wave forms, Memory decoding, Memory expansion , Static RAM Cell-Bipolar RAM cell, MOSFET RAM cell, Dynamic RAM cell, ROM organization – PROM, EPROM, EEPROM, EAPROM ,Programmable Logic Devices, Programmable Logic Array (PLA), Programmable Array Logic (PAL).Basic Ideas of IC-Technology, Monolithic IC's, IC Components- Resistors (Integrated, Diffused, Thin Film), MOS Capacitors, Inductors, Bipolar Transistors, Thin Film Technology, LSI, MSI.

Reference Books:

1. Integrated Electronics ,Millman & Halkias , (McGraw Hill)
2. Electronic devices and circuit theory, Bolested
3. Electronics-fundamentals and applications, Ryder, (PHI)
4. Optical fibre communications Keiser, (McGraw Hill)
5. Nonlinear fibre optics, Agarwal ,(AP)
6. Digital Principles and Applications , Malvino& Leach:
7. Digital Design , Morris Mano
8. Digital Fundamentals, Thomas L. Floyd;
9. Hand Book of Electronics, Gupta Kumar. Pragati prakashan
10. Digital electronics: Principle and Practice, Avinashi Kapoor and Maheshwari, Macmillon Publications

List of experiments: At least 10 experiments are to be performed

1. Study of regulated power supply (723).
2. Study of Timer (555).
3. A to D and D to A convertor
4. 1 of 16 Decoder/Encoder
5. Study of Multiplexer/Demultiplexer
6. Study of Comparator
7. Study of different flip- flop circuits (RS, JK, D Type, T-type, Master Slave).
8. Study of Digital combinational and sequential circuits
9. Study of Microprocessor (8085)
10. Study of SCR, DIAC, TRIAC
11. Study of IC- Based Power supply
12. Shift Registers

13. e/m by Zeeman effect
14. G.M. Counter
15. Study of IC- Based Power supply
16. Absorption spectroscopy by spectrophotometer
17. Study of optoelectronic devices
18. Measurement of thickness of thin wire using laser.
19. Logicom AND/OR/NAND/NOR/NOT gates
20. Study of pin connection and biasing of various linear IC's and timers 555

M.Sc. IV Semester

COMPUTATIONAL PHYSICS

Interpolation: Roots of functions, Finite differnces, Interpolation with equal and intervals, Central difference Interpolation, Inverse interpolation, Numerical differentiation , Numerical integration, integration by trapezoidal and Simpson's rules, Least square fitting method: Straight line, fitting, fitting of parabola, exponential function

Solution of ordinary differential equations and linear equations: Tylor's series, Eulers method, Runge-Kutta Method. Eigenvalues and eigenvectors of matrices, power and Jacobi method, solution of simultaneous linear equations Gaussian elimination, Pivoting, Iterative method, matrix inversion.

Fortran Programming : Flowchart and algorithm, Problem analysis, flowchart of some basic problems. Fundamentals of Fortran 90/95, constant and variables , input/output statements, conditional statements, loops and control, constructs, arithmetic and logical operators and expressions, Format statements, Strings, arrays, pointers, control constructs, Functions, sub programs and modules.

Solutions of physics problems using Fortran Programming : Sum of finite Sin, Cos, Log and exponential series, Integration by Simpson 1/3, 3/8th and Trapezoidal rules, Matrix product and transpose, Roots of Quadratic equation, Projectile motion, Equation of motion, Motion in central field, Solutions of linear equations, Least square fitting of straight line and parabola.

Reference Books:

1.B.D.Hahn: Fortran 90 for Scientists and engineers.
2.VRajaraman: Computer Programming in c.
3. Computer Oriented numerical methods V Rajaraman:
4.Wong: Computational methods in Physics and engineering.
5.S.BalachandraRao: Numerical Methods.
6. Computer programming in Fortran 90/95, V Rajaraman, PHI
7.Numerical Analysis by G Shankar Rao, New Age International

ENVIRONMENTAL PHYSICS

Essentials of Environmental Physics: Structure and thermodynamics of the atmosphere. Composition of air, Green House Effect, Tramnsport of Matter, Energy and momentum in Nature. Stratification and stability of atmosphere.Laws of motion, hydrostatic equilibrium.

Solar and Terrestrial: Physics of Radiation, Interaction of light with matter,Rayleigh and Mie scattering, laws of radiation(Kirchoff's law, Plank's law, Wein's displacement law etc.) , solar and terrestrial spectra, UV radiation. Ozone depletion problem, I R absorption.

Environmental Pollution and Degradation: Elementary fluid dynamics, Diffusion, Turbulence and turbulent diffusion, Factors Governing air, water and noise Pollution, Air and water quality standards. Waste Disposal. Gaseous and particulate matters, wet and dry deposition. Energy sources and combustion processes.

Environmental Changes, Remote Sensing Global and regional Climate: Renewable Sources of energy, Solar energy, wind energy, bioenergy, hydropower, fuel cells, Nuclear energy.Elements of whether and climate. Stability and vertical motion of air, Horizontal motion of air and water, Pressure gradient forces, viscous forces.Inertia forces, Reynolds number, enhanced Greenhouse effect, Global Climate Models.

Referene Books:

1. Egbert Boeker&Rienk Van Groundelle : Enviromental Physics (john wiley)
2. J.T. Hougtion : The Physics of Atmosphere (Cambridge Univ.Press. 1977)
3. J. Twidell and J.Weir : Renewable Energy Resources (Elbs, 1988)
4. Sol Wieder : An Introduction to Solar Energy for Scientists and Engineers (John Wiley,1982
5. R.N. Keshavsamurthy and M.ShankarRao : The Physics of Monsoons(Allied Publuishers,1992)
6. J. Haltiner and R.T. Williams : Numerical Weather Prediction (John Wiley, 1980)

LASER PHYSICS

Basic principles: Basic principles and theory of absorption and emission of radiation, Einstein's coefficients, line-broadening mechanisms, rate equations for three and four level laser systems, population inversion, theory of optical resonators, laser modes, spatial and temporal coherence,

Types of lasers: Gas lasers, He-Ne, argon ion, N_2, CO_2 lasers; dye lasers, solid state, Semiconductor lasers: Ruby, Nd:YAG and Nd:glass lasers, Fabrication technology of lasers, diode lasers, colour centre and spin flip lasers, laser spikes, mode locking Q-switching, CW and pulsed lasers.

Non linear optics: Theory of non linear phenomenon, second and third harmonic generation, phase matching, parametric generation, self focussing

Laser spectroscopy: Laser fluorescence spectroscopy using CW and pulsed lasers, Single photon counting, Laser Raman apectroscopy, multiphoton processes, photo accoustic and photon electron spectroscopy, stimulated Raman spectroscopy, Coherent antistokes Raman spectroscopy.

Reference Books:

1. Ghatak and Thyagrajan: Lasers
2. O. Svelto: Principles of Lasers
3. Silvfast: Lasers
4. B.B.Loyd: Lasers

Elective-I: CONDENSED MATTWER PHYSICS- B

Free electron and Nearly free electron Theory: Nearly free electron model, One dimensional free electron case, Sommerfiel model,, Fermi-Dirac distribution, Quantum theory of free electron in a box, Fermi gas, Nearly free electron case, energy bands in one dimension, tight binding approximation, energy surfaces, Wigner Seitz cellular method, Orthogonalized plane wave (OPW) method, Pseudo potential method, Limitations of band theory .

Transport Properties of Solids and ordered phase: Boltzmann transport equation, Mean free path, Hall effect, Hall voltage and coefficient, experimental determination of hall coefficient, resistivity of metals and semiconductors, thermoelectric phenomena, Onsager coefficients. Ordered phases of matter, translational and orientational order, kinds of liquid crystalline order. Quasi crystals.

Superconductivity: Experimental Survey, Occirance of super conductivity, destruction of superconductivity by magnetic field and temperature, Meissner effects, Type-I and Type-II superconductors, Isotope effect, Thermodynamics of Superconducting transition, London Equations, Coherence length, BCS Theory, Cooper pairs, Josephson superconductor tunneling, AC & DC Josephson effect, High temperature superconductors, critical fields and critical currents.

Nano Material Science and Technology: History, Origin, Quantum dots, Synthesis, Applications and advantages, Quantum wires, Quantum well & application, Fullerenes, Carbon nanobuds, carbon nanotubes as quantum wires, Areas of Nanotechnology, nanomaterials, nanoelectronics, nanobiotechnology, nanofabrication, microelectromechanical systems (MEMS)

Reference books

1. Principle of condensed matter Physics : Chaikimand Lubensky
2. Solid State Physics : Kubo and Ngamia
3. Elements of Solid State Physics : Srivastava
4. Introduction to Solid State Physics : Madelung
5. Introduction to Solid State Physics : Paterson
6. Introduction to Solid State Physics : Kittel
7. Solid State Physics-N W Ashcroft & N David Mermin
8. Solid State Physics-Ajay Kumar Saxena
9. Introduction to Nano Technology: Poole and Owners
10. Quantum Dots: Jacak, Hawrylak and Wojs
11. Handbook of Nano Structureed Materials and Nano Technology: Nalva(Editor)
12. Nano Technology/ Principles and Practices: S K Kulkarni
13. Carbon Nano Tubes: SilvanaFiorito
14. Nano Technology: Richard Booker and Earl Boysen

Elective-II: ELECTRONICS - B

Modulation and Demodulation: AM and FM (Transmission and reception): Modulation, AM generation, Power consideration, Balanced modulator, SSB transmission AM detection, AGC, Signal to noise ratio, FM analysis, noise considerations, generation, direct method and reactance tube method, FM transmitter, AFC, FM Propagation, phase discriminator. Envelope diode detector, super regenerative detection, Ratio Detector

Propagation of radio waves and Radar system: Ground wave, sky wave and space wave propagation, Ionosphere (Eccle- larmer theory, magneto ionic theory), Appleton-Hartee theory of skywave propagation. Principle of Radar, Basic arrangement of Radar system, Azimuth and Range measurement, operating characteristics of systems, Radar transmitters and Receivers, Duplexers, Indicator unit, maximum range of a Radar set.

Transmission Lines: TL Equations and their solutions, transmission line as a two conductor system, transit time effect, calculation of line parameters, voltage and current relation on radio frequency transmission line, propagation constant and its physical significance, line distortion and attenuation, characteristic impedance, characteristic impedance, lossless open and short circuited lines, standing wave ratio and refection coefficient, stub matching, quarter wave length and half wave length lines.

Antenna: Radioactive field strength, power and radiation patterns of an elementary electric doublet and linear antenna, effects of ground reflection. Hertz antenna, Marconi antenaa, Yagi antenna, loop antenna, direction finding, Resonant & Non resonant Antenna, Antenna array (Broad side & End fire arrays), T.V. aerials .Horn Antenna, dish antenna, Parabolic reflectors, Lens Antenna. Satellite communication.

Reference Books :

1. F.E. Terman – Radio Engineering
2. G. Kennedy & B. Davis – Electronic Communication Systems
3. G.K. Mithal – Radio Engineering Vol. II
4. G. Keiser – Optical Fiber Communication
5. C.K. Sirkar& S.K. Sirkar, Fiber optical Communication Systems.
6. Gupta & Kumar – Handbook of Electronics
7. Frenzel – Communication Electronics
8. Rody&Coolen - Communication Electronics.
9. L.E. Frenzel – Communication Electronics

List of experiments/Dissertation:

1. Study of computational software's.
2. Study of numerical techniques.
3. Computer programming.
4. Study of Modulation and Demodulation (Amplitude & Frequency).
5. Study of operational amplifier
6. Dielectric constant
7. Measurement of wavelength of He-Ne laser using interference and diffraction pattern
8. Fiber Optics communication.

Note: Either student should perform the experiments or complete the dissertation.

Department of Zoology

M. Sc. (Zoology)

Course Contents & Syllabus

Sri Dev Suman Uttarakhand Vishwavidhyalay,
Badshahithaul, Tehri Garhwal, Uttarakhand 249 199.

M.Sc. Course in Zoology

Sri Dev Suman Uttarakhand Vishwavidhyalay,
Badshahithaul, Tehri Garhwal, Uttarakhand 249 199.

The M.Sc. course will be spread over two years (four semesters). There shall be Four theory papers and one practical examination every semester. Each theory paper has been divided into four units.

Course Contents & Teaching Schedules:

M.Sc. Ist Semester (July to November)				
Paper	Paper Title	Lectures/ week	Teaching hours/week	MM
Theory Paper C01	Animal Diversity (Invertebrate)	3	03	100
Theory Paper C02	Cell Biology	3	03	100
Theory Paper C03	Genetics, Evolution & Taxonomy	3	03	100
Theory Paper C04	Developmental Biology	3	03	100
Lab Course LC01	Based on Theory Papers	12	12	100
M.Sc. 2nd Semester (December to April)				
Theory Paper C05	Microbiology & Parasitology	3	3	100
Theory Paper C06	Animal Physiology	3	3	100
Theory Paper C07	Immunology	3	3	100
Theory Paper C08	Molecular biology and Elementary Biotechnology	3	3	100
Lab Course LC02	Based on theory papers	12	12	100
M.Sc. 3rd Semester (July to November)				
Theory Paper C09	Animal Diversity (Chordata)	3	3	100
Theory Paper C10	Ecology & Wildlife	3	3	100
Theory Paper E01	Methods &Techniques / Dissertation (Fish Biology/ Entomology/ Environmental Biology	3	3	100
Theory Paper E02 Special Paper E02 a Special Paper E02 b Special Paper E02 c	 Fish Biology I Entomology I Environmental Biology I	3	3	100
Lab Course LC03	Lab Course Based on Theory papers	12	12	100
M.Sc. 4th Semester (December to April)				
Theory Paper C11	Endocrinology & Animal Behaviour	3	3	100
Theory Paper C12	Biochemistry	3	3	100
Theory Paper E03 Special Paper E03 a Special Paper E03 b Special Paper E03 c	 Fish Biology II Entomology II Environmental Biology II	3	3	100
Theory Paper E04 Special Paper E04 a Special Paper E04 b Special Paper E04 c	 Applied Fish Biology Applied Entomology Applied Environmental Biology	3	3	100
Lab Course LC04	Lab Course Based on Theory papers	12	12	100
* Students securing Minimum 70% marks in I & II Semester together can opt for dissertation in place of Theory paper C11				

M.Sc. Zoology 1st Semester
Paper C01: Animal Diversity

No. of Lectures / week
(3 lectures of 60 minutes each)

UNIT I

Protozoa: Comparative morphology of all classes. Locomotor organelles and locomotion. Nutrition: holophytic, holozoic, saprozoic, myxotrophic and parasitic. Reproduction: sexual and asexual reproduction,

UNIT II

Porifera: Comparative morphology of all classes. Types of canal system, Reproduction: Asexual and sexual reproduction, regeneration in sponges.

Coelenterata: Comparative morphology of all classes. Polymorphism in Coelentrates, Coral reefs & its formation, Affinities of Ctenophora.

Helminthes: Comparative external and internal morphology of platyhelminthes and Aschelminthes,

UNIT III

Minor Group: Characters and Affinities of Phoronida and Rotifera.

Annelida: Comparative morphology of all classes, Coelom, Segmental organs. Parasitic adaptations in Hirudinaria.

Arthropoda: Appendages & Mouth parts in insects, Larval forms in Crustacea, Arachnida. Organization and taxonomic importance of Onychophora.

UNIT IV

Mollusca: Comparative morphology of all classes, Major features of the Respiratory and Reproductive Systems, Larval forms, Torsion in gastropods, Pearl formation.

Echinodermata: Water vascular system, Larval forms and affinities.

Recommended Books:

1. Barnes: Invertebrate Zoology (4th ed.), Holt-Saunders, 1980.
2. Barrington: Invertebrate Structure and function, Nelson, 1987.
3. Hickman, Roberts & Hickman: Integrated principles of Zoology (7th ed) Times-Mirror, Mosby
4. Kotpal R.L: Modern Text Book of zoology: Invertebrates. Rastogi
5. Nigam : Biology of Non-Chordates, Nagin Chand, 1985.
6. Parker TJ & Haswell WA: A Text book of Zoology Vol I & II, McMillan
7. Hyman L: Invertebrate Series, Academic Press
8. Starr et al: Biology, The Unity and Diversity of Life
9. Twenhofel et al: Principles of Invertebrate Palaeontology

M.Sc. Zoology 1st Semester
Paper C02: Cell Biology

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Ultra structure of pro-and eukaryotic cells.

Plasma membrane: Structure - organisation, lipid bilayer, proteins & glycoconjugates, liposomes. Function- Ionic transport, transporter proteins, types of transport (symport, antiport, active & passive, endocytosis, exocytosis).

Endomembrane system: Intracellular compartments/organelles involved in protein sorting, secretary and endocytic pathways.

Cytoskeleton: Components, functions & derived organelles (cilium, flagellum).

UNIT II

Mitochondria: Structure, function & genetic organisation.

Ribosome: Biosynthesis & formation in nucleolus.

Cell cycle: Molecular events during interphase, genetic regulation of cell cycle (including yeast as model system).

UNIT III

Cellular communication: general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins,

Cellular transformation and malignancy. Retroviruses, Apoptosis and Ncrosis, Causes of cancer. Nuclear cytoplasmic interaction.

UNIT IV

Mechanisms of signal transduction; Endocrine, Exocrine & Synaptic signaling, Surface and intracellular receptors, G Proteins & generation of second messengers, mode of action of cAMP & Ca++Calmodulin, Signal transduction pathways, regulation of signaling pathways,

Recommended Books:

1. Lodish-el al, Molecular Cell Biology 6th ed 2007 Free Man
2. Pollard and Earnshaw, Cell Biology 2002 Saunders
3. Karp: Cell and Molecular Biology 2007, Wiley
4. P.K. Gupta: Cell Biology and Genetics, Rastogi

M.Sc. Zoology 1st Semester
Paper C03: Genetics, Evolution & Taxonomy

No. of Lectures /week
(3 lectures of 60 minutes each)

Genetics

UNIT I

Mendelian Laws along with molecular explanations. Exceptions to Mendelian Laws. Lethal alleles. Multiple alleles. Gene interactions (Modification of Dihybrid Ratios) and their biochemical basis. Pedigree analysis in man. Sex linked inheritance and genetic disorders. Cytoplasmic inheritance & Extrachromosomal inheritance.

UNIT II

Linkage, genetic mapping techniques (Three point test cross). Gene maps in some organisms.Hardy-Weinberg law & its applications. Mutation (including Molecular basis).Chromosomes: Structure, chemical composition, (histones, DNA. Nucleosome) classification, karyotype, euchromatin and heterochromatin. Giant chromosomes: Polytene and Lampbrush chromosomes

Evolution

UNIT III

An overview of the concepts of organic evolution and evolutionary theories. Origin of life (including aspects of prebiotic environment and molecular evolution); Variations. Natural selection: Concept; Types of selection and selection coefficient. Role of mutation in evolution. Speciation: Isolating mechanisms; Modes of speciation (allopatric, sympatric, parapatric). Micro and macroevolution. Animal distribution: Zoogeographical divisions of the world (characteristics & fauna). Insular fauna. Fossils and fossilization. Geological distribution of animal. Evolution of Horse and Man; Extinctions.

Taxonomy

UNIT IV

History of animal taxonomy. Introduction and scope of Systematics. Species concepts (Typological, Nominalistic, Biological and Evolutionary). Principal of classification, functions, systems of classification; Linnean hierarchy. Nomenclature: ICZN; Taxon, Rank and Categories. Methodologies in taxonomy. Preparation of Keys, Techniques of museum preparation.

Recommended Books:

1. Lewin: Genes, Vol. VII Oxford, 1998, Inded.
2. Straehan & Read: Human Molecular Genetics 1999, John Wiley & Sons Pte. Ltd.
3. Snustad et al: Principles of Genetics 1997, John Wiley & Sons,
4. Strickberger: Genetics, 1996, Prentice Hall
5. Friefelder: Molecular Biology (2nd ed.), 1996 Narosa Publ. House,
6. Moody : Introduction to evolution (Indian Edition) Kalyani Publ., 1978.
7. Strickberger : Evolution, (Indian Edition). CBS Publ., 1994.
8. Richard Swann Lull: Organic Evolution Seema Publications, 1976
9. Simpson G.G.: Principles of Animal Taxonomy, Columbia Univ. Press, 1961.
10. Mayr, E. Systematics and the Origin of Species, Columbia Univ. Press, 1942.

M.Sc. Zoology 1st Semester
Paper C04: Developmental Biology

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Development and differentiation of sperm and oocytes, capacitation, vitellogenesis.

Fertiligation: Mechanism of fertilization, acrosomal reaction, cortical reaction and formation of fertilization membrane. Blocks to polyspermy, Parthenogenesis.

UNIT II

Concept of organiser and embryonic inductions: primary, secondary & tertiary cellular interactions. Development of Eye and limb.

UNIT III

Development in Drosophila: Cleavage, gastrulation; Molecular basis of development, maternal-effect genes, segmentation genes and homeotic selector genes.

Teratogenesis: Genetic and environmental Teratogenesis, phenocopies, developmental mechanisms of teratogenesis

UNIT IV

Regeneration and Metaplasia: Distribution of regenerative ability, polarity in regeneration, mechanism of regeneration of amphibian limb and lens, metaplasia, super-regeneration and heteromorphosis

Metamorphosis: Kind of metamorphosis. Amphibian metamorphosis. Physiological and biochemical changes during metamorphosis, hormonal control of metamorphosis.

Recommended Books:

1. Gilbert: Developmental Biology 1997 Sinauers Ass. Publ. Massachusetts
2. Wolpert: Principles of Development 3rd ed 2007, Oxford
3. Kolthoff: Analysis of Biological development 1996 McGrawHill
4. Balinsky: Introduction to Embroylogy Saunders co. Philadelphia and London
5. Berill: Developmental Biology Tata McGraw Hill

M.Sc. Zoology 2nd Semester
Paper C05: Microbiology & Parasitology

No. of Lectures /week
(3 lectures of 60 minutes each)

Microbiology

UNIT I

Bacteria - classification, staining techniques, pathological significance. Physiology, genetics & reproduction of viruses of plants and animals, Bactriophage, lysogenic & lytic cycle, Bacterial genetics. Microbial culture techniques & media enrichment techniques. Microbial fermentation: Microbes in decomposition and recycling processes. Microbes as pathological agents in plants, animals and man.

UNIT - II

Laboratory facilities, culture media for animal cell culture, Primary culture, cell lines and cloning, Tissue and organ culture, minisatellites, microsatellites. Application of animal cell culture.

Parasitology

UNIT III

Parasitism and evolution of parasitism. Protozoan parasites: Biology, life cycle and diseases caused by selected pathogenic protozoans of man their preventive and control measures (*Entamoeba histolytica,* Trypanosomes, *Leishmania donovani*, *Trichomonas vaginalis, Giardia intestinalis & Plasmodium).*

UNIT IV

Parasitic adaptations in Platyhelminthes and Aschelminthes. Common trematode, cestode and nematode parasites. Biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris, Schistosoma, Fasciola, Wuchereria)* Taenia. Introduction to arthropods and vectors of human diseases (mosquitoes, lice, flies & ticks). Parasitism in Crustacea

Recommended Books:

1. Pelczar: Microbiology, Tata McGraw Hill,1993
2. Davis: Microbiology (3rd ed.) Harper & Row, Publ. Inc., 1980
3. Chandler and Read: Introduction to Parasitology 1970, Wiley
4. Marr et al : Molecular Medical Parasitology 2003, Elsevier
5. Noble and Noble: Parasitology 1996, Cambridge University press
6. Schmidt and Roberts: Williams and Wilkins Foundations Parasitology (4th ed), 1989
7. Ash and Orihel: Parasites, A guide to laboratory procedures and identification, Raven press

M.Sc. Zoology 2nd Semester
Paper C06: Animal Physiology

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Physiology of respiration: Exchange of respiratory gases at the pulmonary surface. Transport of respiratory gases by blood. Factors affecting oxyhaemoglobin dissociation. Neural and chemical control of respiration.

Physiology of digestion & absorption: Functional anatomy of the gastrointestinal tract. Gastrointestinal motility and its regulation. Secretions of the gastrointestinal tract. Liver and biliary system. Digestion and absorption of proteins, fats and carbohydrates.

Physiology of excretion: Formation of urine: Functional anatomy of the kidney. Glomerular filtration and its control. Reabsorptions & secretions in the tubules. Mechanisms of active transport. Excretion and control of urea, sodium, potassium and other ions.

Functions of aldosterone, antidiuretic hormone and renin-angiotensin system in renal physiology. Osmoregulatory mechanisms.

UNIT II

Physiology of cardiovascular system: Characteristics of vertebrate cardiac muscle. Initiation, conduction and regulation of heart beat. Cardiac cycle and cardiac output. Regulation of cardiac amplitude and frequency. ECG and myocardial infarction. Blood pressure and its regulation. Circulation (open and closed, blood composition and function). Blood groups.

The cascade of biochemical reactions involved in coagulation of blood. Lymphatic systems.

UNIT III

Nervous system: Neuron - the basic functional unit, the sensory & motor divisions. Ionic basis of resting and action potentials of neurons, significance of myelinated nerve fibers and velocity of conduction. Physiologic anatomy of the synapse. Mechanism of synaptic transmission, transmitters (acetylcholine, norepinephrine, histamine, GABA). Reflexes and types of reflexes.

Neuromuscular physiology: Structural proteins of muscle cells, actin myosin complex and source of energy for contraction. Sliding filament theory of muscle contraction. Excitation-contraction coupling.

UNIT IV

Sensory physiology: The eye and visual processes - Functional anatomy of the structural elements of the retina. Photochemistry of vision. Extra-retinal photoreception. Visual adaptations in vertebrates.

The ear and auditory processes - Tympanic membrane and the ossicular system. Conduction of sound from tympanum to cochlea. Functional anatomy of cochlea. Sound transmission in cochlea.

Mechanism of thermoregulation in poikilotherms, homeotherms and heterotherms. Aestivation and hibernation.

Recommended Books:

1. Ganong: Review of Medical Physiology 22nd ed 2005. Lang Medical Publ.
2. Guyton and Hall: Text book of Medical Physiology 11th ed 2006 WB Saunders.
3. Keel et al: Samson Wright's Applied Physiology 13th ed 1989 Oxford Press
4. C.C. Chatterjee: Human Physiology
5. Nielson: Animal Physiology, Cambridge.
6. Jain A.K: Textbook Of Physiology 6/E, Avichal Publishing Company
7. Singh H R & Kumar N : Animal Physiology.

M.Sc. Zoology 2nd Semester
Paper C07: Immunology

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Historical aspects of immunology, scope and applications, recent advancements and future prospects. Ontogenetic and Phylogenetic developments of immune system in animals including human beings.

UNIT II

Overview of the Immune System. Hematopoiesis – formation of B-lymphocytes and T-lymphocytes and its regulation. Cells of the immune system- NK Cells, B-lymphocytes, T-lymphocytes, Granulocytic cells, Dendritic cells. Primary lymphoid organs and their functional role- Bone marrow, Thymus. Secondary lymphoid organs and its functional role- Lymph nodes, Spleen, Mucosal-Associated Lymphoid Tissue [MALT], Intraepithelial Lymphocytes [IEL], Cutaneous-Associated Lymphoid Tissue [CALT]

UNIT III

Antigens, Antigenicity versus Immunogenicity, Haptens and Adjuvants.

Basic structure of immunoglobulin. Classes of immuglobulins and its biological activities. Major Histocompatibility Complex [MHC] - Structure, types and function. Antigen processing and presentation. Structure and functions of BCR & TCR.

UNIT IV

Cytokines. The Complement System. Cell mediated cytotoxicity: Mechanism of T cell & NK cell mediated lysis. Ab-dependent cell mediated cytotoxicity (ADCC) Overview of Hypersensititivity and Autoimmunity. Introduction to Transplantation.

Vaccines: Active and Passive Immunization.

Introduction to Monoclonal Antibodies and Hybridoma technology. Antigen-Antibody Interactions: Precipitation Reaction, Agglutination Reactions, Immuno precipitation, Immuno-fluorescence.

Recommended Books:

1. Kuby's immunology- Goldsmith et al, 6th Ed, WH Freeman, New York, USA.
2. Basic immunology: functions and disorders of immune system- Abbas, Litchman. Saunders Publications, Philadelphia, USA
3. Janeway's Immunology- Kenneth Murphy, 8th Ed, Garland Science, Pennsylvania, USA.
4. Roitt's Immunology- Delves et al, 12th Ed, Willey-Blackwell Science, Oxford, UK.
5. History of Immunology, 2nd Ed- Silverstein [2009], Academic Press, New York, USA.
6. Exploring immunology: Concepts and Evidence- Macpherson and Austyn, Willey-Blackwell Science.

M.Sc. Zoology 2nd Semester

Paper C08: Molecular Biology & Elementary Biotechnology

No. of Lectures /week
(3 lectures of 60 minutes each)

Molecular Biology

UNIT I

The central Dogma of Molecular Biology. DNA: Structure and conformation, supercoiling, packing of DNA into chromosomes. Structural polymorphism of DNA & RNA. Three dimensional structure of t-RNA.

UNIT II

DNA replication – Prokaryotic and eukaryotic DNA replication, Enzymes and accessory protein involved in DNA replication. Genetic code. Transcription and translation in prokaryotes and eukaryotes. RNA processing. Mutations & DNA repair systems (excision repair, mismatch repair and SOS repair)

Regulation of Gene expression in Prokaryotes and Eukaryotes: Operon concept (*E. coli* lac operon, trp operon, ara operon),

Biotechnology

UNIT III

History, definition & Scope. General steps of Gene cloning-cutting, legation, transformation and analysis of clones, genomic & C-DNA library. A general idea of cloning vectors based on plasmid & phages, blotting techniques, DNA-sequencing, polymerase chain reaction.

UNIT IV

Gene therapy, DNA finger printing, Transgenic animals and plants. Potential hazards of recombinant DNA technology. Products of recombinant DNA technology, Human genome project and its applications,

RIA, ELISA, Northern Blotting, Western Blotting, Southern Blotting.

Recommended Books:

1. De Robertes & Robertis: Cell & Molecular Biology, 1987, Lee & Fabiger Philadelplna
2. Friefelder: Molecular Biology (2nd ed.), 1996 Narosa Publ. House,
3. Alberts et al: Molecular biology of the cell (4th ed.) 1994, Garland Publ. New York.
4. Elliott & Elliott: Biochemistry and Molecular Biology, 1996, Oxford

M.Sc. Zoology 3rd Semester
Paper C09: Animal Diversity (Chordata)

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

General Characters development of Urochordata and Cephalochordata.

Affinities of Hemichordata, Urochordata & Cephalochordata.

UNIT II

Characters and affinities of Cyclostomata

Salient features of different groups of fishes; comparison between Chondrichthyes and osteichthyes; Dipnoi.

Origin and evolution of Amphibia. Parental care in Amphibia

UNIT III

Origin of Reptilia and adaptive radiation in Reptilia.

Characters and affinities of Chelonia and Rhynchocephalia

Origin and ancestory of birds, Characters and affinities of Ratitae. Origin and mechanism of flight in birds. Palate in birds. Migration in birds.

UNIT IV

Origin of mammals.

Characters and affinities of Prototheria and Metatheria. Dentition in mammals. Aquatic and flying adaptations in mammals, Adaptive radiation in mammals.

Recommended Books:

1. Pandey B.N. and Mathur V. Biology of Chordates, PHI Learning, 2018
2. Parker T.J. & Haswell WA: A Text Book of Zoology, Vol II, ed. 7th, Macmillan & Co. Ltd, London, 1962.
3. Young JZ: The Life of Vertebrates, Oxford, 1950.
4. R.L. Kotpal: Modern Text-book of Zoology, Vertebrates. Rastogi Publication.
5. E.L. Jordan and P.S. Verma: Chordate Zoology. S. Chand & Co. Ltd.
6. Hildebrand: Analysis of Vertebrate structure.
7. Romer & Parsons: The Vertebrate Body, Saunders.

M.Sc. Zoology 3rd Semester
Paper C10: Ecology & Wild Life

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Ecology: Definition, Scope, Importance, Application. Limiting Factors: Liebig's law of the minimum, Shelford's law of tolerance. Combined concept of limiting factor, Factor interaction. Homeostasis. Biogeochemical cycle: Concept & Types of biogeochemical cycle (nitrogen, phosphorus, carbon & water cycle). Ecosystem. Concept; Energy flow; Food chains & Ecological pyramids. Habitat Ecology: Concept of habitats & ecological niche.

UNIT- II

Population: Concept & attributes: Biotic potential, Density, Natality, Mortality; Intrinsic rate of natural increase, survivorship curves. Population growth forms; Carrying capacity; Population regulation (Density dependent and independent). Cycles and fluctuations. Community: Concept & characteristics: Density, Dominance, Diversity & Stratification. Ecotones & Edge effect; Succession of communities; Key stone species.

UNIT III

Biodiversity: Endemism, Genetic, Species and ecosystems diversity; Factors influencing biodiversity Economic valuation of biodiversity: Concepts & Importance. Environmental pollution (Air, water, solid waste, Radioactive); Environmental Impact Assessment. Cumulative Impact Assessment of hydropower development; Environmental flows: need, methodologies, DRIFT, BBM

UNIT IV

Techniques in wildlife: Identification by natural marking, pug marks, calls, behavioural idiosyncracies etc. Passive marking (collars, tags, branding, rings etc). Dynamic marking (radiotelemetry, satellite telemetry, radioisotopic tracers). Population estimation techniques: Absolute versus relative density, total count versus estimates. Census methods (Drive count, aerial count, point count). Indices (pug marks, droppings, nests, burrows, dens, calls). Biogeography of India: Topography & Climate. Patterns of distribution of biota. Wildlife Conservation and Management: Wildlife as a resource; Principles of wildlife management. Habitat management; General introduction to Sanctuaries, National Parks and Biosphere Reserves of India; Captive breeding; Conservation of germ plasma (frozen zoo). Endangered species: IUCN categories for conservation. Endangered fauna of Himalaya (distribution, habitat, habits).

Recommended Books.

1. Kendeigh : Animal ecology, Prentice Hall 1961.
2. Odum: Fundamentals of ecology, Saunders Co. Publ., 1993 Indian ed.
3. Faabourg: Ornithology. An ecological approach Prentice Hall.
4. Krebs: Ecology (4th ed.) Harper Collins College Publisher
5. Negi: An Introduction to Wildlife Management, 1983.
6. Majupuria T C: Wildlife Wealth of India Tecprress Service, Bangkok, 1986.
7. Saharia: Wild life of India Nataraj Publishers, Dehradun.
8. Robert H. Giles: Wildlife Management Techniques (3rd ed.) Natraj Publishers, Dehradun,
9. Negi: Handbook of National Parks, Sanctuaries and Biosphere Reserves in India, 1995.
10. Negi: Himalayan Wildlife: Habitat &Conservation, 1992. Indus Publi. Comp., New Delhi.
11. Sharma: High Altitude Wildlife of India Oxford & IBH Publishing Co. Pvt. Ltd.1994.
12. Richard D. Teague: A Manual of Wildlife Conservation Nataraj Publishers, 1989.
13. Smith RL: Ecology and Field Biology, Harper Collins Publ. 1996.
14. Dodson: Ecology Oxford
15. Dash MC: Fundamental of Ecology, Tata Mc Graw Hill 2001, New Delhi

M.Sc. Zoology 3rd Semester
Paper 11: Methods and Techniques

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Microscopic Techniques: Visualization of cells and sub cellular components by microscopy; Microscopy of living cells; measuring cell size, Scanning and transmission microscopy,

Histochemical and Immunotechniques: Microtomy; Localization of Protein, lipids and carbohydrates in tissues. Antibody generation; Detection of molecules using ELISA, RIA; Western Blot; Fluo- cytometry and Immunofluorescence.

Biophysical Methods: Molecular analysis using UV/visible; Fluorescence; Spectrophotometry; NMR and ESR Spectroscopy;

UNIT II

Molecular Biology and Recombinant DNA Methods: Isolation and purification of RNA, DNA and proteins. Analysis of RNA, DNA and proteins by one or two dimensional gel electrophoresis. Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. DNA sequencing methods, strategies for genome sequencing.

Radio labeling techniques: Detection and measurements of different types of radio isotopes normally used in biology; incorporation of radioisotopes in biological tissues of cells; molecular imaging of radioactive material; safety guidelines.

UNIT III

Methods in field biology: Methods of estimating population density of animals and plants; ranging patterns through direct, indirect and remote observation. Estimation of Physico-chemical Parameter- pH, Free CO_2, D.O., Turbidity in water samples; Estimation of Nitrates, base deficiency in different soil samples.

UNIT IV

Statistical methods: Measures of central tendency and Dispersal; Probability distributions (Normal, Binomial and Poisson); Sampling distribution; difference between Parametric and Non parametric statistics; Confidence interval; Errors; Correlation and Regression analysis; t-test; Anova and X^2 test.

Recommended Books:

1. Sharma, V.K.: Techniques in Microscopy and Cell Biology Tata McGraw Hill, 1991.
2. Alberts et al.: Molecular Biology of the cell (2nd ed.), Garland, 1989.
3. Biochemical Technique: Theory & Practical J.F. Robyt & B.J. White $ 30.95 Waveland Press, Inc.
4. Wilson & Walker: Practical Biochemistry (4th ed) Univ. of Hertfordshire Cambridge Univ. Press
5. Jayraman: Laboratory Manual in Biochemistry
6. Arnold L. Demain & Julian E. Davies: Manual of Industrial Microbio. & Biotech. 2nd ed.

M.Sc. Zoology 3rd Semester
Paper E02 a : Fish Biology I

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Systematics and Phylogeny: Introduction and History of Ichthyology. Zoogeographical distribution Origin, evolution, and phylogeny of fishes. Schemes of classification of fossil and recent fishes. General Characters of Teleost and Elasmobranch fishes. Agnatha: Characters, basic biology and affinities of Cyclostomes and Ostracoderms. Placoderms: General characters and affinities. Holocephali: Salient features external and internal morphology and affinities. Dipnoi: Salient features and affinities.

UNIT II

Comparative Morphology of Telesosts and Elasmobranchs: Morphometric and meristic study of fishes. Integuments (Teleosts and Elasmobranchs), colouration and its significance, mechanism of colour change. Exoskeleton: Structure and development of placoid and nonplacoid scales.Fins and their origin. Skeletal system : Vertebrae, Girdles, Opercular bones, Pharyngeal bones

UNIT III

Alimentary canal and associated glands. Modifications based on different feeding behaviour. Structure of heart, afferent and efferent branchial arteries. Structure of a Gill and Pseudobranch. Brain and cranial nerves in fishes. Urino-genital system of a teleost and an elasmobranch fish. Techniques for the study of histology, histochemistry and biochemistry.

UNIT IV

Fish Physiology Respiration: Functional organization of Gill lamellae, Blood supply of gill, Mechanism of gas exchange, Counter current mechanism. Physiology of excretion and osmo-regulation, Mechanism of water- salt balance in freshwater, marine and estuarine fishes. Reproductive physiology: Spawning patterns and stimulating factors, Follicular atresia. Haemopociesis: Composition of Blood, haemopoietic tissues, synthesis of Haemoglobin. Physiology of Thermo-regulation in fishes.

Recommended Books:

1. Srivastava: Fish Biology, Narendra Publication House, 2008.
2. Ojha: Biology of Hill Stream Fish, Narendra Publication House, 2002.
3. Kyle: The Biology of Fishes, 2007.
4. Singh: Advances in Fish Biology, Hindustan Publishing Corp., 1994.
5. Munshi & Munsi: Fundamental of Freshwater Biology, Narendra Publ. House, 1995.
6. Carlander: Handbook of Freshwater Fishery Biology, vol. 2, Iowa State Univ. Press,1977.
7. SS Khanna & H.R. Singh: Fish & Fisheries

M.Sc. Zoology 3rd Semester
Paper E02b : Entomology I

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Introduction to external morphology: body wall, segmentation. The head: structure of head; appendages, and antennae. The thorax: pro, meso and metathorax; legs. The wings: origin, structure and articulation. The abdomen: structure, appendages; external female and male genitalia.

UNIT II

Classification of insect with special reference to that of different orders. General characters, habits, habitats, importance of the insect orders-Collembola, Protura, Diplura, Thysanura, Ephimerida, Placoptera, Odonata. General characters, habits, habitats, importance of the insect orders-Embioptera, Orthoptera, Phasmida, Dermaptera, Blattaria, Menteodea, Isoptera, Zoraptera.

UNIT III

General characters, habits, habitats, importance of the insect orders-Psocoptera, Thysanoptera, Heteroptera, Homoptera, Anoplura, Neuroptera, Megaloptera, Trichoptera.

UNIT IV

General characters, habits, habitats, importance of the insect orders-Coleoptera, Strepsiptera, Hymenoptera, Lepidoptera, Diptera.

Recommended Books.

1. Mani MS: An Introduction to Entomology, National Book Trust, 1971.
2. Mani MS, Introduction to High Entomology, Mathuen & Coy. Ltd. 1962.
3. Snodgrass RE: Arthropod Anatomy, Comstock Publ. Associates, NY, 1952.
4. Wigglesworth VB: Insect Physiology, Cambridge University Press, 1954.
5. Essig EO: College Entomology, Satish Book Enterprise, Agra, 1982.
6. Fox RM & Fox JW: Introduction to Comparative Entomology. Affiliated East-West Press Pvt. Ltd. New Delhi, 1968.
7. Little VA: General & Applied Entomology, Oxford & IBH Publ. Copy, 1963.
8. Imms AD: Insect Natural History, Collinns St. James's Place London, 1947.
9. Elzinga RJ: Fundamentals of Entomology, Prentice Hall of India Pvt. Ltd., 1978.
10. Comstock JH: An Introduction to Entomology, Comstock Publ. Coy. INC., 1950.
11. Richard DW and Davies RG: A General Text Book of Entomology, Mathuen & Coy., Ltd.

M.Sc. Zoology 3rd Semester
Paper E02c : Environmental biology I

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Introduction to Environmental biology, its multidisciplinary nature and scope. Components of Environment: atmosphere, lithosphere & hydrosphere. Climate (micro, regional and global); Hydrological cycle; Soil profile. Changing interactions between man and environment (cultural, political, ecological).

UNIT II

Terrestrial biomes of the world their characteristics and major biota (Grassland, Desert, Forest, Tundra). Aquatic biomes (lotic, lentic, marine, estuaries, coral reef), their status. Wetlands of India. Environmental adaptations: Aquatic, Aerial, Desert, Arboreal, Fossorial, Defensive.

UNIT III

Island biogeography theory. Habitat fragmentation, Habitat selection, Corridors, Community patterns (gradients and Continuum), Community indices. Ecological niche. Population cycles and fluctuations; Dispersal. Intra & Inter specific relationship. Models of succession; Pioneer & climax concept.

UNIT IV

Concept of biological indicators; biological monitoring; Indicator organisms. Invasive species and its impact. Biological control: Biomagnification, Bioassimilation & Bioaccumulation. Xenobiotics: Carcinogenic (heavy metals, pesticides).

M.Sc. Zoology 4th Semester

Paper C11: Endocrinology and Animal Behaviour

No. of Lectures /week
(3 lectures of 60 minutes each)

Endocrinology

UNIT I

Endocrine messengers: hormones, neurohormones, hormone like substances (neuronal peptides, autocoids, pheromones, neurosecretion). Hormones and Physiological actions of the following endocrine glands in vertebrates: Thyroid, Parathyroid, Pancreas, Gastro-intestinal tract, Adrenal cortex and Medulla, Thymus & Pineal. Hormone biosynthesis: Protein peptide hormones (gonadotrophins, thyrotrophin, corticotrophin, Steroids and catecholamines). Mechanism of action of Protein hormones and Catecholamines: membrane bound receptors, G-protein and control of adynelate cyclase, Cyclic nucleotide cascade.

UNIT II

Mechanism of action of Steroid and Thyroid hormones: Cytosolic receptors, effect on transcriptional and translational processes. Organisation & physiological actions of the Testis: Androgen binding protein (ABP), Inhibin. Neurendocrine control of testicular functions (Gn RH regulation, FSH- effects on germinal epitheluim, LH-effects on Leydig cells, negative feed back regulation). Organisation & physiological actions of the Ovary: Folliculogensis, Ovulaton, Luteinization, Ovarian cycles; Seasonal reproductive cycles; sexual dysfunctions in man.

Animal Behaviour

UNIT III

The science of behaviour: History, scope and terminology. Proximate and ultimate causes of behaviour. Instinct: Definition and characteristics (sign stimuli and Fixed Action Pattern). Learning behaviour: Definition. Spatial learning. Associative learning, classical conditioning, operant conditioning, language learning. Imprinting. Kin recognition. Instinct versus learning behaviour. Timing of behaviour: Biological rhythms. The Biological Clock. Circadian rhythms and their synchronisation seasonal rhythms. Photoperiodism.

UNIT IV

Communication: Visual, olfactory, accoustic. Bird songs. Amphibian calls. Communication in bats. (echolocation in bats, electrolocation in fish) Chemoreception: Chemicals (pheromones) as signals in insects, fish and mammals. Role of olfaction in communication behaviour (territorial, sex recognition, feeding etc) in fish and mammals. Neural control of behavior: Components of brain involved in various behaviours. Neural control of drinking, learning, eating, activity & rest, sleep, aggression, sexual behaviour. Hormonal Control of behaviour. Hormone brain relationships. Sexual behaviour in mammals (eg. rat). Sociobiology: Elements of sociality and social grouping in animals. Grouping versus predation. Grouping vs foraging. Evolutionary and ecological aspects of animal behaviour. Territoriality. evolution of migratory behaviour, costs and benefits of migration. Ecology of foraging behaviour: Prey detection. Prey capture. Antipredator behaviour. Cooperation and conflict: Evolution of altruism. Evolution of cooperative breeding in birds and mammals.

Recommended Books:

1. Alcock : Animal behaviour Sinaur Associates, Inc. 1989.
2. Goodenough et al.: Perspectives on animal behaviour. Wiley & Sons, New Youk. 1993.
3. Grier : Biology of animal behaviour, Mosby 1984.
4. Krebs & Davies : An introduction to behavioural ecology (3rd ed.) Blackwell 1993.
5. Lehner : Handbook of ethological methods, Garland STPM Press, New York, 1979.
6. Halliday, T.R.: Animal Behaviour Vol. 1 & 2 Communication, 1983.
7. Saunders : Insect Clocks Pergamon Press. 1982.
8. Palmer: An Introduction to Biological Rhythms Academic Press New York.1976
9. Ross & Salisbury: Plant Physiology, Indian ed. (FOR BIOLOGICAL RHYTHMS)
10. Mac E. Hadley: Endocrinology, Prentice-Hall International ed.1988/1992.
11. G J Goldsworthy et al: Endocrinology, Blackie, 1981.

M.Sc. Zoology 4th Semester
Paper C12: Biochemistry

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Enzymes: Classification (rationale, overview and specific example) Zymogens and their activation (protease and Prothrombin). Enzyme substrate complex : concept of E-S complex, binding sites, active site, specificity, Lock and Key Hypothesis, Induced –Fit Hypothesis, Michaelis- Menten equation and its derivation, Different plots for the determination of Km and Vmax.

UNIT II

Carbohydrate Metabolism I: Pathway and regulation of Glycolysis, Gluconeogenesis, Glycogenolysis, Glycogenesis. Carbohydrate Metabolism II: Citric acid cycle and its regulation, electron transport chain and oxidative phosphorylation, pentose phosphate pathway and its regulation.

Amino Acid Metabolism: Overview of Amino acid degradation, Urea cycle (conversion of ammonia into urea, linkage between urea cycle and citric acid cycle) and its regulation. Conversion of nitrogen to ammonia by microorganisms, overview of amino-acid biosynthesis.

UNIT III

Fatty Acid Metabolism: Fatty Acid Oxidation and regulation β-oxidation, Oxidation of unsaturated fatty acids and odd chain fatty acids. β-oxidation in peroxisomes, ketone bodies and their overproduction. Fatty Acid Biosynthesis and Regulation. Reactions of fatty acid synthase, synthesis of triglycerols, membrane phospholipids & prostaglandins. Cholesterol biosynthesis and regulation.

UNIT IV

Nucleic Acid Metabolism: Purine biosynthesis and its regulation, pyrimidine biosynthesis and its regulation. Formation of deoxyribonucleotides. Salvage pathway for purine & pyramid in nucleotides, Degradation of purines and pyrimidines into uric acid and urea. Integration of Metabolism.

Recommended Books

1. Lehninger: Principles of Biochemistry, 4th ed., Nelson & Cox, WH Freeman and Co., 2007
2. Voet & Voet: Biochemistry, 2nd ed., Wiley & Sons.
3. Berg, Tymoczko, Stryer: Biochemistry, 5th ed., WH Freeman and Company, 2003.
4. Garett & Grisham: Biochemistry, 4th ed., Brooks/Cole Cengage learning, 2010.
5. Murray, Granner, Rodwell: Harper's Illustrated Biochemistry, 27th ed. McGraw Hill, 2006
6. Conn & Stumpf: Outlines of Biochemistry, 5th ed., Willey India, 2007.

M.Sc. Zoology 4th Semester
Paper E03a : Fish biology II

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Specialized Characters: Accessory Respiratory organs in fishes. Swim Bladder and its modifications, Blood supply of Air bladder, Gas secreting complex, Functions Weberian ossicles: Structure and arrangement, Working mechanism and functions. Electric organs: Structure, Mechanism of electric discharge, Functions. Bioluminescence: Luminiscent organs, Mechanism of light emission, Significance. Sound production in fishes

UNIT II

Fish Behaviour Fish behavior: Social, ecological, reproductive, migratory, foraging behavior. Parental care in fishes. Receptor organs: Eye, Acoustico-Lateralis system, olfactory organs and Taste buds Migration in fishes: Pattern, Causes and Factors influencing. Parental care and viviparity in fishes. Pheromones and their role in sexual behavior of fish

UNIT III Fish Embryology Fertilization and development of fish egg (Teleost). Cleavage, Blastulation, Gastrulation and fate map. Hatching and post-embryonic development.

UNIT IV Endocrine and Biochemistry Pituitary gland: Micro-anatomy, Hormones of Pituitary and their physiological actions. Thyroid gland: Structure and function Structure and functions of Pancreatic islets in fishes. Location and functions of Corpuscles of Stannius, Pineal and Urophysis in fishes.

Recommended Books

1. Agarwal N K : Fish Reproduction, APH Publication
2. Srivastava CBL: Fish Biology, Narendra Publication House, 2008.
3. Carlander: Handbook of Freshwater Fishery Biology, vol. 2, Iowa State Univ.Press,1977.
4. Ojha J: Biology of Hill Stream Fish, Narendra Publication House, 2002.
5. Singh H R: Advances in Fish Biology, Hindustan Publishing Corp., 1994.
6. Munshi & Munsi: Fundamental of Freshwater Biology, Narendra Publ. House, 1995.
7. Kyle: The Biology of Fishes, 2007.
8. Khanna & Singh: Fish & Fisheries

M.Sc. Zoology 4th Semester
Paper E03b : Entomology II

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Digestive system: structure, physiology of digestion and absorption of different types of food. Structure of circulatory system: haemolymph its composition and function. Physiology of respiration; the tracheal system, spiracles, respiration in aquatic insects. Nervous system: structural basis, Excretion: structure and physiology of malpighian tubules and its secondary functions. Reproduction: male and female gonads.

UNIT II

Structure of compound eye, mosatic vision. Production and reception of sound. Light producing organs. Hormones: neurosecretion and co-ordination, Metamorphosis: types, hormonal control of metamorphosis, Pheromones.

UNIT III

Structure of the insect egg, maturation, cleavage, formation of blastoderm, gastrulation, blastokinesis, germ layers, Various types of larvae and pupae, moulting, diapauses, Oviparity, viviparity, ovo-viviparity in insects.

UNIT IV

Abiotic factors: effect of temperature, light and humidity on growth of insect population; biotic potential, Malthusian principle and dynamics of population fluctuation, hibernation, aestivation. Biotic factors: parasitism, predation and social life in insects, phase theory of locust, parental care.

Recommended Books.

1. Mani MS: An Introduction to Entomology, National Book Trust, 1971.
2. Mani MS, Introduction to High Entomology, Mathuen & Coy. Ltd. 1962.
3. Snodgrass RE: Arthropod Anatomy, Comstock Publ. Associates, NY, 1952.
4. Wigglesworth VB: Insect Physiology, Cambridge University Press, 1954.
5. Essig EO: College Entomology, Satish Book Enterprise, Agra, 1982.
6. Fox RM & Fox JW: Introduction to Comparative Entomology. Affiliated East-West Press Pvt. Ltd. New Delhi, 1968.
7. Little VA: General & Applied Entomology, Oxford & IBH Publ. Copy, 1963.
8. Imms AD: Insect Natural History, Collinns St. James's Place London, 1947.
9. Elzinga RJ: Fundamentals of Entomology, Prentice Hall of India Pvt. Ltd., 1978.
10. Comstock JH: An Introduction to Entomology, Comstock Publ. Coy. INC., 1950.
11. Richard DW and Davies RG: A General Text Book of Entomology, Mathuen & Coy., Ltd.

M.Sc. Zoology 4th Semester

Paper E03c : Environmental Biology II

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Natural Resources: Management & conservation; Renewable & non-renewable resources; Concept and currencies of Sustainable development. Biodiversity & its conservation. Environment Protection laws. Earth Summit, Rio+20.

UNIT II

Concept of Protected areas: Sanctuary, National Parks & Biosphere Reserves. IUCN. Categories Biodiversity hot spots, conventions on biodiversity. International efforts in biodiversity conservation (UNFP, IUCN, WWF); CITES; UNESCO's World heritage mission; Convention on Biological Diversity (CBD).

UNIT III

Global Environmental Problems: Climate change, Green house effect; Acid rain; Ozone layer depletion; Deforestation; Desertification; Marine pollution; Urbanization.

UNIT IV

Environmental Problems/Hazards in Hills: Earthquake; Land slide; Soil erosion; Sedimentation; Cloud burst; Flash floods; Glacial retreat. Application of Remote sensing & Geographical Information Systems (GIS) in environment management

M.Sc. Zoology 4th Semester
Paper E04a : Applied Fish Biology

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Aquaculture: Scope, importance and present status. Concept of different culture systems: Extensive and intensive fish culture, Fish culture in ponds and reservoirs. Culture in rice fields, bheries, Cage culture, Pen culture, Monoculture and polyculture. Preparation and maintenance of fish farm: Fertility and pH maintenance. Role of fertilizers, required water quality and its maintenance. Control of aquatic weeds, insects and predatory fishes. Fish nutrition: Development of natural food and supplementary feeding. Culture techniques Procurement of stocking material from natural sources, Induced breeding and use of new generation drugs, ovaprim, different hatching techniques, Transport of fish seed.

UNIT II

Culture Practices: Culture of Common carp and Exotic Trouts. Prawn culture. Sewage – fed Fisheries and Integrated fish farming Common fish diseases and their control. Mahseer and Schizothoracid fishery. Current status, problems and perspectives. Culture of Larvicidal fishes. Characters and importance

UNIT III

Harvesting and Post harvesting Fishing gears used in inland waters and seas. Fish preservation and processing techniques. Fish by-products and their uses. Fish spoilage: Causes of rigor mortis, precautions to control rancidity, microbial spoilage. Nutritive value of fish, biochemistry of fish flesh of Indian major carps. Storage, transportation and marketing.

UNIT IV

Capture and Ornamental Fishery: Rivers, Lakes, Dams / Reservoir fishery- Problems and perspectives in Capture fisheries. Estuarine fishery. Characteristics and species dynamics. Marine fishery: Coastal, Off shore and deep sea fishery. Exclusive Economic Zone. (Hilsa, Oil sardine, mackerel, Bombay duck, Sole, Ribbon, Shark and Rays). Recreational fishery and Cooperative movements. Fish Farmers Development Agencies (FFDA). Climate change and fishery. Major, Marine and freshwater ornamental fishes, their food & breeding needs. Health management of ornamental fishes. Specific diseases and their cure. Setting and maintenance of aquaria.

Recommended Books

1. Singh & Lakra: Cold Water Aquaculture and Fisheries, Narendra Publication House, 2000.
2. S.K. Gupta, P.C. Gupta: General and Applied Ichthyology, S. Chand & Comp., 2006.
3. Vadapalli Satyanarayana: Fish Culture, Narendra Publ. House, 2002.
4. R.K. Rath: Freshwater Aquaculture, 2nd ed., Scientific Publishers, 2000.
5. Singh & Mittal: Dictionary of Aquaculture, Daya Publishing House, 1963.
6. Tor G. Heggberget: The Role of Aquaculture in World Fisheries, Oxford Univ. Press,1996.
7. Jhingran: Fish and Fisheries of India.
8. Thomas P.C., Rath, S.C. and Mohapatra, Kanta Das. Breeding and Seed Production of Fin Fish and Shell Fish.

M.Sc. Zoology 4th Semester
Paper E04b : Applied Entomology

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT I

Insects in relation to man: sericulture, apiculture and lac culture and its parasites, predators and diseases. Insect of veterinary importance; sand fly, horse fly, sucking louse, fleas.

UNIT II

Brief knowledge of important household, vegetable, store grain and fruit pests with special reference to distribution, habits, habitat, nature of damage, life history and control. Cut worm (*Agrotis ipsilon*) Cabbage cateripillar (*Pieris brassicae*) Rice weevil (*Sitophilus oryzae*) Mustard aphid (*Lipaphis erysimi*) Red cotton bug (*Dysdercus cingulatus*) Woolly apply aphid (*Eriosoma lanigerum*) Termite: important termites of Fam. Termatidae (*Odontotermis sp*.)

UNIT III

Origin of pests, Insect pest control; mechanical, physical, culture, biological. Fenetical control: chemosterilants, radiation.

UNIT IV

Integrated Pest Management (IPM), Role of pheromones and hormones in insect pest management. Legislative control of insect pests and quarantine law. Nomenclature and classification of insecticides on the basis of mode of action, chemical nature. Environmental factors influencing effectiveness of insecticides, persistence, biodegradability, hazards of insecticides, precaution and antidodes.

Recommended Books:

1. Ananthakrishnan TR: Applied Entomology
2. Atwal: Agricultural Pests of India and South East Asia (1986, Kalyani Publishers)
3. Fernald HT, HH Shepard: Applied Entomology, McGraw-Hill, 1955 .
4. Hill: Pest of stored foodstuffs and their control (2002, Springer)
5. McGavin: Essential Entomology (2001, Oxford Univ Press)
6. Metcal & Flint: Destruction and useful Insects, Tata McGraw-Hill, 1979.
7. Mullen and Durden: Medical and Veterinary Entomology (2002, Academic Press)
8. Pruthi HS: Text Book on Agricultural Entomology, ICAR Publication, 1969.
9. Srivastava: A text book of applied entomology, Vol I & II (1993, Kalyani Publishers)

M.Sc. Zoology 4th Semester

Paper E04c : Applied Environmental Biology

No. of Lectures /week
(3 lectures of 60 minutes each)

UNIT II

Air: Air pollutants (chemistry, sources & control); Air Quality standards, carbon credits, carbon footprint, Thermal pollution sources and effect. Water: Biochemical aspects of water pollutants (domestic, industrial & agricultural waste). Waste water treatment (Aerobic & anaerobic treatment processes); Water quality standards. Case study-Ganga Action Plan. Noise Pollution: Effects of noise and its control.

UNIT II

Radioactive fallouts its effects & safe disposal. Solid waste management: Sources & control methods (composting, Vermi Culture, Biogas). Hazardous waste & their management. Bioremediation (herbicides, pesticides, hydrocarbons, oil spills). Ecological Restoration: wasteland & its reclamation & restoration.

UNIT III

Environmental Impact Assessment (EIA): Case study of River valley projects & Mining. Bioassay: Dose-response relationships; Frequency; Response & cumulative response; statistical concepts (LD50-potency v/s Toxicity). Concept of hyper & hypo sensitivity factors affecting Toxicity.

UNIT IV

Ecological experimentation & models: Theories & hypothesis; experimentation; Inductive & deductive methods.Models: Analytical & simulation models; Validation & verification. Biological pest control: Use of predators; Parasites, parasitoids & pathogenes; Integrated Pest Management.

M.Sc. Previous (Zoology) 1ST Semester
Lab Course LC01

Non Chordate (Invertebrate)

1. Study of museum specimens/slides (WM/TS/LS) of: Protozoa to Echinodermata
2. Collection, fixation and permanent stained preparation of rectal ciliates and Helminthes

Cell biology

1. Study of meiosis in grasshopper testes by squashing method
2. Temporary squash preparation of polytene chromosomes from salivary glands of *Drosophila* larvae
3. Study of colchicinised metaphase chromosomes in bone marrow of rodent by air dry method
4. Study of permanent slides for the following
   a. Dicentric bridge in the anaphase 1 chromosomes of grasshopper
   b. Inversion in polytene chromosomes
   c. Lampbrush chromosomes of *Triturus* oocyte
   d. G-banded and C-banded metaphase chromosomes
   e. Chromatid exchanges and chromosomal anomalies
   f. Sister chromatid exchanges
   g. Premature chromosome condensation

Genetics

1. Handling of *Drosophila* and study of its life cycle
2. Examination of wild type (males and females) and mutants of *Drosophila*
3. Sex linked inheritance in *Drosophila melanogaster*
4. Linkage and crossing over in *Drosophila melanogaster*

Developmental Biology

1. Collection of frog spawns and observation of different developmental stages
2. Study of embryonic developmental stages in frog through models
3. Study of spiral cleavage in eggs of snail
4. Study of embryonic development in chick through slides
5. Window preparation to study chick embryo development
6. Whole mount preparation of chick embryos at various stages of development

Distribution of marks: Duration 5 hrs.

1.	Spotting (10) (Protozoa to Echinodermata)	20
2.	Exercise on Cell biology	10
3.	Exercise on Genetics	10
4.	Exercise on Developmental Biology	10
5.	Permanent slide making (2)	10
6.	Record and collection	10
7.	Viva Voice	10
8.	Sessional Marks	20
	Total	**100**

M.Sc. Previous (Zoology) 2nd Semester
Lab Course LC02

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Microbiology

1. Sterilization techniques, media preparation and agar plate preparation
2. Measurement of growth curve of *E.coli*., calculation of its generation time and viable cell counting
3. Induction of β-galactosidase in *E.coli*

Parasitology:

Study of permanent slides of parasitic protozoans, helminthes and insects

Physiology

1. Estimation of total leucocyte and erythrocyte number per cubic mm.
2. Differential count of leucocytes
3. Determination of clotting time
4. Determination of heamoglobin percentage
5. Preparation of haematin crystals
6. Blood group test
7. Determination of respiratory rate of fish
8. Action of amylase, pepsin and lipase on their respective substrates

Immunology

1. Separation of macrophages from mice and their identification on the basis of non specific esterase staining
2. Immunization of rabbit and collection of antisera
3. Demonstration of antigen-antibody reaction by immunodiffusion
4. Demonstration of direct ELISA
5. Demonstration of western blotting

Molecular Biology and Biotechnology

Demonstration of DNA amplification by polymerase chain reaction and Southern hybridization

Distribution of marks: Duration 5 hrs.

1. Spotting (10) Parasitology	20
2. Exercise on Physiology	10
3. Exercise on Immunology	10
4. Exercise on Microbiology/Biotechnology	10
5. Permanent slide making (2) Parasites	10
6. Record and collection	10
7. Viva Voice	10
8. Sessional Marks	20
Total	**100**

M.Sc. Final (Zoology) 3rd Semester
Lab course LC03

Study of museum specimens of: Protochordates; Cyclostomes; Fishes; Amphibia; Reptiles; Birds; Mammals

Prepration of Permanent slides:

Ecology

1. Determination of standing crop energy status in a grassland area and construction of number'and 'biomass (wet weight) pyramids
2. Study of biotic components of a terrestrial ecosystem and description of themorphological adaptations of the collected organisms
3. Study of biotic components of a pond ecosystem and description of morphological adaptations of the collected organisms
4. Estimation of autotrophs in a terrestrial ecosystem
5. Frequency of different species
6. Abundance of species in the community
7. Density of different species in the community by quadrat method
8. Estimation of heterotrophs in a terrestrial ecosystem
9. Determination of texture, pH, carbonate, nitrate and base deficiency in different soil samples
10. Measurement of chlorophyll content per unit area of a grass field
11. Estimation of grasshopper population density of an area by capture-recapture Method
12. Measurement of oxygen change and productivity differences in a pond ecosystem by Wrinkler's method

Biological tools

1. Study of different components of student's microscope and its assembly
2. Study of different components of stereobinocular microscope and its assembly
3. Study of different parts of binocular research microscope
4. Measurement of microscopic object using ocular and stage micrometers
5. Setting up of darkfield and phase contrast microscope
6. Demonstration of working of fluorescence, confocal and electron microscopes

Distribution of marks: Duration 5 hrs.

1. Spotting (10) (Protochordate to Mammal; Histology; Osteology)	20
2. Exercise on Ecology	10
3. Exercise on Biological tools	10
4. Microtomy of fish/Insect tissue or	15
5. Comment upon dissected Chordates	05
6. Record and collection	10
7. Viva Voice	10
8. Sessional Marks	20
Total	**100**

M.Sc. Final (Zoology) 4th Semester
Lab Course LC 04

Animal Behaviour

1. Study of habitat selection in spiders or larvae of *Drosophila melanogaster* or woodlice
2. Study of learning behaviour in mice by using a zigzag or T-shaped maze
3. Study of wall-seeking behaviour in mice
4. A field study of foraging or trail making behaviour in a seed harvester or predatory ant species
5. Study of nest building behavior in birds

Endocrinology

1. Study of histological slides of TS/ LS of major endocrine glands of frog and mammal
2. Comment upon the photographs of patients suffering from various endocrine disorders

Biochemistry

1. Preparation of buffer and measurement of pH using pH meter
2. Demonstration of separation of subcellular organelles by differential centrifugation
3. Verification of Beer's law and preparation of absorption spectrum of riboflavin
4. Demonstration of separation of protein by native and SDS-polyacrylamide gel Electrophoresis
5. Separation of amino acids by paper chromatography
6. Studies on quantitation of proteins by various methods : Biuret, Lowry, Bradford, and UV spectrophotometry

Fish biology/ Entomology/

1. Study of external morphology and internal anatomy of common fishes/insects.
2. Taxonomic identification of locally available common fishes/insects.
3. Dissection of accessory respiratory organs and webarian ossicle of locally available food fishes
4. Permanent preparation of material/tissues from common fishes/insects
5. Study of histological slides of different organ systems of fishes/insects
6. Determination of Age in Fishes by Scale, otolith and vertebrae methods.
7. Estimation of fecundity, Measurement of egg size(Fish/insect) by micrometry

Environmental biology

(Exercise on environmental biology based on theory paper E03c and E04c)
Water quality analysis: Measurement of dissolved oxygen, free carbon dioxide, pH, turbidity, hardness, alkalinity, BOD, COD, dissolved nutrients (Nitrates, phosphates, sodium, potassium, chloride, etc.), Sampling of terrestrial flora and fauna by quadrate method and their population study. Sampling and study of aquatic fauna and flora (plankton, periphyton, micro and macroinvertebrates, nekton, etc.).Measurement of soil pH, water holding capacity, organic matter, soil nutrients (nitrate, nitrite, calcium and magnesium),

Distribution of marks: Duration 5 hrs.

1.	Spotting (10)	20
2.	Exercise on Anatomy (Fish/Insect)/ or /Exercise on environmental biology based on theory paper 15c	10
3.	Exercise on Identification (Fish/Insect) or Exercise on environmental biology based on theory paper 16c	10
4.	Exercise on Endocrinology	10
5.	Exercise on Biochemistry/Animal behaviour	10
6.	Record and collection	10
7.	Viva Voice	10
8.	Sessional Marks	20
	Total	**100**