C.S.J.M. UNIVERSITY KANPUR

M.Sc. (Previous)

CHEMISTRY

There shall be five written Papers and a Practical Examination as follows-

		Max. Marks
Paper -I	Inorganic Chemistry	120
Paper -II	Organic Chemistry	120
Paper -III	Physical Chemistry	120
Paper -IV	Group Theory and Spectroscopy	100
Paper -V (a)	Mathematics for Chemists (for Biology Students)	
	OR	30
	Biology for Chemists (for Mathematics Students)	
(b)	Computers for Chemists	60
	Total Theory	**550**
	Practical	200

Candidates will be required to pass in Theory and Practical separately.

Paper - I

Inorganic Chemistry

I Stereochemistry and Bonding in Main Group Compounds

VSEPR, Walsh diagrams (tri- and penta- atomic molecules), $d_\pi - p_\pi$ bonds, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules

II Metal-Ligand Equilibria in Solution

Stepwise and overall formation constants and their interaction, 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.

III Reaction Mechanism of Transition Metal complexes

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affection, acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand, bond cleavage. Substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reaction. Redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, outersphere type reactions, cross reactions and Marcus-Hush theory , inner sphere type reactions.

IV Metal-*Ligand Bonding*

Limitation of crystal field theory, molecular orbital theory, octahedral, tetrahedral and square planar complexes, π-bonding and molecular orbital theory.

V Electronic Spectra and 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, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

VI Metal π-Complexes

Metal carbonyls, structure and bonding , vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding , structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes; tertiary phosphine as ligand.

VII Metal Clusters

Higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyl and halide clusters, compounds with metal-metal multiple bonds.

VIII Isopoly and Heteropoly Acids and Salts

Books Suggested

1. Advanced Inorganic Chemistry, F.A.Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E.Huhey, Harper & Row.
3. Chemistry of the Elements, N.N.Greenwood and A.Earnshow, Pergamon.
4. Inorganic Electronic Spectroscopy, A.B.P.Lever, Elsevier.
5. Magnetochemistry, R.L.Carlin, Springer Verlag.
6. Comprehensive Coordination Chemistry Eds., G.Wilkinson, R.D. Gillars and J.A.McCleverty, Pergamon.

Paper - II
Organic Chemistry

1 Nature of Bonding in Organic Molecules

Delocalized chemical bonding-conjugation, cross conjugation, resonance, hyperconjugation, bonding in fullerenes, tautomerism.

Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, energy level of π- molecular orbitals, annulenes, antiaromaticity, σ- aromaticity, homo-aromaticity, PMO approach.

Bonds weaker than covalent- addition compounds, crown ether complexes and cryptands, inclusion compounds , cyclodextrins, catenanes and rotaxanes.

II Stereochemistry

Conformational analysis of cycloalkanes, decalins effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding.

Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape.

Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

III 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. Hard and soft acids and bases.

Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes.

Effect of structure on reactivity- Resonance and field effects, steric effect, quantitative treatment. The Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation.

IV Aliphatic Nucleophilic Substitution

The S_N2, SN_1, mixed SN_1 and SN_2 and SET mechanisms.

The neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbonyl system, common carbocation rearrangements. Application of NMR spectroscopy in the detection of carbocations.

The SN_1 mechanism.

Nucleophilic substitution at an 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.

V Aliphatic Electrophilic Substitution

Bimolecular mechanisms- SE_2 and SE_i. The SE1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

VI Aromatic Electrophilic Substitution

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

VII Aromatic Nucleophilic Substitution

The $SNAr$, SN_1, benzyne and SRN_1 mechanisms. Reactivity- effect of substrate structure, leaving group and attacking nucleophile. The Von Richter, Sommelet-Hauser, and smiles rearrangements.

VIII Free Radical Reactions

Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity of 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.

IX Addition to Carbon-Carbon Multiple Bonds

Mechanistic 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.

X Addition to Carbon-Hetero Multiple Bonds

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids , esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction.

Mechanism of condensation reactions involving enolates - Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.

Hydrolysis of esters and amides, ammonolysis of esters.

XI Elimination Reactions

The E_2, E_1 and E_1 cB 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.

XII 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 disrotatory motions, 4n, 4n+2 and allyl systems. Cycloadditions-antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3, dipolar cycloadditions and chelotropic reactions.

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

Book Suggested

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A.Carey and R.J.Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K.Ingold, Cornell University Press.
5. Organic Chemistry, R.T.Morrison and R.N.Boyd, Prentice-Hall.
6. Modern Organic Reactions, H.O House, Benjamin.
7. Principles of Organic Synthesis, R.O.C.Norman, and J.M.Coxon, Blackie Academic & Professional.
8. Pericyclic Reactions, S.M.Mukherji, Macmillan, India.
9. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P.Singh,Macmillan.

10. Stereochemistry of Organic Compounds, *D.Nasipuri*, New Age International.

11. Stereochemistry of Organic Compounds, P.S.Kalsi, New Age International.

PAPER - III

Physical Chemistry

I Quantum Chemistry

A Introduction to Exact Quantum Mechanical Results

The Schrodinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz., particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom.

B Approximate Methods

The variation theorem, linear variation principle. Perturbation theory (first order and non degenerate). Applications of variation method and perturbation theory to the Helium atom.

C Angular Momentum

Ordinary angular momentum, generalized angular momentum, eigenfunctions for angular momentum, eigenvalues of angular momentum, operator using ladder operators, addition of angular momenta, spin, antisymmetry and Pauli exclusion principle.

D Electronic Structure of Atoms

Electronic configuration, Russell-Saunders terms and coupling schemes, Slater-Codon parameters, term separation energies of the p^n configuration, term separation energies for the d^n configurations, magnetic effects: spin-orbit coupling and Zeeman splitting, introduction to the methods of *self-consistent field*, the virial theorem.

E Molecular Orbital Theory

Huckel theory of conjugated systems, bond order and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc. Introduction to extended Huckel theory.

II Thermodynamics

A Classical Thermodynamics

Brief resume of concepts of laws of thermodynamics, free energy, chemical potential and entropies. Partial molar properties; partial molar free energy, partial molar volume and partial molar heat content and their significances. Determinations of these quantities.

Concept of fugacity and determination of fugacity.

Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient, Debye-Huckel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients; ionic strength.

Application of phase rule to three component systems; second order phase transitions.

B Statistical Thermodynamics

Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical , grand canonical and microcanonical ensembles, corresponding distribution laws(using Lagrange's method of undetermined multipliers)

Partition functions- translational, rotational, vibrational and electronic partition functions, Calculation of thermodynamic properties in terms of partition functions. Applications of partition functions.

Heat capacity behaviour of solids- chemical equilibrium and equilibrium constant in terms of partition functions.

Fermi-Dirac statistics, distribution law and applications of metal Bose-Einstein statistics- distribution law and application to helium.

C **Non Equilibrium Thermodynamics**

Thermodynamics 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 stationary states, phenomenological equations, microscopic reversibility and Onsager's reciprocity relations, electrokinetic phenomena, diffusion, electric conduction, irreversible thermodynamics for biological systems, coupled reactions.

III **Chemical Dynamics**

Method of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory. Arrhenius equation and the activated complex theory, ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions.

Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-chlorine reactions) and oscillatory reactions (Belousov-Zhabotinsky reaction), homogeneous catalysis, kinetics of enzyme reactions, general features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method. Dynamics of molecular motions, probing the transition state, dynamics of barrierless chemical reactions in solution, dynamics of unimolecular reactions(Lindemann-Hinshelwood and Rice-Ramsperger -Kassel-Marcus [RRKM] theories of unimolecular reactions).

IV **Surface Chemistry**

A **Adsorption**

Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electro-kinetic phenomenon), catalytic activity at surfaces.

B **Micelles**

Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization - phase separation and mass action models, solubilization, micro emulsion, reverse micelles.

C **Macromolecules**

Polymer- definition, types of polymers, electrically conducting, fire resistant, liquid crystal polymers, kinetics of polymerization, mechanism of polymerization.

Molecular mass, number and mass average molecular mass, molecular mass determination (osmometry, viscometry, diffusion and light scattering methods), sedimentation, chain configuration of macromolecules, calculation of average dimensions of various chain structures.

V **Electrochemistry**

Electrochemistry of solutions. Debye-Huckel - Onsager treatment and its extension, ion solvent interactions. Debye-Huckel-Jerum mode. Thermodynamics of electrified interface equations. Derivation of electro-capillarity, Lippmann equations (surface excess), methods of determination, structure of electrified

interfaces. Guoy -Chapman, stern, Graham - Devanathan-Mottwatts, Tobin, Bockris, Devanathan models.

Over potentials, exchange current density, derivation of Butler - Volmer equation, Tafel plot.

Quantum aspects of charge transfer at electrodes-solution interfaces, quantization of charge transfer, tunneling.

Semiconductor interfaces - theory of double layer at semiconductor, electrolyte solution interfaces, structure of double layer interfaces. Effect of light at semiconductor solution interface.

electrocatalysis - influence of various parameters. Hydrogen electrode.

Bioelectrochemistry, threshold membrane phenomena, Nernst-Planck equation, Hodges - Huxley equations, core conductor models, electrocardiography.

Polarography theory, Ilkovic equation; half wave potential and its significance.

Introduction to corrosion, homogenous theory, forms of corrosion, corrosion monitoring and prevention methods.

Book 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.

4 Coulson's Valence, R McWeeny, ELBS.

5 Chemical Kinetics, K.J.Laidler, McGraw-Hill.

6 Kinetics and Mechanism of Chemical Transformations, J.Rajaraman and J.Kuriacose, McMillan.

7 Micelles, Theoretical and Applied Aspects, V.Moroi, Plenum.

8 Modern Electrochemistry Vol. I and Vol. II, J.O.M. Bockris and A.K.N.Reddy, Plenum.

9 Introduction to Polymer Science, V.R.Gowarikar, N.V. Vishwanathan and J. Sridhar, Wiley Eastern.

PAPER - IV

Group Theory, Spectroscopy and Diffraction Methods

I Symmetry and Group Theory in Chemistry

Symmetry elements and symmetry operation , definitions of group, subgroup, relation between orders of a finite group and its subgroup. Conjugacy relation and classes. Point symmetry group. Schonflies symbols, representations of groups of matrices (representation for the C_n, C_{nv}, C_{nh}, D_{nh} etc. groups to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use; spectroscopy.

II Unifying Principles

Electromagnetic radiation, interaction of electromagnetic radiation with matter-absorption, emission, transmission, reflection, refraction, dispersion, polarisation and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, results of the time dependent perturbation theory, transition moment, selection rules, intensity of spectral lines, Born-Oppenheimer approximation, rotational, vibrational and electronic energy levels.

III Microwave Spectroscopy

Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor. Stark effect, nuclear and electron spin interaction and effect of external field. Applications.

IV Vibrational Spectroscopy

A Infrared Spectroscopy

Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strengths; anharmonicity. Morse potential energy diagram, vibration-rotation spectroscopy, P,Q,R branches. Breakdown of Oppenheimer approximation; vibrations of polyatomic molecules. Selection rules, normal modes of vibration , group frequencies, overtones, hot bands, factors affecting the band positions and intensities, far IR region, metal-ligand vibrations, normal co-ordinate analysis.

B Raman Spectroscopy

Classical and quantum theories of Raman effect. Pure rotational , vibrational and vibrational-rotational, Raman spectra, selection rules, mutual exclusion principle. Resonance Raman spectroscopy, coherent anti Stokes Raman spectroscopy (CARS).

V Electronic Spectroscopy

A Atomic Spectroscopy

Energies in atomic orbitals, vector, representation of momenta and vector coupling, spectra of hydrogen atom and alkali metal atoms.

B Molecular Spectroscopy

Energy levels, molecular orbitals, vibranic transitions, vibrational progressions and geometry of the excited states. Franck-Condon Principle, electronic spectra of polyatomic molecules. Emission spectra; radiative and non-radiative decay, internal conversion, spectra of transition metal complexes, charge-transfer spectra.

C Photoelectron Spectroscopy

Basic principles, photo-electric effect, ionization process, Koopman's theorem. Photoelectron spectra of simple

molecules, ESCA, chemical information from ESCA.

Auger electron spectroscopy- basic idea.

VI Magnetic Resonance Spectroscopy

A Nuclear Magnetic Resonance Spectroscopy

Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors influencing chemical shift, deshielding , spin spin interactions, factors influencing coupling constant 'J'. Classification (ABX, AMX, ABC, A_2 B_2 etc.), spin decoupling, basic ideas about instrument, NMR studies of nuclei other than proton - ^{13}C, ^{19}F and ^{31}P, FT NMR, advantages of FT NMR, use of NMR in medical diagnostics.

B Electron Spin Resonance Spectroscopy

Basic principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value, Isotropic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities and McConnell relationship, measurement techniques, applications.

C Nuclear Quadruple Resonance Spectroscopy

Quadrupole nuclei, quadrupole moments, electric field gradient, coupling constant, splittings, Applications.

VII Photoacoustic Spectroscopy

Basic principles of photoacoustic spectroscopy (PAS), PAS-gases and condensed systems, chemical and surface applications.

VIII X-ray Diffraction

Bragg condition, 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.

IX Electron Diffraction

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

X Neutron Diffraction

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

Books Suggested

1 Modern Spectroscopy, J.M Hollas, John Wiley

2 Applied Electron Spectroscopy For Chemical Analysis Ed.H.Windawi and F.L.Ho, Wiley Interscience.

3 NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V.Parish, Ellis Harwood.

4 Physical Methods in Chemistry, R.S.Drago, Saunders College.

5 Chemical Applications of Group Theory, F.A.Cotton.

6 Introduction to Molecular Spectroscopy, G.M.Barrow, Megraw Hill.

7 Basic Principles of Spectroscopy, R.Chang, McGraw Hill

8 Theory And Applications of UV Spectroscopy, H.H.Jaffe and M.Orchin, IBH-Oxford.

9 Introduction of Photoelectron Spectroscopy, P.K. Ghosh, John Wiley.

10 Introduction of Magnetic Resonance, A.Carrington and A.D Maclachalan, Harper & Row

PAPER - V

(a) Mathematics for Chemists)

(For students without Mathematics in B.Sc.)

Note: This paper should be taught before teaching papers III and IV

I Vectors and Matrix Algebra

A Vectors

Vectors, dot, cross and triple products etc. The gradient, divergence and curl. Vector calculus, Gauss's theorem, divergence theorem etc.

B Matrix Algebra

Addition and multiplication; inverse, adjoint and transpose of matrices, special matrices (Symmetric, skew-symmetric, Hermitian, skew-Hermitian, unit, diagonal, unitary etc.) and their properties. Matrix equations: Homogeneous, non-homogeneous linear equations and conditions for the solution, linear dependence and independence.

Introduction to vector spaces, matrix eigenvalues and eigenvectors, diagonalization, determinants (examples from Huckel theory).

Introduction to tensors; polarizability and magnetic susceptibility as examples.

II Differential Calculus

Functions, continuity and differentiability, rules for differentiation, applications of differential calculus including maxima and minima (examples related to maximally populated rotational energy levels, Bohr's radius and most probable velocity from Maxwell's distribution etc.), exact and inexact differentials with their applications to thermodynamic properties

integral calculus, basic rules for integration, integration by parts, partial fraction and substitution. Reduction formulae, applications of integral calculus.

functions of several variables, partial differentiation, co-ordinate transformations e.g. cartesian to spherical polar), curve sketching.

III Elementary Differential Equations

Variables-separable and exact first-order differential equations, homogeneous, exact and linear equations. Applications to chemical kinetics, secular equilibria, quantum chemistry etc. Solutions of differential equations by the power series method, Fourier series, solutions of harmonic oscillator and Legendre equation etc., spherical harmonics, second order differential equations and their solutions.

IV Permutation and Probability

Permutation and combinations, probability and probability theorems, probability curves, average, root mean square and most probable errors, examples from the kinetic theory of gases etc., curve fitting (including least squares fit etc.) with a general polynomial fit.

Book Suggested

1 The Chemistry Mathematics Book, E.Steiner, Oxford University Press.

2 Mathematics for Chemistry, Doggett and Sucliffe, Longman.

3 Mathematical Preparation for Physical Chemistry, F.Daniels, McGraw Hill

4 Chemical Mathematics D.M.Hirst, Longman.

5 Applied Mathematics for Physical Chemistry, J.R.Barrante, Prentice Hall

6 Basic Mathematics for Chemists, Tebbutt,Wiley.

PAPER - V

(a) Biology for Chemists

(For students without Biology in B.Sc.)

I Cell Structure and Functions

Structure of prokaryotic and eukaryotic cells, intracellular organelles and their functions, comparison of plant and animal cells. Overview of metabolic processes - catabolism and anabolism, ATP- the biological energy currency. Origin of life - unique properties of carbon, chemical evolution and rise of living systems. Introduction to biomolecules, building blocks of bio-macromolecules.

II Carbohydrates

Conformation of monosaccharides, structure and functions of important derivatives of monosaccharides like glycosides, deoxy sugar, myoinositol, amino sugars. N-acetylmuramic acid, sialic acid, disaccharides and polysaccharides. Structural polysaccharides- cellulose and chitin. Storage polysaccharides - starch and glycogen. Structure and biological functions of glucoseminoglycans or mucopolysaccharides. Carbohydrates of glycoproteins and glycolipids. Role of sugars in biological recognition. blood group substances. Ascorbic acid.

Carbohydrate metabolism- Kreb's cycle, glycolysis, glycogenesis and glycogenolysis, gluconeogenesis, pentose phosphate pathway.

III Lipids

Fatty acids, essential fatty acids, structure and function of triacylglycerols, glycerophospholipids, sphingolipids, cholesterol, bile acids, prostaglandins, Lipoproteins - composition and function ,role in atherosclerosis.

Properties of lipid aggregates - micelles, bilayers, liposomes and their possible biological functions,

Biological membranes. Fluid mosaic model of membrane structure

Lipid metabolism β- oxidation of fatty acids.

IV Amino-acids, Peptides and Proteins

Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing. Secondary structure of proteins, forces responsible for holding of secondary structures. α- helix, β- sheets, super secondary structure, triple helix structure of collagen, Tertiary structure of protein folding and domain structure. Quaternary structure

Amino acid metabolism- degradation and biosynthesis of amino acids, sequence determination: chemical/enzymatic/mass spectral, resemization/detection. Chemistry of oxytocin and tryptophan releasing hormone (TRH).

V Nucleic Acids

Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding. Structure of ribonucleic acids (RNA) and deoxyribonucleic acids (DNA), double helix model of DNA and forces responsible for holding it. Chemical and enzymatic hydrolysis of nucleic acids. The chemical basis for heredity, an overview of replication of DNA, transcription, translation and genetic code. Chemical synthesis of mono and trinucleoside.

Book Suggested

1 Principal of Biochemistry, A.L.Lehninger, Worth Publishers.

2 Biochemistry, L.Stryer, W.H.Freeman

3 Biochemistry, J.David Rawn, Neil Patterson.

4 Biochemistry, Voet And Voet, John Wiley

5 Outlines of Biochemistry, E.E.Conn and P.K.Stumpf, John Wiley.

PAPER - V

(b)Computer for Chemists

This is a theory -cum- laboratory course with more emphasis on Laboratory work.

i Introduction to computers and computing

Basic Structure and functioning of computers with a PC as an illustrative example. Memory, I/O devices. Secondary storage. Computer languages. Operating systems with DOS as an example. Introduction to UNIX and WINDOWS. Data Processing, principle of programming. Algorithms and flow-charts.

II Computer Programming in FORTRAN/C/BASIC

(The language features are listed here with reference to FORTRAN the instructor may choose another language such as BASIC or C and the features may be replaced appropriately). Elements of the computer language. Constants and variables. Operations and symbols. Expressions, Arithmatic assignment statement, Input and Output, Format statement. Termination statements, Branching statements such as IF or GO TO statement, LOGICAL variables, Double precision variables, Subscripted variables and DIMENSION, DO statement, FUNCTION and SUBROUTINE, COMMON and DATA statements. (Students learn the programming logic and these language features by 'hands on' experience on a personal computer from the very beginning of this topic).

III Programming in Chemistry

Development of small computer codes involving simple formulae in chemistry, such as vander Waals equation, pH titration, kinetics, radioactive decay. Evaluation of lattice energy and ionic radii from experimental data. Linear simultaneous equations to solve secular equations within

the Huckle theory. Elementary structural features such as bond lengths, bond angles, dihedral angles etc. of molecules extracted from a database such as Cambridge data base.

IV Use of Computer Programes

The students will learn how to operate a PC and how to run standard programmes and packages. Execution of linear regression, X-Y plot, numerical integration and differentiation as well as differential equation solution programmes. Monte Carlo and Molecular dynamics. Programmes with data preferably from physical chemistry laboratory. Further, the students will operate one or two of the packages such as MATLAB, EASYPLOT, LOTUS, FOXPRO and Word Processing software such as WORDSTAR, MS-WORD.

Book Suggested

1. Computers and Common Sense, R.Hunt and J.Shelley, Prentice Hall.
2. Computational Chemistry, A.C.Norris.
3. Microcomputer Quantum Mechanics, J.P.Killingbeck, Adam Hilger.
4. Computer Programming In FORTRAN IV,V. Rajaraman, Prentice Hall.
5. An Introduction to Digital Computer Design, V.Rajaraman and T.Radhakrishnan, Prentice Hall.

PRACTICAL

The duration of Practical Examination will be of Twelve Hours and will comprise two exercises (one quantitative containing gravimetric and volumetric both and one qualitative Preparation) from Inorganic practicals, two exercises(one qualitative/ quantitative and one single step synthesis) from Organic Practicals, and one experiment from Physical.

The Distribution of marks will be as follows.

(a) Inorganic Exercise	
(i) Quantitative	45
(ii) Qualitative/ Preparation	30
(b) Organic Exercise	
(i) Qualitative/ Quantitative	30
(ii) Synthesis	10
(c) Physical Experiment	35
(d) Viva- voice	30
(e) Record	20

Note:- The number of candidates to be examined per Board should not exceed Twenty Five.

Inorganic Chemistry

Qualitative and Quantitative Analysis

(a) Less common metal ions- Tl, Mo, W, Ti, Zr, Th, Zr, V, U (Two metal ions in cationic/anionic forms).

(b) Insoluble- oxides, sulphates and halides.

(c) Separation and determination of two metal ions. Cu-Ni, Ni-Zn, Cu-Fe etc. involving volumetric and gravimetric methods.

Chromatography

Seperation of cations and anions by

(a) Paper Chromatography.

(b) Column chromatography- Ion exchange.

Preparations

Preparation of selected inorganic compounds and their studies by I.R., electronic spectra, Mossbauer, E.S.R. and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds.

(1) $VO(acac)_2$

(2) $TiO(C_9H_8NO)_2.2H_2O$

(3) cis - $K[Cr(C_2O_4)_2(H_2O)_2]$

(4) $Na[Cr(NH_3)_2(SCN)_4]$

(5) $Mn(acac)_3$

(6) $K_3[Fe(C_2O_4)_3]$

(7) Prussian Blue, Turnbull's Blue

(8) $Co(NH_3)_6][Co(NO_2)_6]$

(9) cis-$[Co(trien)(NO_2)_2]Cl.H_2O$

(10) $Hg[Co(SCN)_4]$

(11) $[Co(Py)_2Cl_2]$

(12) $[Ni(NH_3)_6]Cl_2$

(13) $Ni(dmg)_2$

(14) $[Cu(NH_3)_4]SO_4.H_2O$

Organic Chemistry

Qualitative Analysis

Separation, purification and identification of compounds of binary mixture (one liquid and one solid) using tlc and column chromatography, chemical tests. IR spectra to be used for functional group identification.

Organic Synthesis

Acetylation: Acetylation of cholesterol and separation of cholesteryl acetate by column chromatography.

Oxidation : Adipic acid by chromic acid oxidation of cyclohexanol.

Grignard reaction: Synthesis of triphenylmethanol from benzoic acid.

Aldol condensation: Dibenzal acetone from benzaldehyde.

Sandmeyer reaction: p-Chlorotoluene from p-toluidine.

Acetoacetic ester Condensation: Synthesis of ethyl-n-butylacetoacetate by A.E.E.condensation.

Cannizzaro reaction: 4-chlorobenzaldehyde as substrate.

Friedel Crafts Reaction : -Benzoyl propionic acid from succinic anhydride and benzene.

Aromatic electrophilic substitutions: Synthesis of p-nitroaniline and p-bromoaniline.

The Products may be Characterized by Spectral Techniques

Quantitative Analysis

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

Physical Chemistry

Number of hours for each experiment: 3-4 hours.

A list of experiments under different headings is given below. Typical experiments are to be selected from each type. Students are required to perform at least 30 experiments.

Error Analysis and Statistical Data Analysis

Errors, types of error, minimization of errors, error distribution curves, precision, accuracy and combination; statistical treatment for error analysis, student 't' test, null hypothesis, rejection criteria, F & Q test; linear regression analysis, curve fitting

Calibration of volumetric apparatus, burette, pipette and standard flask

Adsorption

To study surface tension- concentration relationship for solutions (Gibbs equation).

Phase Equilibria

(i) Determination of congruent composition and temperature of a binary system (e.g. diphenylamine- benzophenone system).

(ii) Determination of glass transition temperature of a given salt (e.g., $CaCl_2$) conductometrically.

(iii) To construct the phase diagram for three component system (e.g., chloroform- acetic acid-water).

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/ionic reaction in micellar media.

(iii) Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide studying the kinetics as an iodine clock 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 oxidised by persulphate ion)

(vi) Oscillatory reaction.

Solutions

(i) Determination of molecular weight of non- volatile and non-electrolyte/electrolyte by cryoscopic method and to determine the activity coefficient of an electrolyte.

(ii) Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.

Electrochemistry

A. 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 acid in a given mixture conductometrically.

(iv) To study the effect of solvent on the conductance of $AgNO_3$/acetic acid 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.

B. Potentiometry/pH metry

(i) Determination of strength of halides in a mixture 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.

Determination of the formation constant of silver-ammonia complex and stoichiometry 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 dissociaton constant of acetic acid in DMSO, DMF, acetone and dioxane by tritrating it with KOH.

(ix) Determination of the dissociation constant of monobasic/dibasic acid by Albert, Serjeant method.

(x) Determination of thermodynamic constants. ΔG, ΔS and ΔH for the reaction by e.m.f. method.

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + 2H$$

Polarimetry

(i) Determination of rate constant for hydrolysis/inversion of sugar using a polarimeter.

(ii) Enzyme kinetics- inversion of sucrose.

Books Suggested

1. Vogel'Es Textbook of Quantitative Analysis, revised. J. Bassett, R. C. Denney, G.H. Jeffery and J. Mendham, ELBS.

2 Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.

3 Experiments and Techniques in Organic Chemistry, D Pasto, C. Johnson and M. Miller, Prentice Hall

4. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath.

5. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.

6 Handbook of Organic Analysis- Qualitative and Quantitative H. Clark, Adward Arnold.

7 Vogel's Textbook of Practical Organic Chemistry, A.R Tatchell, John Wiley

8 Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.

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

10 Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill.

M.Sc (FINAL)

There shall be seven written papers (three compulsory and four elective) and a practical examination as follows-

(a) Compulsory Papers

		Max. Marks	
Paper -I	(a) Application of Spectroscopy	60	
	(b) Photochemistry	30	120
	(c) Solid State Chemistry	30	
Paper -II	(a) Bioinorganic Chemistry	33	
	(b) Bio- rganic Chemistry	33	100
	(c) Bio- Physical Chemistry	34	
Paper -III Environmental Chemistry			60

(b) Elective Paper

There shall be four elective papers of sixty marks Each Which are to be chosen by the students from sixtem elective papers given in the syllabus. 240

(c) Seminar Internal assesment 30

Total Theory Marks	550	198
Practical	200	72

Candidate will be required to pass in Theory and Practical separately

PAPER - I

(a) Applications of Spectroscopy

Inorganic Chemistry

I Vibrational Spectroscopy

Symmetry and shapes of AB_2, AB_4, AB_5 and AB_6, mode of bonding of ambidentate ligands, ethylenediamine and diketonato complexes, application of resonance Raman spectroscopy particularly for the study of active sites of metalloproteins.

II Electron Spin Resonance Spectroscopy

Hyperfine coupling spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, application to transition metal complexes (having one unpaired electron) including biological systems and to inorganic free radicals such as PH_3, F_2 and $[BH_3]^-$.

III Nuclear Magnetic Resonance of Paramagnetic Substances in Solution

The contact and pseudo contact shifts, factors affecting nuclear relaxation, some applications including biochemical systems, an overview of NMR of metal nuclides with emphasis on $^{195}P_t$ and $^{119}S_n$ NMR.

IV Mosshauer Spectroscopy

Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin, (2) Sn^{+2} and Sn^{+4} compounds - nature of M-L bond, coordination number, structure and (3) detection of oxidation state and inequivalent MB atoms

Organic Chemistry

I Ultraviolet and Visible Spectroscopy

Various electronic transitions (185-800 nm), Beer-Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds. Steric effect in biphenyls.

II Infrared Spectroscopy

Instrumentation and sample handling. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance. FT IR. IR of gaseous, solids and polymeric materials.

III Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD)

Definition, deduction of absolute configuration, octant rule for ketones.

IV Nuclear Magnetic Resonance Spectroscopy

General introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, mechanism of measurement, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), chemical exchange, effect of deuteration, complex spin-spin interaction between two, three,four and five nuclei (first

order spectra), virtual coupling. Stereochemistry, hindered rotation, Karplus curve variation of coupling constant with dihedral angle. Simplification of complex spectra-nuclear magnetic double resonance, contact shift reagents, solvent effects. Fourier transform technique, nuclear Overhauser effect (NOE). Resonance of other nuclei-F,P.

V Carbon-13 NMR Spectroscopy

General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants.

Two dimension NMR spectroscopy- COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques.

VI Mass Spectrometry

Introduction, ion production- EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metalstable peak, McLafferty rearrangement. Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

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. Cradock, ELBS
3. Infrared and Raman Spectra : Inorganic and Coordination Compounds, K.Nakamoto, Wiley.
4. Progress in Inorganic Chemistry vol. 8 ed., F.A. Cotton, vol., 15, ed. S.J. Lippard, Wiley.
5. Transition Metal Chemistry ed. R.L. Carlin vol. 3, Dekker
6. Inorganic Electronic Spectroscopy, A.P.B. Lever, Elsevier.

7. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Horwood

8. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.

9. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley

10. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley.

11. Application of Spectroscopy of Organic Compounds, J.R. Dyer, Prentice Hall.

12. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill.

PAPER - I

(b) Photochemistry

I Photochemical Reactions

Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.

II 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.

III Photochemistry of Alkenes

Intramolecular reactions of the olefinic bond- geometrical isomerism, cyclisation reactions, rearrangement of 1,4- and 1,5- dienes.

IV Photochemistry of carbonyl Compounds

Intramolecular reactions of carbonyl compounds saturated, cyclic and acyclic, β, γ- saturated and, α, β-unsaturated compounds. Cyclohexadienones.

Intermolecular cycloaddition reactions- dimerisations and oxetane formation.

V Photochemistry of Aromatic Compounds

Isomerisations, additions and substitutions.

VI Miscellaneous Photochemical Reactions

Photo-Fries reactions of amides. Photo-Fries rearrangement.

Barton reaction. Singlet molecular oxygen reactions. Photochemical formation of smog. Photodegradation of polymers. Photochemistry of vision.

Books Suggested

1. Fundamental of Photochemistry ,K.K.Rohtagi-Mukherji, Wiley-Eastern.

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.

PAPER - I

(c) Solid State Chemistry

I Solid State Reactions

General principle, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions.

II Crystal Defects and Non-stoichiometry

Prefect and imperfect crystals, intrinsic and extrinsic defects- point defects, line and plane defects, vacancies- Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centres, non stoichiometry and defects.

III Electronic Properties and Band Theory

Metals, insulators and semiconductors, electronic structure of solids- band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors.

Optical properties- Optical reflectance, photoconduction -photoelectric effects.

Magnetic Properties- Classification of materials, Quantum theory of paramagnetics- cooperative phenomena- magnetic domains, hysteresus.

IV Organic Solids

Electrically conducting solids, organic charge transfer complex, organic metals, new superconductors.

Books Suggested

1. Solid State Chemistry and its Applications, A.R.West, Plenum.
2. Principles of the Solid State, H.V.Keer, Wiley Eastern.
3. Solid State Chemistry, N.B.Hannay.
4. Solid State Chemistry, D.K.Chakrabarty, New Age International.

PAPER - II

(a) Bioinorganic Chemistry

I Metal Ions in Biological Systems

Essential and trace metals.

II Na^+/K^+ Pump

Role of metals ions in biological processes.

III Bioenergetics and ATP Cycle

DNA polymerisation, glucose storage, metal complexes in transmission of energy, chlorophylls, photosystem - I and photosystem - II in cleavage of water. Model systems.

IV 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.

V Electron Transfer in Biology

Structure and function of metalloproteins in electron transport processes - cytochromes and iron-sulphur proteins, synthetic models.

VI Nitrogenase

Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

Books Suggested

1. Principles of Bioinorganic Chemistry, S.J.Lippard and J.M.Berg, University Science Books.
2. Biomorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J. S. Valentine, University Science Books.
3. Inorganic Biochemistry Vols I and II ed. G.L. Eichhorn, Elsevier.
4. *Progress in Inorganic Chemistry, Vols 18* and 38 Ed. J.J.Lippard, Wiley.

PAPER - II

(b) Bioorganic Chemistry

I Introduction

Basic considerations, Proximity effects and molecular adaptation.

II 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.

III Mechanism of Enzyme Action

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.

IV Kinds of Reactions Catalysed by Enzymes

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 reaction, β- cleavage and condensation , some isomerization and rearrangement reaction. Enzyme catalyzed carboxylation and decarboxylation.

V Co-Enzyme Chemistry

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 B_{12}. Mechanisms of reactions catalyzed by the above cofactors.

VI Enzyme Models

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.

VII Biotechnological 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

1. Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C.Penny, Springer-Verlag.
2. Understanding Enzymes, Trevor Palmer, Prentice Hall.
3. Enzyme Chemistry : Impact and Applications Ed. Collin J.Suckling, Chapman and Hall.
4. Enzyme Mechanisms 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. Immobilized Enzymes: An Introduction and Applications in Biotechnology, Michael D.Trevan, John Wiley .

7. Enzymatic Reaction Mechanisms, C.Walls, W.H.Freeman.
8. Enzyme Structure and Mechanism, A.Fersht, W.H.Freeman.
9. Biochemistry: The Chemical Reactions of Living Cells, D E. Metzler, Academic Press.

PAPER - II

(c) Biophysical Chemistry

I Biological Cell And Its Constituents

Biological cell, structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition.

II Bioenergetics

Standard free energy change in biochemical reactions, energonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.

III Statistical Mechanics in Biopolymers

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.

IV Biopolymer Interactions

Forces involved in biopolymer interactions. Electrostatic charges and molecular expansion, hydrophobic forces, dispersion force interartions. Multiple equilibria and various types of binding processes in biological systems. Hydrogen ion titration curves.

V Thermodynamics of Biopolymer Solutions

Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical system.

VI Cell Membrane and Transport of Ions

Structure and functions of cell membrane ion transport through cell membranes, irreversible thermodynamic treatment of membrane transport. Nerve conduction.

VII 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.

VIII Diffraction Methods

Light scattering, low angle X-ray scattering. X-ray diffraction and photo correlation spectroscopy, ORD.

Books Suggested

1. Principles of Biochemistry, A.L. Lehninger, Wurth Publishers.
2. Biochemistry, L. Stryer, W.H. Freeman.
3. Biochemistry, J. David Rawn, Neil Patterson.
4. Biochemistry, Voet and Voet, John Wiley.
5. Outlines of Biochemistry, E.E. Conn and P.K. Stumpf, John Wiley.
6. Bioorganic Chemistry : A Chemical Approach to Enzyme Action, H. Dugas and C. Penny, Springer- Verlag
7. Macromolecules : Structure and Function, F. Wold Prentice Hall.

PAPER - III

Environmental Chemistry

I Environment

Introduction. Composition of atmosphere., vertical temperature, heat budget of the earth atmospheric

system, vertical stability atmosphere. Biogeochemical cycles of C, N, P, S and O. Biodistribution of elements.

II Hydrosphere

Chemical composition of water bodies-lakes, streams, rivers and wet lands etc. Hydrological cycle.

Aquatic pollution - inorganic, organic, pesticide, agricultural, industrial and sewage, detergents, oil spills and oil pollutants. Water quality parameters- dissolved oxygen, biochemical oxygen demand, solids, metals, content of chloride, sulphate, phosphate, nitrate and micro-organisms. Water quality standards.

Analytical methods for measuring BOD, DO, COD, F, Oils, metals (As, Cd, Cr, Hg,Pb, Se etc.), residual chloride and chlorine demand.

Purification and treatment of water.

III Soils

Composition, micro and macro nutrients. Pollution - fertilizers, pesticides, plastics and metals. Waste treatment.

IV Atmosphere

Chemical composition of atmosphere- particles, ions and radicals and their formation.

Chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, O and their effect pollution by chemicals, petroleum, minerals, chlorofluorohydrocarbons. Green house effect, acid rain, air pollution controls and their chemistry.

Analytical methods for measuring air pollutants, Continuous monitoring instruments.

V Industrial Pollution

Cement, sugar, distillery, drug, paper and pulp, thermal power plants, nuclear power plants, metallurgy. Polymers,

drugs etc. Radionuclide analysis. Disposal of wastes and their management.

VI Environmental Toxicology

Chemical solutions to environmental problems, biodegradability, principles of decomposition, better industrial processes. Bhopal gas tragedy, Chernobyl, three mile island. Seveso and minamata disasters.

Books Suggested

1. Environmental Chemistry, S.E. Manahan, Lewis Publishers.
2. Environmental Chemistry, Sharma & 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.Landaberger and M Creatchman, Gordon and Breach Science Publication.
8. Environmental Chemistry, C.Baird, W.H.Freeman.

ELECTIVE PAPERS

Students are required to select any four of the following elective papers. Each paper will carry 60 marks.

1. Organotransition Metal Chemistry
2. Bioinorganic and Supramolecular Chemistry
3. Photoinorganic Chemistry

4. Analytical Chemistry
5. Organic Synthesis-I
6. Organic Synthesis-II
7. Heterocyclic Chemistry
8. Chemistry of Natural Products
9. Medicinal Chemistry
10. Physical Organic Chemistry
11. Chemistry of Materials
12. Computational Chemistry
13. Advanced Quantum Chemistry
14. Liquid State
15. Polymers
16. Nuclear and Radiochemistry.

ELECTIVE PAPER - 1 Organotransition metal chemistry

I Alkyls and Aryls of Transition Metals

Types, routes of synthesis, stability and decomposition pathways, organocopper in organic synthesis.

II Compounds of Transition Metal-Carbon Multiple Bonds

Alkylidenes, alkylidynes, low valent carbenes and carbynes- synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

III Transition Metal π- complexes

Transition metal π- complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparations, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis.

IV Transition Metal Compounds with bonds to Hydrogen

Transition metal compounds with bonds to hydrogen.

V Homogenous Catalysis

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.

VI Fluxional Organometallic compounds

Fluxionality and dynamic equilibria in compounds such as η^2- olefin, η^3- allyl and dienyl complexes.

Books Suggested

1. Principles and application of Organotransition Metal Chemistry, J.P. Collman, L.S.Hegedus, J.R.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.

ELECTIVE PAPER - 2

Bioinorganic and Supramolecular Chemistry

I Metal Storage Transport and Biomineralization

Ferritin, transferrin and siderophores

II Calcium in Biology

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

III **Metalloenzymes**

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 B_{12}

IV **Metal- Nucleic Acid Interactions**

Metal ions and metal complex interactions, Metal complexes-nucleic acids.

V **Metals in Medicine**

Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs.

VI **Supramolecular chemistry**

Concepts and language.

(A) Molecular recognition : Molecular receptors for ifferent types of molecules includin arsonic substrates, design and synthesis of coreceptor molecules and multiple recognition.

(B) Supramolecular reactivity and catalysis.

(C) Transport processes and carrier design.

(D) Supramolecular devices. Supramolecular photochemistry,supramolecular electronic, ionic and switching devices.

Some example of self-assembly in supramolecular chemistry.

Books Suggested

1. Principle of Bioinorganic Chemistry, S.J.Lippard and J.M.Berg, University Science Books.

2. Bioinorganic Chemistry, I.Bertini, H.B Gray, S.J.Lippard and J.S.Valentine, University Science Books.

3. Inorganic Biochemistry Vols, I And II ed. G.L. Eichhorn, Elsevier.

4. Progress in Inorganic Chemistry, Vols 18 and 38 Ed. J.J.Lippard, Wiley.

5. Supramolecular Chemistry, J.M.Lehn, VCH.

ELECTIVE PAPER - 3 Photoinorganic Chemistry

I **Basics of Photochemistry**

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

II **Properties of Excited States**

Structure, dipole moment, acid-base strengths, reactivity. Photochemical kinetics-calculation of rates of radiative processes. Bimolecular deactivation- quenching.

III **Excited States of Metal Complexes**

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.

IV **Ligand Field Photochemistry**

Photosubstitution, photooxidation and photoreduction, liability 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.

V **Redox Reactions by Excited metal Complexes**

Energy transfer under conditions of weak interaction and

strong interaction-exciplex 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- phenonthrolin complexes), illustration of reducing and oxidising character of Ruthenium2+ (bipyridal complex, comparision with Fe(bipy)3; role of spin-orbit coupling-life time of these complexes. Application of redox processes of electronically excited states for catalytic purposes, transformation of low energy reactants into high energy products, chemical energy into light.

VI Metal Complex Sensitizers

Metal complex sensitizer, electron relay, metal colloid systems, semiconductor supported metal or oxide systems, water photolysis, nitrogen fixation and carbon dioxide reduction.

Books Suggested

1. Concepts of Inorganic Photochemistry, A.W.Adamson and P.D.Fleischauer, Wiley.
2. Inorganic Photochemistry, J.Chem. Educ., Vol. 60, No. 10 1983.
3. Progress in Inorganic Chemistry, Vol. 30, Ed. S.J.Lippard, Wiley.
4. Coordination Chem. Revs., 1981, Vol. 39, 121; 1975,15,321; 1990,97,313.
5. Photochemistry of Coordination Compounds, V.Balzan and V.Carassiti, Academic Press.
6. Elements of Inorganic Photochemistry, G.J.Ferraudi, Wiley.

ELECTIVE PAPER - 4

Analytical Chemistry

I 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 decomposition. Gravimetric techniques. Selecting and handling of reagents. Laboratory notebooks, Safety in the analytical laboratory.

II Errors and Evaluation

Definition of terms in mean and median, precision-standard deviation, relative standard deviation. Accuracy-absolute error, relative error. Types of error in experimental data determinate (systematic), indeterminate (or random) and gross. Sources of errors and the effects upon the analytical results. Methods for reporting analytical data. Statistical evaluation of data-indeterminate errors. The uses of statistics.

III Food Analysis

Moisture, ash, crude protein, fat, crude fibre, carbohydrates, calcium, potassium, sodium and phosphate. Food adulteration -common adulterants in food, contamination of food stuffs. Microscopic examination of foods for adulterants. Pesticide analysis in food products. Extraction and purification of sample. HPLC Gas chromatography for organophosphates. Thin-layer chromatography for identification of chlorinated pesticides in food products.

IV Analysis of Water Pollution

Origin of waste water, types, water pollutants and their effects. Sources of water pollution-domestic, industrial, agricultural soil and radioactive wastes as sources of pollution. Objectives of analysis parameter for analysis-colour, turbidity, total solids, conductivity, acidity, alkalinity, hardness, chloride, sulphate, fluoride, silica, phosphates and different forms of nitrogen. Heavy metal pollution-public health significance of cadmium, chromium, copper, lead, zinc, manganese, mercury and arsenic. General survey of instrumental technique for the analysis of heavy metals in aqueous systems. Measurements of DO, BOD and COD. Pesticides as water pollutants and analysis. Water pollution laws and standards.

V Analysis of Soil, Fuel, Body Fluids and Drugs

a) **Analysis of soil:** moisture, pH, total nitrogen, phosphorus, silica, lime, magnesia, manganese, sulphur and alkali salts.

b) **Fuel analysis:** solid, liquid and gas, Ultimate and proximate analysis- heating values grading of coal. Liquid fuels-flash point, aniline point, octane number and carbon residue. Gaseous fuels-producer gas and water gas-calorific value.

c) **Clinical chemistry :** Composition of blood-collection and preservation of samples. Clinical analysis, serum electrolytes, blood glucose, blood urea, nitrogen, uric acid, albumin, globulins, barbiturates, acid and alkaline phosphatases. Immunoassay: principles of radio immunoassay (RIA) and applications. The blood gas analysis-trace elements in the body.

d) **Drug analysis:** Narcotics and dangerous drugs. Classification of drugs. Screening by gas and thin-layer chromatography and spectrophotometric measurements.

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. Leary, W.B. Saunders.
6. Principles of Instrumental Analysis, D.A.Skoog, W.B.Saunders.
7. Quantitative Analysis, R.A.Daty, Jr. and A.L.Underwood, Prentice Hall.
8. Environmental Solution Analysis, S.M. Khopkar, Wiley Eastern.
9. Basic Concepts of Analytical Chemistry, S.M.Khopkar, Wiley Eastern.
10. Handbook of Instrumental Techniques For Analytical Chemistry, F.Settle, Prentice Hall.

ELECTIVE PAPER - 5 Organic Synthesis - I

I Organometallic Reagents

Principle, preparations, properties and applications of the following in organic synthesis with mechanistic details.

Group I and II metal organic compounds

Li, Mg, Hg, Cd, Zn and Ce compounds.

Transition metals

Cu, Pd, Ni, Fe, Co, Rh, Cr and Ti compounds.

Other Elements

S, Si, B and I compounds.

II Oxidation

Introduction, different oxidative processes.

Hydrocarbons: alkenes, aromatic rings, saturated C-H groups (activated and unactivated). Alcohols, diols, aldehydes, ketones, ketals and carboxylic acids.

Amines, hydrazones and sulphides.

Oxidations with ruthenium tetroxide, iodobenzene diacetate and thallium (III) nitrate.

III Reduction

Introduction. Different reductive processes.

Hydrocarbons: alkanes, alkenes, alkynes and aromatic rings.

Carbonyl compounds- aldehydes, ketones, acids and their derivatives. Epoxides, Nitro, nitroso, azo and oxime groups.

Hydrogenolysis

IV Rearrangements

General mechanistic considerations- nature of migration, migratory aptitude, memory effects.

A detailed study of the following rearrangements

Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Eistert synthesis, Neber, Beckmann, Hofman, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction.

V 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 University 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.

ELECTIVE PAPER - 6

Organic Synthesis - II

I Disconnection Approach

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

II Protecting Groups

Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

III One Group C-C disconnections

Alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.

IV Two Group C-C disconnections

Diels-alder reaction, 1,3-difunctionalised compounds, α,β-unsaturated carbonyl compounds, control in carbonyl

condensations, 1, 5,-difunctionalised compounds. Michael addition and Robinson annulation.

V **Ring Synthesis**

Saturated heterocycles, synthesis of 3-, 4-, 5- and 6-membered rings, aromatic heterocycles in organic synthesis.

VI **Synthesis of Some Complex Molecules**

application of the above in the synthesis of following compounds

Camphor, Longifolene, Cortisone, Reserpine, Vitamin D, Juvabione, Aphidicolin and Fredericamycin A.

Books Suggested

1. Designing Organic Synthesis, S.Warren, Wiley.
2. Organic Synthesis- Concept, Methods and starting Material, J. Fuhrhop and G. Penzillin, Verlage VCH.
3. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.
4. Modern Synthetic Reactions, H.P. House, W.A. Benjamin.
5. Advanced Organic Chemistry: Reactions, Mechanisms and Structure, J. March, Wiley.
6. Principles of Organic Synthesis, R. Norman and J. M. Coxon, Blackie Academic & Professional.
7. Advanced Organic Chemistry Part B. F. A. Carey and R. J. Sundberg, Plenum Press.

ELECTIVE PAPER - 7

Heterocyclic Chemistry

I **Nomenclature of Heterocycles**

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

II **Aromatic Heterocycles**

General chemical behaviour of aromatic heterocycle, classification (structural type), criteria of aromaticity (bond lengths, ring current and chemical shifts in 1H NMR- spectra, empirical resonance energy, delocalization energy and Dewar resonance energy, diamagnetic susceptibility exaltations).

Heteroaromatic reactivity and tautomerism in aromatic heterocycles.

III **Non-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 interaction.

Stereo-electronic effects: anomeric and related effects. Attractive interactions- hydrogen bonding and intermolecular nucleophilic- electrophilic interactions.

IV **Heterocyclic Synthesis**

Principle of heterocyclic synthesis involving cyclization reactions and cycloaddition reactions.

V **Small Ring Heterocycles.**

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

VI **Benzo-Fused Five-Membered Heterocycles**

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

VII **Meso-ionic Heterocycles**

General classification, chemistry of some important meso-ionic heterocycles of type-A and B and their applications.

VIII Six-membered Heterocycles with One Heteroatom

Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium & thiopyrylium salts and pyridones.

Synthesis and reactions of quinolizinium and benzopyrylium salts, coumarins and chromones.

IX Six-Membered Heterocycles with Two or More Heteroatoms

Synthesis and reactions of diazines, triazines, tetrazines and thiazines

X Seven-and Large Membered Heterocycles

Synthesis and reactions of azepines, oxepines, thiepines, diazepines thiazepines, azocines, diazocines dioxocines and dithiocines.

XI Heterocyclic Systems Containing P, As, Sb and B

Heterocyclic rings containing phosphorus: Introduction, nomenclature, synthesis and characteristics of 5- and 6- membered ring systems-phosphoranes, phosphorines, phospholanes and phosphols.

Heterocyclic rings containing As and Sb: Introduction, synthesis and characteristics of 5- and 6-membered ring systems

Heterocyclic rings containing B: introduction, synthesis, reactivity and spectral characteristics of 3-,5- and 6- membered ring systems

Books Suggested

1. Heterocyclic Chemistry Vol. 1-3, 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 Scientific 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 Press.

ELECTIVE PAPER - 8

Chemistry of Natural Products

I Terpenoids and Carotenoids

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule.

Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Citral, Geraniol, α- Terpeneol, Menthol, Farnesol, Zingiberene, Santonin, Phytol, Abietic acid and β-Carotene.

II Alkaloids

Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkeloids in plants.

Structure, stereochemistry, synthesis and biosynthesis of the following: Ephedrine,(+) Conviine, Nicotine, Atropine, Quinine and Morphine.

III Steroids

Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry.

Isolation ,structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrone, Progestrone, Aldosterone.

Biosynthesis of steroids.

IV Plant Pigments

Occurrence, nomenclature and general methods of structure determination, isolation and synthesis of Apigenin, Luteolin, Quercetin, Myricetin, Quercetin-3-glucoside, Vitexin,Daidzein, Butein, Aureusin, Cyanidin-7-arabinoside, cyanidin, Hirsutidin.

Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.

V Porphyrins

Structure and synthesis of Hemoglobin and Chlorophyll.

VI Prostaglandins

Occurrence, nomenclature, classification, biogenesis and physiological effects.

Synthesis of PGE_2 and PGF_2.

Pyrethroids and Rotenones

Synthesis and reactions of Pyrethroids and Rotenones.

(For structure elucidation, emphasis is to be placed on the use of spectral parameters wherever possible)

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 Americas, 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. Choudhary, Harwood Academic Publishers.
8. Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers.

ELECTIVE PAPER - 9

Medicinal Chemistry

I 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 constants, 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)

II **Pharmacokinetics**

Introduction to drug absorption, disposition, elimination using pharmacokinetics, important pharmacokinetic parameters in defining drug disposition and in the rapeutics. Mention of uses of pharmacokinetics in drug development process.

III **Pharmacodynamics**

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

IV **Antineoplastic Agents**

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.

V **Cardiovascular Drugs**

Introduction, cardiovascular diseases, drug inhibitors of peripheral sympathetic function, central intervention of cardiovascular output. Direct acting arteriolar dilators.

Synthesis of amyl nitrate, sorbitrate, chlitazem, quinidine, verapamil, methyldopa, atenolol, oxyprenol.

VI **Local Antiinfective Drugs**

Introduction and general mode of action.

Synthesis of sulphonamides, furazolidone, nalidixic acid, ciprofloxacin, norfloxacin, dapsone, amino salicylic acid, isoniazid, ethionamide, ethambutal, fluconazole, econozole, griseofulvin, chloroquin and primaquin.

VII **Psychoactive Drugs- The chemotherapy of Mind**

Introduction neurotransmitters, CNS depressants, general anaesthetics, mode of action of hypnotics, sedatives, anti-anxiety drugs, benzodiazipines, buspirone, neurochemistry of mental diseases, antipsychotic drugs- the neuroleptics, antidepressants, butyrophenones, serendipity and drug development, stereochemical aspects of psychotropic drugs.

Syntheses of diazepam, oxazepam, chlerazepam, alprazolam, phenytoin, ethosuximide, trimethadione, barbiturates, thiopental sodium, glutethimide.

VIII **Antibiotics**

Cell wall biosynthesis, inhibitors,- lactam rings, antibiotics inhibiting protein synthesis. Synthesis of penicillin G, penicillin V, ampicillin, amoxycillin, chloramphenicol, cephalosporin, tetracyclin and streptomycin.

Books Suggested

1. Introduction to Medicinal Chemistry, A.Gringauge, Wiley-VCH
2. Wilson And Gisvold/Ke 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-1(Chapter-9 and Ch-14), 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.

ELECTIVE PAPER - 10

Physical Organic Chemistry

I **Concepts of Molecular Orbital (MO) and Valence Bond(VB) Theory**

Introduction to Huckel molecular obribal (MO) method as a means to explain modern theoretical methods. Advanced techniques in PMO and FMO theory. Molecular mechanics, semi empirical methods and ab into and density functional methods. Scope and limitations of several computational programmes.

Quantitative MO theory- Huckel molecular orbital (HMO) method as applied to ethene, allyl and butadiene.

Qualitative MO theory- ionisation potential. Electron affinities. MO energy levels. Orbital symmetry. Orbital interaction diagrams.MO of simple organic systems such as ethene, allyl, butadiene, methane and methyl group. Conjugation and hyperconjugation. Aromaticity.

Valence bond (VB) configuration mixing diagrams. Relationship between VB configuration mixing and resonance theory. Reaction profiles. Potential energy diagrams. Curve-crossing model-nature of activation barrier in chemical reactions.

II **Principles of Reactivity**

Mechanistic significance of entropy, enthalpy and Gibb's free energy. Arrhenius equation. Transition state theory. Uses of activation parameters, Hammond's postulate. Bell-Evans-Polanyi principle. Potential energy surface model. Marcus theory of electron transfer. Reactivity and selectivity principles.

III **Kinetic Isotope Effect**

Theory of isotope effects. Primary and secondary kinetic isotope effects. Heavy atom isotope effects. Tunneling effect. Solvent effects.

IV **Structural Effects on Reactivity**

Linear free energy relationships (LFER). The Hammett equation, substituent constants, theories of substituent effects. Interpretation of σ- values. Reaction constant ρ. Deviations from Hammett equation. Dual-parameter correlations, inductive substituent constant. The Taft model, σ_I and σ_R scales.

V **Solvation and Solvent Effects**

Qualitative understanding of solvent-solute effects on reactivity. Thermodynamic measure of solvation. Effects of solvation on reaction rates and equilibria. Various empirical indices of solvatim based on physical properties, solvent-sensitive reaction rate, spectroscopic properties and scales for specific solvation. Use of solvation scales in mechanistic studies. Solvent effects from the curve-crossing model.

VI **Acids, Bases, Electophiles, Nucleophiles and Catalysis**

Acid-base dissociation. Electronic and structural effects, acidity and basicity. Acidity functions and their applications. Hard and soft acids and bases. Nucleophilicity scales. Nucleofugacity. The α-effect. Ambivalent nucleophiles, Acid-base catalysis- specific and general catalysis. Bronsted catalysis. Nucleophilic and electrophilic catalysis. Catalysis by non-covalent binding -micellar catalysis.

VII **Steric and Conformational Properties**

Various type of steric strain and their influence on reactivity. Steric acceleration . Molecular measurements of steric effects upon rates, Steric LFER. Conformational barrier to bond rotation-spectroscopic detection of individual conformers. Acyclic and monocyclic systems. Rotation around partial double bonds. Winstein-Holness and Curtin-Hammett principle.

VIII Nucleophilic and Electrophilic Reactivity

Structural and electronic effects on SN_1 and SN_2 reactivity. Solvent effects. Kinetic isotope effects. Intramolecular assistance. Electron transfer nature of SN_2 reactions. Nucleophilicity and SN_2 reactivity based on curve crossing model. Relationship between polar and electron transfer reactions. SRN_1 mechanism. Electrophilic reactivity, general mechanism. Kinetic of reaction SE_2-Ar reaction. Structural effects on rates and selectivity. Curve-crossing approach to electrophilic reactivity.

IX Radical and Pericyclic Reactivity

Radical stability, polar influences, solvent and steric effects. A curve crossing approach to radical addition, factors effecting barrier heights in additions, regioselectivity in radical reactions.

Reactivity, specificity and periselectivity in pericyclic reactions.

X Supermolecular Chemistry

Properties of covalent bonds- bond length, inter-bond angles, force constant, bond and molecular dipole moments. Molecular and bond polarizability, bond dissociation enthalpy, entropy. Intermolecular forces, hydrophobic effects. Electrostatic, induction, dispersion and resonance energy, magnetic interactions, magnitude of interaction energy, forces between macroscopic bodies, medium effects. Hydrogen bond.

Principles of molecular association and organization as exemplified in biological macromolecules like enzymes, nucleic acids, membranes and model systems like micelles and vesicles. Molecular receptors and design principles. Cryptands, cyclophanes, calixeranes, cyclodextrines. Supramolecular reactivity and catalysis. Molecular channels and transport processes. Molecular devices and nanotechnology.

Books Suggested

1. Molecular Mechanics, U.Burkert and N.L. Allinger, ACS Monograph 177, 1982
2. Organic Chemist's Book of Orbitals, L. Salem and W.L. Jorgensen Academic Press.
3. Mechanism and Theory in Organic Chemistry, T.H. Lowry And K.C. Richardson, Harper and Row.
4. Introduction to Theoretical Organic Chemistry and Molecular Modeling , W.B. Smith, VCH, Weinheim.
5. Physical Organic Chemistry, N.S.Isaacs, ELBS/ Longman.
6. Supramolecular Chemistry: Concepts and Perspectives, J.M. Lehn, VCH.
7. The Physical Basis Of Organic Chemistry, H. Maskill, Oxford University Press.

ELECTIVE PAPER - 11

Chemistry of Materials

I Multiphase Materials

Ferrous alloys: Fe-C phase transformations in ferrous alloys; stainless steels, non-ferrous alloys, properties of ferrous and non-ferrous alloys and their applications.

II 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 fibre-reinforced composites, macroscopic composites. Nanocrystalline phase, preparation procedures, special properties, applications.

III **Thin Films and Langmuir - Blodgett Films**

Preparation techniques, evaporation/sputtering, chemical processes, MOCVD, sol-gel etc. Langmuir - Blodgett (LB) film, growth techniques, photolithography, properties and applications of thin and LB films

IV **Liquid Crystals**

Mesomorphic behaviour, 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 A and smectic C phases, optical properties of liquid crystals. Dielectric susceptibility and dielectric constants. Lyotropic phases and their description of ordering in liquid crystals.

V **Polymeric Materials**

Molecular shape, structure and configuration, crystallinity, stress strain behaviour, thermal behaviour, polymer types and their applications, conducting and ferro-electric polymers.

VI **Ionic Conductors**

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

VII **High T_C Materials**

Defect perovskites, high T_c 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, positron lifetimes,

microwave absorption-pairing and multigap structure in high T_c materials, applications of high T_c Materials.

VIII **Materials for Solid State Devices**

Rectifiers, transistors, capacitors - IV- V compounds, low-dimensional quantum structures; optical properties.

IX **Organic Solids, Fullerenes, Molecular Devices**

Conducting organics, organic superconductors, magnetism in organic materials.

Fullerenes- doped, fullerenes as superconductors.

Molecular rectifiers and transistors, artificial photosynthetic devices, optical storage memory and switches- sensors.

Nonlinear optical materials; nonlinear optical effects, second and third order-molecular hyperpolarisability and second order electric susceptibility - materials for second and third harmonic generation.

Book 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

ELECTIVE PAPER - 12

Computational Chemistry

I **Fortran/C Programming and Numerical Methods.**

Advanced programming features of FORTRAN/C. Basic theory, discussion of algorithms and errors for the following numerical methods. Examples from chemistry should be selected for illustrating the methods. The teacher may select ANY THREE of the following subtopics considering the background of students, available time etc.

a. Solutions of Equations

Bisection, regular falsi, Newton-Raphson and related methods for solving polynomial and transcendental equations. Convergence ; Errors and ill-conditioning.

b. Linear Simultaneous Equations

Gaussian elimination, Gauss- Seidel method, Gauss-Jordan method. Pivoting strategy. Errors and ill conditioning.

c. Eigen values and Matrix Diagonalization

Jacobi and Householder methods, analysis of errors.

d. Interpolation

Newton forward and backward difference, central difference formulae. Lagrange and Hermite interpolation. Polynomial wiggle problem.

e. Numerical Differentiation

Solution of simple differential equations by Taylor series and Runge-Kutta methods.

f. Numerical Integration

Newton-Cotes formulae, Romberg integration, errors in integration formulae.

The students should develop computer programmes for some of the above numerical methods.

I **Running of Advanced Scientific Package**

The students are expected to get hands on experience of running a few selected advanced level scientific software packages after a brief introduction to the basic theory and methodology ab initio quantum chemical packages such as GAUSSIAN/GAMES with carefully designed exercises for illustrating various features of the packages. Semi empirical/Dynamics/Simulation packages such as MOPAC, CHARM, AMBER, QUANTA etc. Basic ideas on structure activity relation, drug and catalysis design etc.

II **Introduction to Networking and Search using Internet**

III **Project**

The students will develop utilities such as analysis of spectra, simulation programmes which will supplement laboratory or theory exercises in physical, organic, inorganic chemistry or biochemistry. This list is only indicative and a variety of small projects designed by the teacher based on the interest of the student and capabilities should be worked out.

Book Suggested

1. Computational Chemistry, A.C.Norris, John Wiley.
2. Computer Programming in FORTRAN 77, R.Rajaraman, Prentice Hall.
3. Numerical Analysis, C.E. Frogberg, Macmillan.
4. Numerical Analysis, A Practical Approach, M.J.Maron, John Wiley.
5. Numerical Methods for Scientists and Engineers, H.M.Antia, Tata McGraw Hill.

ELECTIVE PAPER - 13

Advanced Quantum Chemistry

(Pre-requisite: Mathematics at least up to First Year B.Sc.

level is necessary. At least one PC among 4 students should be available)

I Theoretical and Computational 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.

II Configuration Interaction and MC-SCF

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

III 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. An introduction to MOPAC and AMI with hands on experience on personal computers.

IV 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.

V Computer Experiments

Computer experiments using quantum chemistry-software packages such as GAUSSIAN/ GAMESS / MOPAC and modeling software e.g. MM2 /AMBER /CHARM etc.

Book 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, Gaussian Inc.
5. Semi-Empirical MO Theory, J.Pople and D.Beveridge.

ELECTIVE PAPER - 14

Liquid State

I General Properties of Liquids

Liquids are dense gases, liquids as disordered solids, some thermodynamic relations, internal pressure and its signification in liquids. Equations of state, critical constants. Different types of intermolecular forces in liquids, different potential functions for liquids, additivity of pair potential approximation.

A classical partition function for liquids, correspondence principle, configuration integral, configuration properties.

II Theory of Liquids

Theory of liquids, partition function method or model approach; single cell models, communal energy and entropy, LTD model, significant structure model.

III Distribution Function and Related Equations

Radial distribution function method, equation of state in terms of RDF. Molecular distribution functions, pair distribution function. Relationship between pair distribution function and pair potential function. The IBG equation, the HNC equation, the PY equation, cluster expansion.

IV **Methods for Structure Determination and Computational Techniques**

Spectroscopic techniques for liquid dynamic structure studies, Neutron and X-ray scattering spectroscopy.

Computation techniques- Monte Carlo and molecular dynamics methods.

V **Supercooled and Ionic Liquids**

Supercooled and ionic liquids, theories of transport properties, non Arrhenius behaviour of transport properties, cohen-Turnbull free volume model, configurational entropy model, Macedo-Litovitz hybrid model, glass transition in supercooled liquids.

Book Suggested

1. An introduction to Liquid State, P.A. Egelstaff, Academic press.
2. The Dynamic Liquid State, A.F.M.Barton, Longman.
3. Introduction to Statistical thermodynamics, T.L.Hill, Addison Wiley.
4. The Liquid State, J.A.Pryde.
5. Significant Liquid Structures, H. Eyring and M.S.John.

ELECTIVE PAPERS - 15

Polymers

I **Basics**

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 copolymerization. Polymerization conditions and polymer reactions. Polymerization in homogeneous and heterogeneous systems.

II **Polymer Characterization**

Polydispersion- Average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular weights. End-group, viscosity, light scattering, osmotic and ultracentrifugation methods. Analysis and testing of polymers-chemical analysis of polymers, spectroscopic methods, X-ray diffraction study, Microscopy. Thermal analysis and physical testing-tensile strength, Fatigue, impact, Tear resistance, Hardness and abrasion resistance.

III **Structure And Properties**

Morphology and order in crystalline polymers-configurations of polymer chains. Crystal structures of polymers. Morphology of crystalline polymers, strain-indured 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.

IV **Polymer Processing**

Plastics, elastomers and fibres. Compounding Processing Techniques; Calendering, die casting, rotational casting, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming, reinforcing and fibre spinning.

V **Properties of Commercial Polymers**

Polyethylene, polyvinyl chloride, polyamides, polyesters, phenolic resins, epoxy resins and silicon polymers.

Functional polymers - Fire retarding polymers and electrically conducting polymers. Biomedical polymers-contact lens, dental polymers artificial heart, kidney, skin and blood cells.

Books Suggested

1. Textbook of Polymer Science, F.W.Billmeyer, Jr.Wiley
2. Polymer Science, V.R.Gowarikar, 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.

ELECTIVE PAPER - 16

Nuclear & Radio Chemistry

II Introduction

Some Historical Landmarks in Nuclear and Radiochemistry. Nuclear Structure and Stability (Nucleus shape, Isotopes, Isobars, Isotones, Nuclear Isomerism and Isomeric Transitions, Nuclear forces, Nuclear Mass & Binding Energy. Frequency distribution of stable Isotopes & Nuclear stability N/Z ratio), Nuclear Reactions, Notation Q-value of Nuclear reactions, Coulomb Barrier, Reaction Cross-section. Types of reactions Scattering reactions (- Induced reactions, Neutrons induced, Proton induced, Deutron, Photon, Heavy ion induced reactions), Natural Radioactivity, Artificial Radioactivity, Nuclear fission and Nuclear fusion; Radioactivity and Types of Nuclear decay - Types and Kinetics of Radioactive Decay, Statistical Aspect of Radioactive Decay, Parent-Daughter Decay (Growth Relationship & Equilibrium), Branching

Decay, Radioactive Equilibrium, Secular Equilibrium and The Auger Effect.

III Radiation detection and Measurements

Interaction of Radioactive with matter, Electromagnetic Interaction (Photoelectric Effect, Compton Scattering and Pair Production), Photo-tube and Photo-multiplier tube, General Principles of Radioactivity Detection and Fundamental particles in Detectors and Nuclear Spectroscopy, Semiconductor Detector, Neutron Detector, SSNT Detector and Cerenkov Detector), Proportional counter, G.M. Counter, Nuclear Electronics, Nuclear Instrument Model.

IV Nuclear Models

Nordhem rules and Magic numbers, Liquid- Drop Model, Fermi-Gas Model, Nuclear -Shell Model, The Optical Model and The collective Model. The Quantum Mechanical Nuclear Potentials- The square well potential, The Harmonic Oscillator potential, The Exponential potential, The Guassian potential and the Yukawa potential.

V Nuclear Reactor & Device

Fisson Chain Reaction- Radiations Decaying into channel width (Fission Cross Section, Control rods operated Neutron Flux and Nuclear chain reactions and MPDQ-92 Computer Programs), Fission and Fertile isotopes, Nuclear Fuel, Fuel Cladding, Moderator, Coolant, Control Rods, Sensing elements, Conversion & Radioactivity; Nuclear Reactors- Boiler Water Reactor, Pressurised Water Reactor, Pressurised Heavy Water Reactor, Light- Water Gas Cooled Reactor, Advanced Gas Cooled Reactor, High Temperature Reactor. INDIAN REACTORS (Apsara, Cirus, Dhurva), Indian Kota Heavy Water Plant and Madras Atomic Power Station; Various Thermochemical Reactors, Laser Fusion Reactors, Lekha -8 (Japanese)

Fusion, India's Tokmann Aditya Toridal Reactor, Accelerates Vande Graff Accelerator, Linear Accelerator, Cyclotron Reactor, Suchrocyclotron Accelerator, Nuclear Materials- **URANIUM-** Uranium Enrichment & Uranium as Fuel, Uranium Metal Ingot, Uranium di-oxide pellet, Freshly prepared Ammonium Duranate, Freshly prepared Magnesium duranate, **PLUTONIUM-** Plutonium Based Fuels, Plutonium Metals, Plutonium Oxide Powder, Safety Asperts of Plutonium, **THORIUM-** Thorium Components, Thorium Bresders and Thorium Fuel Cycle, **HEAVY WATER-** Deuterium Enrichment Process and Radiolysis of Water, **ZIRCONIUM & ALLOYS, BERYLLIUM -** Use of Beryllium in Nuclear System and its application in other industries.

VI Applications of Isotopes

Production of Isotopes, Radiopharmaceuticlas and Radio-nuclide Therapy- NAME of the Pharmaceuticals and their application and Radioimmunoassay; Radiation Sterilization of Medical Products, Food Preservation and Gamma Radiography, Age Determination (Carbon Dating, Diagnostic Radiopharmaceutical - Bone Density Measurements, Bone Imaging, Cardiovascular Studies, Central Nervous System, Gastro-Intestinal System, Endocrine, Lungs and Kidneys, Tumor Infection and Inflammation, Environmental Radioactivity and Safety- Natural Radionuclides, Fall out from Nuclear Weapons, Testing., Nuclear Power Production , other sources of Radioactive Contaminations Transfer of Radionuclides to Food-stuffs, Caesium in the Environment, Iodine-131 in the Milk, Protective actions.

VII Radioactive and Nuclear Techniques

Radioactive Analytical Techniques, Radiometric Titrations, Sub-Stoichiometric Isotope Dilution Analysis, Reverse Isotope Dilution Analysis & Radio-Immune Assay; Neutron Activation Analysis and Chemical

Separation in NAA, Prompt Gamma Neutron Activation Analysis, Charged Particle Activation Analysis , Particle-Induced X-ray emission analysis (PIGE), Instrumental Photon Activation Analysis (IPAA) , Different Methods of NAA: Absolute Method, Relative Method and Single Component Methods, NAA and its application in Archaeology Forensics, Geology and Geochemistry and Industrial Products. X-ray Fluorescence and its applications

Book Suggested

1. Nuclear and Radioactivity:, Friedlander G, Kennedy J.M., Macias E.S., Miller J.M., Wiley Inter Science N.Y. (1981)
2. Introduction to Nuclear Physics and Chemistry: Harvey B.G., Prentice Hall Englewood Cliffs (N.J.) 1963. EEE Edn (1965)
3. Source Book of Atomic Energy, Glasstone S. Affiliated East-West Press, New Dehli 1969.
4. Environmental Chemistry P.S. Sindhu , New Age International, NewDelhi.
5. Nuclear Reactions R.Singh & S.N Mukherjee, New Age International, New Dehli
6. Nuclear and Radiochemistry (Text book) Arnikar, New Age International, New Dehli.

PRACTICAL.

The duration of practical examination will be of eighteen hours, and will comprise two exercises each from Inorganic, Organic and Physical Laboratory courses. Out of six practical exercises two exercises should be of advanced nature out of two advanced exercises the candidate may select one project-work / industrial training.

The advanced practical will carry a weightage of 35 marks each and the rest four experiments will be of 20 marks each. Viva will carry 30 marks and record will carry a weightage of 20 marks.

Note: In case the candidate opts for project work/ industrial training, he/she can do so in place of one advance practical of 35 marks.

Inorganic Chemistry

Preparation

Preparation of selected inorganic compounds and their study by IR, electronic spectra, Mossbauer, ESR and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds involving vacuum lines.

Selection can be made from the following.

1. Sodium amide. Inorg. Synth., 1946,2 ,128
2. Synthesis and thermal analysis of group II metal oxalate hydrate. J.Chem. Ed., 1988, 65,1024
3. Atomic absorption analysis of Mg and Ca.
4. Trialkoxyboranes- Preparation, IR and NMR spectra.
5. $PhBCl_2$ Dichlorophenylborane- Synthesis in Vacuum line
6. Preparation of Tin(IV) iodide, Tin(IV) chloride and Tin(II) iodide. Inorg. Synth., 1953, 4, 119.
7. Relative stability of Tin(IV) and Pb(IV). Preparation of ammonium hexachlorostannate $(NH_4)_2 SnCl_6$, ammonium hexachloroplumbate $(NH_4)_2PbCl_6$
8. Hexa- bis (4-nitrophenoxy) cyclotriphosphazene.
9. Synthesis of trichlorodiphenylantimony (V) hydrate. Inorg. Synth., 1985, 23, 194.
10. Sodium tetrathionate $Na_2S_4O_6$.
11. Metal complexes of dimethyl sulfoxide (IR): $CuCl_2$. 2DMSO, $PdCl_2$. 2DMSO, $RuCl_2$. 4DMSO. J.Chem. Educ., 1982, 59, 57.
12. Synthesis of metal acetylacetonate; magnetic moment, IR, NMR ; Inorg. synth. 1957, 5, 130; 1963, 1, 183.

13. Bromination of Cr(acac)3, J.Chem. Edu., 1986,63,90.
14. Magnetic Moment of $Co(acac)2\ H_2O$.
15. Cis and Trans $[Co(en)_2Cl_2]^+$
16. Separation of optical isomer of cis-$[Co(en)_2\ Cl_2]\ Cl$ J.Chem. Soc., 1960, 4369.
17. Ion exchange separation of oxidation state of vanadium. J.Chem. Educ. 1980, 57, 316; 1978, 55,55.
18. Determination of Cr(III) complexes.

    $[Cr(H_2O)_6](NO_3)_3H_2O$, $[Cr(H_2O)_4Cl_2]Cl.2H_2O$, $[Cr(en)_3]Cl_3$. Cr(acac)3. Inorg. Synth., 1972, 13,184
19. Preparation of N,N bis (salicyldehyde) ethylenediamine, salen H_2, Co(salen)

    J.Chem. Educ., 1977, 54,443; 1973, 50,670.

    Determination of O2 absorption by Co(salen)

    Acct. Chem. Res., 1975, 8, 384.

    Reaction of oxygen adduct with $CHCl_3$ (deoxygenation)
20. Preparation of Fe(II) chloride use it as Friedel-Crafts chlorination source: J.Org. Chem., 1978, 43, 2423; J.Chem. Edu., 1984, 61,645; 1986, 63, 361
21. Reaction of Cr(III) with a multidentate ligand, a kinetics experiment (visible spectra Cr-EDTA complex.) J.A.C.S., 1953, 75, 5670.
22. Preparation of [Co phenanthroline- 5,6- quinone].

    J.Chem. Soc., A., 1970, 447, J.Chem. Edu, 1977, 54,710.
23. Preparation and use of Ferrocene

    J.Chem. Edu, 1966,43,73; 1976, 53,730.
24. Preparation of copper glycine complex-cis and trans bis (glycinato Copper(II). J.Chem. Soc. Dalton., 1979, 1901, J.Chem. Edu. 1982, 59,1052.
25. Preparation of phosphine Ph_3P and its transition metal complexes.

26. Any other experiment such as conversion of p-xylene to terephthalic acid catalyzed by $CoBr_2$ (homogeneous catalysis)

Spectrophotometric Determinations

(a) Manganese /Chromium /Vanadium in steel sample.

(b) Nickel/ molybdenum/tungsten /vanadium/uranium by extractive spectrophotometric method.

(c) Fluoride/nitrite /phosphate

(d) Iron-phenanthroline complex: Job's Method of continuous variations.

(e) Zirconium-Alizarin Red-S complex: Mole-ratio method.

(f) copper-Ethylene diamine complex: Slope-ratio method.

Flame Photometric Determinations

(a) Sodium and potassium when present together

(b) Lithium/calcium/barium/strontium

(c) Cadmium and magnesium in tap water.

Naphelometric determinations

(a) Sulphate

(b) Phosphate

(c) Silver

Chromatographic Separations

(a) Cadmium and zinc

(b) Zinc and magnesium

(c) Thin-layer chromatography-separation of nickel, manganese, cobalt and zinc.

Determination of Rf values

(d) Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of Rf values.

Organic Chemistry

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, chemical analysis, IR, PMR and mass spectral data

Multi-step Synthesis of Organic Compounds

The exercises should illustrate the use of organic reagents and may involve purification of the products by chromatographic techniques

Photochemical reactions

Benzophenone → Benzpinacol → Benzpinacolone

Beckmann rearrangement: Benzanilide from benzene

Benzene → Benzophenone → Benzophenone oxime → Benzanilide

Benzilic acid rearrangement: Benzilic acid from benzoin

Benzoin → Benzil → Benzilic acid

Synthesis of heterocyclic compounds

Skraup synthesis: Preparation of quinoline from aniline

Fisher-Indole synthesis

Preparation of 2- phenylindole from phenylhydrazine

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

Synthesis using microwaves

Alkylation of diethyl malonate with benzyl chloride

Synthesis using phase transfer catalyst

Alkylation of diethyl malonate or ethyl acetoacetate with an alkyl halide

Extraction of Organic Compounds from Natural Sources

1. Isolation of caffeine from tea leaves.
2. Isolation of casein from milk (the students are required to try some typical colour reactions of proteins).
3. Isolation of lactose from milk (purity of sugar should be checked by TLC and PC and Rf value reported).
4. Isolation of nicotine dipicrate from tobacco.
5. Isolation of cinchonine from cinchona bark.
6. Isolation of piperine from black pepper.
7. Isolation of lycopene from tomatoes.
8. Isolation of β-carotene from carrots.
9. Isolation of oleic acid from olive oil (involving the preparation of complex with urea and separation of linolenic acid).
10. Isolation of eugenol from cloves.
11. Isolation of (+) limonene from citrus rinds.

Paper Chromatography

Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of Rf values.

Spectroscopy

Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR & MS).

Spectrophotometric (UV/VIS) Estimations

1. Amino acids
2. Proteins
3. Carbohydrates
4. Cholesterol
5. Ascorbic acid
6. Aspirin
7. Caffeine

Physical Chemistry

Number of hours for each experiment : 4 hours

A list of experiments under different headings are given below. Typical experiments are to be selected from each type.

Thermodynamics

(i) Determination of partial molar volume of solute (e.g., KCl) and solvent in a binary mixture.

(ii) Determination of the temperature dependence of the solubility of a compound in two solvents having similar intermolecular interactions (benzoic acid in water and in DMSO- water mixture) and calculate the partial molar heat of solution.

Spectroscopy

(i) Determination of pKa of an indicator (e.g., methyl red) in (a) aqueous and (b) micellar media.

(ii) Determination of stoichiometry and stability constant of inorganic (e.g. ferric- salicylic acid) and organic (e.g. amine-iodine) complexes.

(iii) Characterization of the complexes by electronic and IR spectral data.

Polarography

(i) Estimation of Pb^{2+} and Cd^{2+}/Zn^{+} and Ni^{2+} ions in a mixture of Pb^{2+} and Cd_2^{+}/Zn^{+} and Ni^{2+} by polarography.

(ii) Determination of dissolved oxygen in aqueous solution of organic solvents.

Electronics

This lab course will have theory as well as Practicals and the lectures shall be delivered during lab hours.

Basic Electronics

Notations used in an electric circuit, study of electronic components and colour codes, conversion of chemical quantities into electrical quantities. Transducer, illustration with electrodes, thermocouples and thermistors.

Passive components. Resistors, capacitors and inductors with some emphasis on solid state properties of materials. Net works of resistors. Thevenin's theorem, superposition theorem, loop analysis, R C circuits, L R circuits, LCR circuits. Illustration of the use of the circuits in NQR spectroscopy, Mossbauer spectroscopy, cyclic voltametry and in power supplies as filter circuits.

Active Components

Introduction to ordinary diodes and Zener diodes with some emphasis on p-n juction as a solid state property. Use of diodes as rectifiers, clipping and clamping circuits. Power supplies.

Transistors. An extension of p-n junction to p-n-p and n-p-n transistors. Characteristics of transistors, hybrid parameters; transistor circuits as amplifiers, high impedance preamplifier circuits, Darlington pairs, *differential amplifiers.*

Operational Amplifiers

Ideal characteristics; inverter, summer integrator, differentiator, voltage follower, illustrative use of operational amplifiers.

Introduction to Fourier transform in instrumentation.

List of Experiments in Electronics

- Measurements of resistance with multimeter.
- To measure the resistance of the given ammeter.
- Voltage measurement with CRO.
- Familiarising with CRO.
- Use of a Wheatstone Bridge for accurate measurement of resistance.
- Capacitor as a charged storage device.
- To study the behaviour of parallel charged capacitors in series charged capacitors placed in parallel.
- The use of *LCR* Bridge.
- Response characteristics of RC network.
- Response characteristics of LR network.
- *Response characteristics of LCR network.*
- Verification of Kirchoff's laws.
- To study the Lissajou's figures.
- Measurement of e.m.f. with thermocouple.
- To plot the characteristic curve of a diode.
- Half-wave and full-wave rectifier.
- Clipping and clamping circuits.
- Capacitors filter for full-wave rectifier.
- Voltage doubler, Zener stabilized bipolar power supply.
- Transistor characteristics.
- Differential amplifier.
- *Transistor amplifier.*

- Introduction of an operational amplifier as a voltage follower
- Op-Amp as non-inverting and inverting amplifier
- Simple integration differentiation with Op-Amp 741
- Op. Amp. as comparator
- Designing and fabrication of a printed circuit board
- Setting up of a thermostat: Constant temperature bath
- Four-probe method for resistivity measurement

Books Suggested

1 Inorganic Experiment, J Derek Woollins, VCH.

2 Microscale Inorganic Chemistry, Z. Szafran, R.M Pike and M.M. Singh, Wiley.

3 Practical Inorganic Chemistry, G.Marr and B.W.Rockett, Van Nostrand.

4 The Systematic Identification of Organic Compounds, R.S Shriner and D.Y. Curtin.

5 Seminacro Qualitative Organic Analysis, N.D.Cheronis, J.B.Entrikin and E.M.Hodnett

6 Experimental Organic Chemistry, M.P.Doyle and W. S.Mungall.

7 Small Scale Organic Preparations, P.J.Hill.

8 Organometallic Syntheses, J.J.Fisch and R.B.King Academic

9 Experimental Physical Chemistry, D.P Shoemaker, C.W Garland and J.W.Niber, McGraw Hill Interscience

10 Findlay's Practical Physical Chemistry, Revised B.P Levitt, Longman.

11 Experiments in Physical Chemistry, J.C Ghosh, Bharti Bhavan.

PROPOSED SYLLABUS FOR THE DEGREE OF MASTER OF SCIENCE IN BOTANY OF CSJM UNIVERSITY, KANPUR.

BOTANY

M.Sc. (Previous) Botany

There shall be five theory papers each of 100 marks and a Practical Examination of 200 marks.

I - Paper: Cytology, Genetics, Plant Breeding and Elementary Bio-Statistics.

II - Paper: Biotechnology and Genetic engineering of microbes and plants.

III - Paper: Diversity of Viruses, Bacteria, Lichens, Fungi and Elementary Plant Pathology.

IV - Paper: Diversity of Cyanobacteria, Algae and Bryophytes.

V - Paper: Diversity of Pteridophytes, Gymnosperms and Palaeobotany.

M.Sc. (Final) Botany

There shall be five theory papers each of 100 marks and a Practical Examination of 200 marks.

VI - Paper: Taxonomy, structure and Reproduction of Angiosperms.

VII - Paper: Plant Ecology and Environmental pollution

VIII - Paper: Plant Resource Utilization and conservation

IX - Paper: Physiology and Biochemistry.

X - Paper: Special papers/ Project Work.

(X a) Cytogenetics, Plant breeding and Biostatistics.

(X b) Advanced Plant Pathology.

(X c) Advanced Physiology

(X d) Environmental Science

Students shall have to undertake at least one field trip for field work/collection and submit a report on the same for which a provision of 15 marks shall be made out of the 30 marks allotted for Record/Collection/Herbaria etc.

M.Sc. (Previous) Botany

First Paper: Cytology, Genetics, Plant Breeding and Elementary Bio-Statistic

UNIT: I

Cytology: Structural organization of plant cell: Origin structure and importance of cell wall, plasmamembrane, chloroplast, mitochondria, ribosomes endoplasmic reticulum, golgi body, microbodies, lysosomes, nucleus and nucleolus. Cell cycle, cell division and cytokinesis.

Chromosomes: Structure,packaging of DNA, nucleolus, euchromatin and heterochromatin. Specialized type of chromosomes: polytene, lampbrush, B-chromosomes and sex chromosomes.

UNIT: II

Genetics: Mendelism and gene interaction. Non-Mendelian inheritance.

Variations: Chromosomal aberrations and their implications in meiosis. Polyploids: Induction and origin. Different types of polyploidy and their role in plant breeding and evolution of crop plants.

Mutations: Spontaneous and induced mutations. Physical and chemical mutagens molecular basis of mutations. Role of mutations in crop improvement. DNA damage mechanisms and repair. Transposable elements in prokaryotes and eukaryotes.

Site directed mutagenesis. The structure and behaviour of different types of DNA and RNA. Genetics of bacteriophages,bacteria and Neurospora.

Modern concept of genes: Chemical structure, composition and behaviour of different types of DNA and RNA,s. Gene action: Genetic code and regulation of gene activity in prokaryotes and eukaryotes.

UNIT: III

Plant Breeding: Method of plant breeding, Graft-hybrid and chimeras. Interspecific and intergeneric hybridization. Knowledge of plant breeding work done in India specially with reference of wheat, paddy, sugarcane, cotton, potato, Cajanus, Bengal gram and Brassica. Genetic basis of inbreeding and heterosis. Exploitation of hybrid vigour.

Elementary Bio-Statistics: Measure of dispersion, variation, standard deviation and error. Test of significance, t-Test, X^2 Test. F-Test, analysis of variance (Mono and bivariant). Regression and co-relation.

Second Paper: Biotechnology and Genetic Engineering of microbes and plants.

UNIT: I

Biotechnology: Basic concepts, principles, scope and potentials.

Plant cell and tissue culture: General Introduction, history, scope, concept of cellular differentiation and totipotency.

Application of plant tissue culture: Clonal propagation, synthetic seeds, production of hybrids and somaclones, production of secondary mtabolites/natural products, cryopreservation and germplasm storage.

Organogenesis and adventive embryogenesis: Fundamental aspects of morphogenesis, somatic embryogenesis and androgenesis, gynogenesis, mechanisms, techniques and utility.

Somatic hybridization: Protoplast isolation, fusion and culture, hybrid selection and regeneration, possibilities, achievements and limitations of protoplast research.

Recombinant DNA technology: Gene cloning principles and techniques, construction of genome/cDNA libraries, choice of vectors, DNA synthesis and sequencing, polymerase chain reaction, DNA finger- printing.

UNIT: II

Genetic Engineering of plants: Aims, strategies for the development of transgenics (with suitable examples). Agrobacterium in the natural genetic engineering, t-DNA and transposon mediated gene tagging, chloroplast transformation and its utility, intellectual property rights, possible socio-ecological risks and ethical concerns.

Microbial genetic manipulations: Bacterial transformation, selection of recombinants and tranformants, genetic improvement of industrial microbes and nitrogen fixers, fermentation technology.

Genomics and Proteomics: Genetic and physical mapping of genes, molecular markers for introgression of useful traits artificial chromosomes, genome projects, bioinformatics, functional genomics, protein profiling and its significance.

UNIT: III

Tools and Techniques for Biology: Principles and uses of analytical instruments–pH meter, calorimeter, spectrophotometer, ultracentrifuge, densitometer, atomic absorption spectrophotometer, Microscopy – Principles and uses of light and electron microscopes. Microphotography. Microbial techniques – media preparation, inoculation and growth monitoring, biochemical mutants and their uses, microbial assays. Cryotechniques – Cryopreservation of cells tissues and organisms. Separation techniques in biology – Chromatography, Electrophoresis. Organelle separation by centrifugation. Density gradient centrifugation. Radio-active isotope tracer techniques.

Third Paper: Diversity of viruses, Bacteria, Lichens, Fungi and Elementary Plant Pathology.

UNIT: I

Bacteria: Archaebacteria and Eubacteria. General account of bacteria, their occurrence, ultra-structure, nutrition, forms, reproduction, classification, and economic importance.

Viruses: A general account of plant viruses with special reference to their nature, ultrastructure, symptomatology, methods of transmission, multiplication and economic importance. Bacteriophages, TMV.

Mycoplasma: General characteristics, structure and their role in causing plant diseases.

Lichens: A general account of lichens with particular reference of their mode of life, structure, reproduction, classification, nutrition and economic importance. A brief account of Cladonia, Parmelia, Usnea, Peltigera, Rocella.

UNIT: II

Fungi: General characteristics of fungi and substrate relationship. Cell ultra-structure, unicellular and multicellular organizations. Cell wall composition, nutrition (saprobic, biotrophic, symbiotic). Reproduction (vegetative, asexual and sexual). Heterothallism, heterokaryosis and parasexuality. Phylogeny, inter-relationship and recent trends in classification. Economic importance of fungi. Mycorrhiza. Rhizosphere.

A brief study of following types: Myxomycetes: Physarum, Dictyostelium or any other allied form. Phycomycetes:

Synchytrium, Allomyces, Monoblepharis, Saprolegnia, Pythium, Phytophthora, Peronospora, Sclerospora, Albugo, Entomophthora and Mucor. Ascomycetes: Taphrina (Exoascus), Protomyces, Aspergillus, Neurospora, Penicillium, Erysiphe, Xylaria, Claviceps, Ascobolus, Peziza, Morchella. Basidiomycetes: Ustilago, Tulyposporium, Sphacelotheca, Urocystis, Graphiola, Melampsora, Puccinia, Phragmidium, Uromyces, Polyporus, Coprinus, Lycoperdon, Deuteromycetes: Colletotrichum, Helminthosporium, Alternaria, Cercospora, Fusarium.

Elementary plant pathology: General principles, classification of plant diseases, symptoms of fungal bacterial and viral diseases. Disease management, forecasting and defense mechanism. Principles of plant disease control (chemical and biological).

Fourth Paper: Diversity of Cyanobacteria, algae and Bryophytes.

UNIT: I

Cyanobacteria and Algae: A general account of occurrence, structure, nutrition, reproduction and life cycles and classification. Ultra-structure of cell, flagella, eye-spot and chloroplast. Pigmentation and reserve food material. Origin, evolution, phylogeny and classification - endosymbiotic theory of origin of algal cell. Salient feature of major phyla of algae. Algal blooms, bio-fertilizers and Economic importance of algae. Toxic algae. Bioluminiscence and Fossil algae.

A brief study of the following types: Microcystis, Oscillatoria, Lyngbya,Nostoc Anabaena, Ghaeotrichia ,Scytonema Porphyra, Batrachospermum, Gelidium, Corallina, Gracilaria, Polysiphonia, Chlamydomonas, Gonium, Pandorina, Eudorina, Volvox, Chlorococcum, Chlorella, Scenedesus ,Hocystis, Pediastrum, Hydrodictuon, Ulothrix, Ulva, Sphaeroplea, Stigeoclonium, Draparnaldiopsis, Fritschiella, Cladophora, Pithophora, Valonia, Coleochate, Oedogonium, Bryopsis, Caulerpa, Codium, Halimeda, Acetabularia, Trentopohlia, Zygnema, Mougeotia, Sirogonium, Cosmarium, Chara and Nitella. Botrydium, Vaucheria, Navicula, Ectocarpus, Cutleria, Laminaria, Sphacelaria, Dictyota, Sargassum.

UNIT: II

Bryophytes: Morphology, structure reproduction, life history and distribution of Bryophytes. Fossil history, origin, evolution, phylogeny affinities and inter-relationships. A general account of Calobryales, Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Funariales and Polytrichales. Economic and ecological importance of Bryophytes.

A brief study of structure and reproduction of following types: **Hepaticopsida:** Sphaerocarpus, Riella, Marchantia, Lunularia, Targonia, Plagiochasma, Cyathodium, Dumortiera, Cenocephalum, Fimbriaria Pellia, Riccardia, **Medotheca**, Calobryum, **Anthocerotopsida:** Anthoceros, Notothylus. **Bryopsida:** Sphagnum, Andreaea, Funaria, Buxbaumia, Pogonatum.

Fifth Paper: Diversity of Pteridophytes, Gymnosperms and Palaeobotany

UNIT: I

Pteridophyta: Morphology, anatomy, reproduction and life histories. Evolution of Stellar system. Heterospory and evolution of seed habit. A general account of fossil Pteridophytes. Affinities and classification. Economic importance of Pteridophytes.

A brief study of following types: **Psilophytopsida:** *Rhynia, Horneophyton, Psilophyton, Zosterophyllum.* **Psilopsida:** *Psilotum, Tmesipteris.* **Lycopsida:** *Protolepidodendron, Lycopodium, Selaginella, Isoetes, Lepidodendron, Bothrodendron, Pleuromeia, Lepidocarpon, Maudesmia.* **Sphenopsida:** *Hyenia, Calamophyton, Sphenophyllum, Cheirostrobus, Calamites, Equisetum.* **Pteropsida:** *Botryopteris, Stauropteris,*

Etupteris Ophioglossum, Botrychium, Marattia, Angiopteris Osmunda, Schizaea, Lygodium, Gleichenia, Matonia, Dicksonia, Cyathea, Polypodium, Alsophila, Dryopteris, Adiantum, Asplenium, Marsilea, Salvinia, Azolla.

UNIT: II

Gymnosperms: A general account of occurrence, morphology, anatomy and reproduction, origin, evolutionary trends, affinities, inter-relationships and classification of gymnosperms. Distribution of Gymnosperms in India. Economic importance of gymnosperms.

A brief account of structure and reproduction of following types: **Pteridospermales:** *Lyginopteris, Heterangium, Medullosa, Trigonocarpus.* **Caytoniales:** *Caytonia.* **Cycadales:** *Cycas.* **Nilsoniales:** *Nilsonia.* **Bennettitales:** *Williamsonia.* **Pentoxylales:** *Pentoxylon.* **Cordaitales:** *Callixylon, Cordaites, Poroxylon,* **Ginkgoales:** *Ginkgo.* **Coniferales:** *Lebachia, Pinus, Abies, Cedrus, Araucaria, Cryptomeria, Taxodium, Cupressus, Thuja, Podocarpus, Cephalotaxus, Taxus.* **Ephedrales:** *Ephedra.* **Welwitschiales:** *Welwitschia.* **Gnetales:** *Gnetum.*

UNIT: III

Palaeobotany: Formation of plant fossils, modes of preservation, methods of fossil study and their importance in stratigraphy and economic geology. Nomenclature, reconstruction, and age of fossils. Index fossils. Fossiliferous beds of India and Palaeoclimate. Standard stratigraphy scale, succession of representative floras in different geological era and their bearing on plant morphology and evolution.

Scheme of M.Sc. Previous Practical Examination

The Practical examination shall be of twelve hours during spread over two days and will consist of following:

Time: 12 hours Maximum marks: 200

1.	Isolation and study of any four of the component of the mixture (A) provided. Identification of the material with the help of suitable temporary preparations diagrams and comments.	16
2	A monographic study of the provided material (B) with the help of temporary slides, comments and anatomical diagrams (Bryophytes).	14
3	Identification and study of the provided material (C) with the help of suitable doubles stained preparation, sketches and comments (Pteridophytes).	12
4	A monographic study of the provided material (D) with the help of suitable double staining permanent preparation. Identification of the material giving diagrams, comments and reasons (Gymnosperms).	18
5	Study of host parasite relationship in the provided material (E) and identification of the parasite with the the help of temporary preparations giving suitable diagrams, reasons and comments (Parasitic fungi).	15
6.	Study and identification of the given material (F) with the help of temporary preparations, diagrams, reasons and comments. (Saprohytic Fungi)	10
7	Preparation of acetocarmine smear of the provided material (G). Tracing out of any two stages/sub-stages of cell division, their identification giving suitable sketches and comments.	10
8	Working out of the given genetical/biostatisticial problems.	10
9	Emasculation of given floral bud (H) and descriptions of the technique with suitable sketches. OR Description of the floral biology of the material provided.	5
10	Exercise on Chromatographic separation of pigments/amino acids	5

11	Exercise on tools and techniques	5
12	Minor project on course prescribed for 2nd paper	10
13	Spotting: 1- 10 spots (Two drawn from each paper)	20
14	Viva-voce	20
15.	Seasonals, Records, Collection, Field trips etc.	30

SUGGESTED LABORATORY EXCERCISES

(As suggested by U.G.C.)

1. Paper First.

1. Chromosomes techniques, pre-treatment ,fixation and staining techniques.
2. Study of various stages of meiosis and mitosis in suitable plant material.
3. Linear differentiations of chromosomes through banding techniques, such as G-banding, C-banding, Q- banding.
4. Orcein and Fuelgen of Salivary gland chromosomes.
5. Characteristics and behaviour of B-chromosomes using maize or any other appropriate material.
6. Induction of polyploidy using colchicines, different methods of application of colchicine.
7. Estimation of nuclear DNA content through microdensitometry.
8. Exercise on emasculation and pollination in the available plant material.
9. Study of floral biology of suitable material.
10. Numerical problems on Mendelian principles/ Non-Mendelian inheritance.
11. Biostatistical problems based on mean deviation, standard deviation and error, χ^2 , 't' , F-test, variance and correlation.

2. Paper Second

1. Excercises on Chromatographic techniques.
2. Demonstration, excercise and use of available tools and techniques detailed in Theory paper.
3. Isolation of micro-organisms from different sources.
4. Gram's staining in Bacteria.
5. Growth characteristics of Escherichia coli using planting and turbidimetric method.
6. Visits to various laboratories & research institutions and preparation of a report on the following excercises till facilities for the same are arranged: Isolation of protoplast from various plant tissues and testing of their viability, Demonstration of androgenesis in Dhatura, DNA Finger-printing and population mapping, Preparation of various types of culture media and cultures.

3. Paper Third.

1. A study of structure symptomology and reproduction of the available parasitic fungi prescribed in theory courses.
2. A study of structure, culture characteristics and reproduction of saprophytic fungi prescribed in theory course.
3. Identification of available fungal culture.
4. Identification of diseases caused by viruses, mycoplasmas and bacteria (symptomology and transmission).
5. Study and identification of available Lichens prescribed in theory course.

4. Paper Fourth.

1. Morphological and/or anatomical study of vegetative and reproductive structures and identification of the available materials prescribed in theory courses (Algae & Bryophytes).

5. Paper Fifth.

1. Morphological and anatomical study of vegetative and reproductive structures and identification of the available materials prescribed in theory courses (Gymnosperms and Pteridophytes).
2. Study and identification of fossil specimens and/or fossil slides.

BOOKS SUGGESTED FOR M.Sc. Part I.

Alberts B., Bray D., Lewis J., Raff M., Roberts K., Watson J.D., 1989. Molecular biology of cell. Garland Publ. Co., Inc., NY.

Alexopoulus C.J., Mims C.W., Blackwell M., 1996. Introductory Mycology. John Wiley & Sons Inc.

Asthana D.K. and Asthana M., 2001. Environment: Problems and Solutions. 2nd Edition. S.Chand and Co. New Delhi.

Atherly A.G., Girton J.R., McDonald J.F., 1999. The Science of Genetics. Saunders College Publ. Fort Worth, USA.

Bhatnagar S.P., Moitra A., 1966. Gymnosperms. New Age International Pvt. Ltd., New Delhi.

Buchanan B.B., Gruissem, W., Jones R.L., 2000. Biochemistry and Molecular Biology of plants. American Society of Plant Physiologists. Maryland, USA.

Burnham C.R., 1962. Discussion in Cytogenetics. Burgess Publishing Co., Minnesota.

Busch H., Rothblum L., 1982. Volume X. The Cell Nucleus rDNA. Part A. Academic Press.

Clifton A., 1958. Introduction to the Bacteria. McGraw Hill Book Co., NY.

De D.N., 2000. Plant cell Variolus: An Introduction. CSIRO Publication, Collingwood, Australia.

Fukui K., Nakayama S., 1996. Plant Chromosomes: Laboratory Methods. CRC Press, Boca Raton, Florida.

Glick, B.R., Thompson J.E., 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton Florida.

Glover D.M., Hames B.D. (Eds), 1995. DNA cloning 1:A practical approach. Core Techniques, 2nd Edn. PAS, IRL, Press at Oxford University Press, Oxford.

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Harkett P.B., Fuchs J.A., Mossing J.W., 1988. An Introduction to Recombinant DNA techniques. Basic experiments in gene manipulation. The Benjamin/Cummings Publ. Co., Inc. Menlo Park, California.

Hall J.L., Moore A.L., 1983. Isolation of Membranes and Organelles from Plant cell. Academic Press, London.

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Karp G., 1999. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons Inc. USA.

Khush G.S., 1973. Cytogenetics of Aneuploids. Academic Press, New York, London.

Kleinsmith L.J., Kish V.M., 1995. Principles of cell and Molecular Biology. (2nd Ed.) Harper Collins College Publishers, NY.

Krishnamurthy K.V., 2000. Methods in cell wall cytochemistry. CRC Press. Boca Raton, Florida.

Kumar H.D., 1988. Introduction to Phycology. Affiliated East West Press Ltd., New Delhi.

Lewin B. 2000. Genes VII. Oxford Univ. Press, New York.

Lewis R., 1997. Human Genetics: Concepts and Applications (2nd Edn.) WCB McGraw Hill, USA.

Lodish H., Berk A., Zipursky S.L., Matsudaira P., Baltimore D., Darnell J., 2000. Molecular Cell Biology. Freeman and Co., NY.

Malarmaki G.M. and Freidfelder D., 1998. Essentials of Molecular Biology (3rd Edn.) Jones and Bartlet Publishers Inc London.

Mandahar C.L., 1978. Introduction to Plant Viruses. S. Chand Co. Ltd. Delhi.

Mehrotra R.S., Aneja R.S., 1998. An Introduction to Mycology. New Age International Press.

Morris I., 1996. An Introductions to Algae. Cambridge University Press, UK.

Pandey S.N., Sinha B.K., Plant Physiology, Plant Physiology. Latest Edn. Vikas Publ. New Delhi.

Pandey S.N., Chada A., Plant Anatomy and Embryology. Latest Edn. Vikas Publ. New Delhi.

Pandey S.N., Chadha A., Economic Botany. Latest Edn. Vikas Publ. New Delhi.

Pandey S.N., Trivedi P.S., A Text Book of Algae. Latest Edn. Vikas Publ. New Delhi.

Parihar N.S., 1991, Bryophyta, Central Book Depot, Allahabad.

Parihar N.S., 1996, Biology and Morphology of Pteridophytes, Central Book Depot., Allhabad.

Puri P., 1980, Bryophytes. Atma Ram & Sons, New Delhi.

Rangaswamy G., Mahadevan A., 1999, Diseases of crop plants in India (4th Edn.) Prentice-All of India Pvt Ltd. New Delhi.

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Round F.E., 1986. The Biology of Agae. Cambridge Univ. Press, Cambridge.

Russel P.J., 1998. Genetics (5th Edn.) The Benjamin/Cummings Publ. Co. Inc. USA.

Sharma A.K., Sharma A., 1999, Plant Chromosomes: Analysis, Manipulations and Engineering. Harwood Academic Publ. Australia.

Shaw C.H. (Ed), 1988. Plant Molecular Biology: A practical Approach. IRL Press, Oxford.

Smstad D.P., Simmons M.J., 2006 Principles of Genetics (2nd Edn.), John Wiley and Sons Inc. USA.

Sporne K.K., 1991, The Morphology of Pteridophytes. B.I Publishing Pvt. Ltd., Bombay.

Stewart W.N., Rathwell G.W., 1993, Palaeobotany and the Evolution of Plants. Cambridge University Press, Cambridge.

Webster, J., 1985, Introduction to Fungi. Cambridge University Press, Cambridge.

Wolfe S.L., 1993, Molecular and Cellular Biology. Wadsworth Publ. Co., California.

M.Sc. (Final) Botany

Sixth Paper: Taxonomy, structure and Reproduction of Angiosperms.

UNIT:I

Taxonomy of Angiosperms:

The species concept: Taxonomic hierarchy species, genus, family and other categories, principles used in assessing relationship, delimitation of taxa and attribution of rank. Fossil history and phylogeny of Angiosperms.
Salient feature of the International Code of Botanical Nomenclature.

Taxonomic evidences: Morphology, anatomy, palynology, embryology, cytology, phytochemistry, genome analysis, and nucleic acids hybridization.

Taxonomic tools: Herbarium, flores, histological cytological, phytochemical, serological, biochemical and molecular techniques. Botanical garden, Herbaria, Botanical survey of India.

Systems of angiosperm classification: Phenetic versus phylogenetic systems, relative merits and demerits of major systems of classification, relevance of taxonomy to conservation. Recent trends of classification.

UNIT:II

A study of following families:

1. Dicotyledons: Magnoliaceae, Annonaceae, Rosaceae, Fabaceae, Cucurbitaceae, Malvaceae, Nyctaginaceae, Capparidaceae, Tamaricaceae, Violaceae, Cucurbitaceae, Caricaceae, Cactaceae, Tiliaceae, sterculiaceae, Malvaceae, Linaceae, Euphorbiaceae, Myrtaceae, salvadoraceae, Oleaceae, Loranthaceae, Euphorbiaceae, Sapotaceae, Rutaceae, Meliaceae, Anacardiaceae, Apocynaceae, Asclepiadaceae, Rubiaceae, Bignoniaceae, Pedaliaceae, Verbenaceae, Ranunculaceae, Nymphaeaceae, Piperaceae, Papaveraceae, Caryophyllaceae, Polygonaceae, Chenopodiaceae, Amaranthaceae, Lythraceae,

Primulaceae, Apiaceae, Asteraceae, Solanaceae, Convolvulaceae, Scrophulariaceae, Acanthaceae, Oxalidaceae, Boraginaceae, Lamiaceae.

2. Monocotyledons: Hydrocharitaceae, Commelinaceae, Musaceae, Zingiberaceae, Liliaceae, Araceae, Lemnaceae, Amarylidaceae, Palmeae, Orchidaceae, Cyperaceae, Poaceae.

UNIT:III

Morphology and Morphognesis: Meristems, organization of root and shoot apices. Anatomy of nodes, internodes. Primary and secondary structures of stem. Anomalous secondary growth. Cork cambium and its derivatives, function of cork, commercial cork. Anatomy of roots (primary and secondary structure), velamen. Anatomy of leaf, distribution and systematic significance of stomatal and cuticular structures. Morphological nature of the flower with special reference to stamen and carpel. Placentation, Organogeny and ontogeny of floral organs.

Embryology: Stamen, Anther, microsporogenesis and microgametogenesis. Gynoecium, ovule, megasporogenesis and megagametogenesis, its organization and nutrition. Fertilization. Endosperm, its haustoria and its morphological nature. Embryos (monocot and dicot), Apomixis, Polyembryony and artificial induction of adventive embryos, control of fertilization, induced parthenogenesis, induced parthenocarpy, ovary culture and embryogeny in relation to taxonomy.

Seventh Paper: Plant Ecology and Environmental Pollution.

UNIT:I

Climate, soils and vegetation patterns of the world: Life zones, major biomes and major vegetation of the world.
Soils, its origin, development, classification, structure, properties and fertility. Soil microflora and fauna. Ch. soil types of India. Problem soils and their reclaimation.

Vegetation Organization: Origin of intrapopulation variations. Population and environment, ecads and ecotypes, evolution and differentiation of species, various models. Concepts of community and continuum, analysis of communities (analytical and synthetic characters), community coefficients, inter specific associations, ordination, concept or ecological niche.

Vegetation development: Temporal changes (cyclic and non-cyclic), mechanism of ecological succession (relay floristics and initial floristic composition, facilitation, tolerance and inhibition models), changes in ecosystem properties during succession.

Ecosystem organization: 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), global biogeochemical cycles of carbon, nitrogen, phosphorus and sulphur, mineral cycles (pathways, processes, budgets) in terrestrial and aquatic ecosystems.

Biological diversity: Concept, levels, importance and role of biodiversity in ecosystem functions and stability, speciation and extinction. IUCN categories of threat, distribution and global patterns. Megadiversity countries. Speciation and extinction and natural longitivity of a species and optimum biodiversity. Causes and consequences of degenerations of biodiversity and its repercussions on the future course of evolution.

UNIT:II

Pollution of environment By organic wastes, pesticides, heavy metals, mining & processing wastes and radioactive wastes. Bio accumulation and bio magnification.

Atmospheric inversion and pollution blankets. Photochemical smog. Acid rains.

Climate change: Accumulation of green house gases, global warming and its causes consequences and control. Pollution of

stratosphere, ozone layer, ozone hole and its consequences and control.

Soil pollution, loss of fertility and degradation of soils. Water pollution by organic wastes, its consequences, treatment and disposal. Eutrophication, the role of nitrogen and phosphorus and algal blooms. Oils spills & associated problems and clean up operations.

Noise, Radioactive and thermal pollution.

Ecosystem stability: Concept (resistance and resilience), ecological perturbation (natural and anthropogenic) and their impact on plants and ecosystem. Ecology of plant invasion. Environmental impact assessment, methods, the cost of damages and its estimation. Ecosystem restoration.

Ecological management: Concept, sustainable development and sustainability indicators.

Concepts of Phytogeography: Endemism, hotspots and hottest hotspots; plant explorations; invasions and introduction, local plant diversity and its socio-economic importance. Vegetation and floristic regions of India.

Eighth Paper : Plant resource utilization and Conservation.

UNIT: I

Plant diversity: Concept and status in India, utilization and concerns.

Sustainable development: Basic objectives, concepts and strategies. Sustainable use and management of biotic and abiotic resources.

Origin of agriculture.

World centers of primary diversity of domesticated plants: The Indo Burmese centre, plant introductions and secondary centre of origin.

Origin, evolution, botany, cultivation and uses of: 1.Food forage and fodder crops. 2.Fibre crops. 3.Medicinal plants and 4.Vegetable oil yielding crops.

Important fire-wood and timber yielding plants and non wood forest products (NWFP): Such as bamboo, rattans, raw materials for paper making, gums, tannins, dyes, resins and fruits.

Green revolution: Benefits and adverse consequences.
Plants used as avenue trees for shade pollution control and aesthetics.

UNIT: II

Principles of conservation. Extinctions. Environmental status of plants based on International Union for Conservation of nature.

Strategies for conservation: 1. In-situ conservation: Principles, practices, advantages and disadvantages. Ideal protected area, its requirements – sanctuaries, national parks, biosphere reserves, wetlands, mangroves, coral reefs. Short comings in the existing system. Management of a protected area. International efforts and Indian initiative. Protected areas in India for conservation of wild biodiversity. Conservation beyond parks, sanctuaries and reserves. Restoration of degraded habitat.

Strategies for conservation: 2. Ex-situ conservation: Principles, practices, advantages and disadvantages. Conservation of biological diversity in botanical gardens, field, gene-banks, seed banks, in-vitro repositories, cryobanks. Short comings and controversies. General account of the activities of Botanical survey of India (BSI), National Bureau of Plant Genetic resources (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR), The department of Biotechnology (DBT) for conservation, non-formal conservation efforts.

Ninth Paper: Physiology and Biochemistry.

UNIT:I

Plant Physiology and metabolism:

Structure of plant cell with special reference to functional aspects of cell, plasmamembrane, chloroplasts, mitochondria,

ribosomes, endoplasmic reticulum, golgi bodies, peroxysomes, vacuoles and nuclei.

Water relations: water movement (water potential, solute potential, pressure potential, diffusion, osmosis, electro-osmosis). Water relations of cell and tissues with reference to idealized cell with an elastic wall. Water movement through soil across roots, structure form and function of water, active and passive water absorption. Water movement through the vascular system of roots, stem and leaves with reference to the recent theories of ascent of sap.

Transpiration mechanisms: pathways of water vapour loss, (stomatal, cuticular, lenticular). Theories of stomatal movement, guttation, anti-transpirents, significance of transpiration.

Ionic relations: Ion transport and membrane structure (amphipathic membrane constituents, membrane protein and ion transport). Driving forces of ion (electrochemical potential gradient and diffusion, direction of active transport. Theories of ion uptake, active and passive uptake.

Mineral nutrition: a brief outline of micro and macronutrients and their deficiency symptoms.

UNIT:II

Photochemistry and Photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus. Photosynthetic pigments and light harvesting complexes, photo-oxidation of water, mechanisms of electron and proton transport. Carbon assimilation and the Calvin Cycle, photo-respiration and its significance, the C_4 cycle, and the CAM pathway physiological and ecological considerations.

Respiration and lipid metabolism: Overview of plant respiration, glycolysis, the TCA cycle, electron transport and ATP synthesis, pentose phosphate pathway, glyoxylate cycle, alternative oxidase system.

Nitrogen fixation, nitrogen and sulphur metabolism:
Overview, biological nitrogen fixation, nodule formation and nod

factor, mechanism of nitrate uptake and reduction, ammonium assimilation, sulphate uptake transport and assimilation.

Membrane transport and translocation of solutes: Comparison of xylem and phloem transport, phloem loading and unloading, membrane transport of proteins.

Plant growth regulators and elicitors: Physiological effects and mechanisms of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid, brassinosteroids, polyamines, jasmonic acid and salicylic acid , harmone receptors, signal transduction and gene expression.

Signal Transduction: Overview, receptors and G-proteins, phospholipids signaling, role of cyclic nucleotides, calcium-calmodulins cascade, diversity in protein kinases and phosphatases, specific signaling mechanisms, e.g., two component sensor-regulator system in bacteria and plants, sucrose-sensing mechanisms.

The flowering process: Photoperiodism and its significance, endogenous clock and its regulation, floral induction and development of genetic and molecular analysis, role of vernalization.

Stress physiology: Plant responses to biotic and abiotic stress, mechanisms of biotic and abiotic stress tolerance, water deficit and drought resistance, salinity stress, metal toxicity freezing and heat stress, oxidative stress.

UNIT:III

Biochemistry:

Fundamentals of Enzymology: General aspects, allosteric mechanism, regulatory and active sites isozymes, kinetics of enzymatic catalysis. Michaelis-Menten equation and its significance.

Energy flow: Principles of thermodynamics, free energy and chemical potential, redox reaction, structure and function of ATP.
A brief outline of classification, function and importance of carbohydrates and lipids.

Proteins: Structural organization, classification of aminoacids. Primary secondary and tertiary structure of proteins. Biosynthesis of Proteins.

Pigments: Chlorophylls, Phycobiliproteins, carotenes and xanthophylls. Biosynthesis of Chlorophyll a & b.
Chemistry and biosynthesis of Nucleic acids.

Tenth Paper: Special papers/ Project Work.

(X a) Advanced Plant Pathology.

(X b) Cytogenetics and Plant Breeding.

(X c) Advance Phycology.

(X d) Environmental Science.

(X e) Advanced Plant Pathology

(X a) Advanced Plant Pathology.

UNIT: I

1. History of plant Pathology. Concept and component of plant diseases. Types and causes of plant diseases.
2. Production and dispersal of inoculum and predisposition factors (Its development in relations to Environment)
3. Physiology of parasitism (Pre-penetration, penetration, post-penetration phase).
4. Role of Enzymes and toxins in disease development.
5. Defence mechanism (structural and biochemical).
6. Epiphytotics and disease forecasting.
7. Management of Disease: Prophylaxis and immunization. Plant quarantine, Physical methods of plant disease control. Biological control. Fungicides and Chemotherapy. Means of securing resistant varieties.
8. Preparation of media; Koch's postulates. Isolation, inoculation and pathogenicity.
9. Genetics of Pathogenesis.
10. Breeding for disease resistance.

UNIT: II

Plant diseases and their control:

Wheat: Rust (Black Yellow and Brown), Loose smut, Bunt, Alternaria leaf spot, Tondu, Ear cockle. **Barley:** Covered smut, Molya disease. **Paddy:** Blast disease, Helminthosporium leaf spot, false smut, bacterial leaf blight, bunt, khaira, pansukh (tip-burn), ufra disease. **Maize:** Smut. **Sorghum:** Grain smut, head smut. **Bajra:** Green ear disease, smut, ergot. **Gram:** Rust, Blight. **Pea:** Powdery mildew, rust. **Arhar:** Wilt, yellow mosaic. **Beam:** Anthracnose. Ground nut: Tikka disease. **Linseed:** Rust, wilt. **Brassica:** Club root, White rust, Alternaria blight. Sesamum: Phyllody. **Sugarcane:** Red rot, whip smut, red strip, grassy shoot, mosaic. **Potato:** Late blight, mosaic, leaf roll, brown rot. **Cotton:** Angular leaf spot wilt. **Tobacco:** Mosaic. Cucurbits: Downy mildew, powdery mildew, mosaic disease. **Cabbage:** Alternaria blight, root knot. **Tomato:** Blight, leaf curl. **Bhindi:** Yellow vein. **Brinjal:** Little Leaf. Coriander: Stem gall. **Turmeric:** Leaf spot (Taphrina maculans). **Chillies:** Anthracnose, die back, leaf curl. **Onion:** Smut. **Mango:** Anthracnose, black tip. **Grapes:** Downy mildew. **Papaya:** Leaf curl. **Banana:** Bunchy top and Panama disease. **Citrus:** Canker, curling gummosis.

(X b) Cytogenetics and Plant breading:

UNIT: I Cytogenetics.

Chromosomes: Structure and function normal prokaryotic and eukaryotic chromosomes, Karyotype analysis and their bearing on evolution. Chromosome banding patterns. Special forms of chromosomes: polytene, lampbrush, B-chromosomes and sex chromosomes. Cell cycle and behaviour of chromosomes during meiotic division, mechanisms and theories of crossing over, recombination models, cytological basis and role of synaptonemal complex.

Structural changes in chromosomes: Deficiencies and duplication, inversion and translocation, their cytological consequences, gene mapping and other uses.

Numerical variations in Chromosomes: Aneuploidy and Euploidy, classification, Cytogenetics, segregations, evolutionary significance and uses in basic and applied research. Synthesis of natural and new polyploids. Haploidy, Diploidic barriers and means to over come them.

Mendelian principles: Gene interactions, qualitative and quantitative characters, multiple allele hypothesis. Isoalleles, pseudoalleles and pleiotropism. Linkage, linkage detection and estimation in various organisms (Virus, Bacteria, Fungi and Eukaryotes). Mechanism of sex determination, sex-linked and sex influences and sex limited traits.

Modern concept of genes: Genetic material - nature, organization, fine structure of DNA, RNA. DNA content variations. Types of DNA sequences, unique and repetitive sequences. VNTRs minisatellites and microsatellites. DNA packaging in eukaryotic chromosomes, Genomics in prokaryotes and eukaryotes. Organelle genome, gene amplification and its significance. Mechanisms of DNA replication and recombination in prokaryotes and eukaryotes. DNA sequencing, split genes, alternative splicing, trans-splicing, pseudogenes, overlapping genes, nested genes.

Mechanism of transcription and its regulation in prokaryotes and eukaryotes, enhancers, suppressors, transcriptomes, transcription factors and their role. mRNA processing, ribozymes and RNA editing. Translation or protein synthesis in prokaryotes and eukaryotes, ribosomes, tRNA and translational factors, proteomics.

Genetic codes: gene regulation in prokaryotes and eukaryotes. Environmental influence on gene expression, transposones and their influence on gene expression.

Extra-chromosomal inheritance, interactions among nuclear, mitochondrial and chloroplast genomes.

Population genetics: Hardy Weinberg equilibrium, changes in genes and genotypes frequencies under selection, migration, mutation and genetic drift. Quantitative inheritance.

Mutation: a general account with special reference to gene

mutations. Experimental mutagenesis - physical and chemical mutagens and mode of their action. Somoclonal variations, biochemical mutations, frame shift. Repair of mutagenic damage. Screening techniques and selection procedures of induced mutations.

UNIT: II Plant breeding:

Methods and Objectives of Plant Breeding

Introduction, domestication and acclimatization. Patterns of evolution in crop plants. Centres of origin, gene pool, concept and gene introgression. Plant genetic resources, collection, evaluation and conservation of germ plasm. Gene banks.

Selection: different methods of selection, criteria of selection, selection limits, multitrait selection and construction of selection index.

Hybridization: Breeding methods of self, cross pollinated and vegetatively crops, pedigree and bulk selection. Mass selection, recurrent selection and population improvement. Breeding composite and synthetic populations. Methods of breeding for disease, pest and drought resistance.

Heterosis concept and theories. Inbreeding depression. Development and improvement of heterotic pools and inbreed lines. Genetics of self-incapatibility. Production of hybrid seeds. Male sterility and its restoration mechanisms in hybrid breeding. Genetic characteristic of pureline, inbred lines, hybrids, clones, mixtures and multilines composites and synthetics, their maintenance and multiplication. Heritability and genetic advance.

Mutation breeding and distant hybridization in plant breeding. Use of polyploidy in plant breeding.

Biotechnology and genetic engineering in relation to crop improvement.

Crop improvement in wheat, maize, paddy, sugar cane, pulses, oil seeds, potato and cotton with reference to work done in India.

(Ac) Advanced Phycology.

UNIT: I General Aspects:

1. Nature of Oceanic algal life.
2. Distribution pattern of marine algal forms on Indian sea coast.
3. Isolation, purification, culture and mass culture of algae.
4. Ecological habitats of algae, and influence of ecological factors on growth of algae.
5. Water blooms their importance in nature and control of algal nuisance.
6. Symbiotic associations with algae.
7. Biochemistry of algal pigments, reserve food material and cell wall composition.
8. Ultrastructure of algae of different phyla and modern systems of classification.

UNIT: II

1. Role of algae as food and fodder.
2. Role of algae in Industry.
3. Study of soil communities and role of terrestrial algae in relation to user land reclamation.
4. Role of algae in agriculture with reference to rice fields and biological nitrogen fixation.
5. Extra-cellular products of algae, growth promoting and growth inhibiting substances of algae with special reference to their role in the production of antibiotics.
6. Algae and environmental pollution with reference to water pollution and its role in municipal water supplies and industrial effluents. Algae as ecological indicators.
7. Sewage biology and role of algae in purification of sewage.
8. Effect of water pollutants especially industrial effluents on quantitative, qualitative growth and composition.

9. Study algal virus with special reference to isolation and assay of cyanophages.

10. Control of undesirable algae.

(X d) Environmental Science:

UNIT:I

A brief outline of earth's environment and its evolution.

Atmosphere, its structure, composition and characteristics.

Hydrosphere, the aquatic environment, lotic and lentic systems, their physio-chemical and biological characteristics

Lithosphere, its composition and characteristics. The rocks of earth's crust, their decomposition and the development of soil, its chemical and biological nature and properties.

Biosphere, its components, trophic structure and the impact of human activity on its constitution. Biological diversity, its importance, pattern of degeneration, causes and consequences of its diminution. Likely changes in future climate and their repercussions on the biological diversity and future course of evolution. Strategies for the conservation of biological diversity. A brief outline of the national and international conservation efforts being carried out by governments and non-government organizations.

Natural Resources: their types -fertile soils, fresh water, mineral and energy resources, live-stock, fisheries, forests and wild life) Finite nature of natural resources, their over exploitation and consequences thereof.

UNIT:II

Pollution of environment: Major types of pollutants - biodegradable, non-degradable and persistent pollutants. Metabolism and environmental fate of pollutants. Bio-accumulation, bio-magnification and degradation of waste material. Bio-geochemical cycles of carbon, oxygen, nitrogen, phosphorus sulphur and changes induced by man and

consequences thereof. Efforts being done to stabilize the biogeochemical cycles.

Air pollution: Meteorological conditions and air pollution. Major pollutants of the atmosphere (Oxides of carbon, nitrogen and sulphur, ozone, hydrocarbons and particulates), their origin, effects on plant and animal life and clearance from the atmosphere. Causes, consequences and control of Global warming, Stratospheric ozone depletion, Photochemical smog and Acids rain.

Water Pollution: Domestic effluents, their characteristics, primary secondary and tertiary methods of their treatment and disposal. Industrial effluents, their characteristics, treatment and disposal. Crude oil pollution, problems caused by oil spills and their clean up operations. Effects of water pollution on aquatic life. Effect of pollution on productivity of the aquatic system and recovery from pollution.

Soil pollution: Origin, behaviour, treatment and disposal of pollutants of the soil with special reference to municipal garbage, pesticides, heavy metals (Lead, Mercury, Cadmium, Chromium, Arsenic, Copper and lead). Mining and processing wastes. Biological aspects of sanitary land fills and composting.

Thermal and noise pollution: Its causes and consequences and impact on living systems.

Radio-activity, its persistence and affects on biological systems. Consequences of enhanced levels of radio-activity on the biosphere.

Environmental degradation, emergence of public awareness and evolution of National and International Legal Framework to prohibit activities leading to degradation of environment and wild life.

UNIT: III

Environmental Management: Sustainable development - objectives and strategies. Control of environmental pollution. Conservation of natural resources and wild-life.

Environmental monitoring: Monitoring of air, water and soil to assess the state deterioration of environmental quality. Biomonitoring and use of biological indicaters of environmental quality.

Exposure of biological systems to environmental contaminants, its fate, absorption, behaviour and elimination. Exposure risk and Environmental impact assessment.

Environmental Education and its necessity.

Scheme of M.Sc. Final Practical examination:

M.Sc Final practical examination shall be of 12 hours duration spread over two days and shall consist of a set of exercises of 150 marks for papers VI to IX and of 50 marks for special/elective papers/project work.

Time: 12 Hours **Max. marks: 200**

1	Discription of two plant specimen provided in semitechnical language and their assignment to their respective systematic position (up to family level) giving suitable sketches, reasons, floral formula and diagrams	4+4=8
2.	Preparation of double stained permanent slide of the angiospermic material. Description of the characters of anatomical interest. Identification giving reasons for the same.	8
..	One exercises on embryology/morphology	
5	One exercise on provided material with the help of sections to study features of ecological interest.	4
	One exercise on the ecological experiment provided or experimental data provided.	8
..	Two exercises or experiments on Environmental factors	4+4=8
.	One exercise on Physiological experiment to be set up and described by the candidate	16
.	Description of the principles involved and comments on one physiological experiment which has already been set.	5

9.	One exercise on biochemistry	6
10.	One exercise on morphology/anatomy/microchemical test on food and forage crop	6
11	One exercise on morphology/structure/microscopic study of any two fibres	4+4=8
12.	Comments, identification importance and uses of any two plants of medicinal value	4+4=8
13.	Practicals on Special/Elective Papers which shall consist of laboratory/field exercises, separate spotting and project work etc	50
14.	Spotting (4-10 spots each of 2 marks)	20
15.	Viva - voce	20
16.	Record/Collections/Field trip/Project work etc	30

SUGGESTED PRACTICAL EXERCISES FOR M.Sc. FINAL.

VI - Paper:

1. Detailed description and identification of locally available flowering plants of the families prescribed in theory course.
2. Study and observation on anatomy (normal and anomalous) of plant parts by sectioning, staining and preparation of permanent slides.
3. Preparation of smears for study of gametophytes and micro-dissections for study of embryos.
4. Study of various stages of reproduction in angiosperms from permanent slides.
5. Study of epidermal peels of Tradescantia /maize/wheat leaves etc. to understand trichomes, glands and stomata.
6. Study of leaf anatomy of C_3 and C_4 plants.
7. Study of live shoot apices by micro-dissections and sections.

VII - Paper:

1. Study of vegetation by point, transect and quadrant methods.
2. Study of environmental factors: Observations on selected physico-chemical parameters of air, water and soil quality.
3. Phytogeographical field trip to study natural vegetation of India.
4. Determination of water holding capacity of different types of soils.
5. Estimation of chlorophyll content in SO_2 fumigated and unfumigated leaves.

VIII - Paper:

1. **Food crops:** Morphology, anatomy and micro-chemical tests for stored food material in wheat rice maize, chick pea (Bengal gram), potato, tapioca, sweet potato and sugar cane.
2. **Fodder crop:** Study of any five important fodder crops of the locality.
3. **Medicinal plants:** Study of live or preserved or herbaria specimen or charts and photographs of the following medicinal plants to familiarize the students with the resource concerned:
   Papaver somniferum, Atropa belladonna, Catharanthus roseus, Adhatoda zeylanica (syn Asaatra), Allium sativum, Rauvolfia serpentina, Withania somnifera, Phyllanthus amarus, Andrographis paniculata, Aloe barbadense, Mentha arvensis, Rosa sp. Pogostemon cablin, Origanum vulgare, Vetiveria zizanioides, Jasminum grandiflorum, Cymbopogon sp. Pandanus odoratissimus.
4. **Vegetable oils:** Study of morphology and microscopic structure of oil yielding tissues of mustard, groundnut, soyabean, coconut, sunflower, castor etc. and determination of saline number.

5. **Fibres:** Morphology anatomy and microscopic study of whole fibre, using appropriate staining procedures of cotton, jute, linen, sun-hemp, coir and silk.
6. Observations on tissues associated with production of gums, resins, tannins and dyes.
7. Minor project and field survey and visits to research laboratories. The students are expected to write a well illustrated report on the same.

IX - Paper:

1. To find out the O.P. of plant cell by plasmolytic methods.
2. To determine the D.P.D. (Water potential) of Potato tuber tissues by weighing method.
3. To determine the D.P.D. of storage tissues by density method.
4. To determine the structure size and frequency of stomata in mesophytic and xerophytic leaves.
5. To determine the rate of transpiration of plant twig: 1.Weight, 2.Potometer method.
6. To determine the rate of transpiration by Cobalt chloride method and to calculate transpiration index, transpiration efficiency of various leaves.
7. To study the effect of various factors on transpiration.
8. To measure the rate of photosynthesis in aquatic plants by Willmotts's bubble counting method.
9. To study the effect of different factors on the rate of photosynthesis in aquatic plants.
10. To study the effect of different factors on the rate of photosynthesis in leaves of land plant.
11. To extract major plant pigment from green leaves by differential solubility method.
12. To determine the chlorophyll a / chloro[illegible] ratio in C_3 and C_4 plants.

13. To determine the Q_{10} for photosynthesis at two light intensities.
14. To compare the RQ of different plant material.
15. To separate the major plant pigments by paper chromatography.
16. To estimate the pigment content of plant tissues by Colorimetric method.
17. To extract free amino acids from germinating seedling by two dimensional paper chromatography.
18. To measure the amylase activity in germinating bean seedlings and to study the effect of substrate concentration, pH and temperature on enzymes.
19. To measure the activity of enzyme catalase by titration method.
20. To extract and test the presence of reducing sugars by Benedict Test.

X - Paper: Special Papers/Elective papers/Projects

(X a)- Advanced Plant Pathology:

1. A study of symptomology, histopathology and identification of pathogen included in the course.
2. A study of symptomology of bacterial, viral and MLO diseases.
3. Methods of culture media preparation, sterilization and isolation of pathogens.
4. Inoculation and pathogenicity experiments.
5. Measurement of fungal spores.
6. Viral disease, mechanical transfer experiment.
7. Use of biological and chemical fungicides for disease control.
8. Demonstration of plant protection appliances.
9. Field collection of diseased plants and preparation of related projects.

(X b)- Applied Cytogenetics and Plant Breeding.

1. Exercises on meiosis and trisomy and plant genotype, fertility and meiotic behaviour.
2. Meiosis of complex translocation heterozygotes.
3. Problems on Mendelian and non-Mendelian inheritance.
4. Problems on Gene-interaction, linkage and gene mapping.
5. Analysis of quantitative inheritance.
6. Identification of various stages of meiosis, study of dinkinesis.
7. Demonstration of crossing over/chiasmata.
8. **Karyotypic studies:** preparation of mitotic metaphase plates and drawing camera lucida drawing of chromosomes and study of chromosome morphology.
9. Cytological analysis of haploids (maize as a model crop).
10. Analysis of chromosome pairing in wheat and Rye hybrids.
11. Male sterility detection and maintenance of self-incompatibility.
12. Estimation, heritability, genetic advance and variance with the help of given data.
13. Study of floral biology in relation to pollination in the available crop plants.

(X c)- Advanced Phycology:

1. Analytical study of Physical and Chemical characteristics of water and soils.
2. Culture and mass culture aspects of algal flora.
3. Isolation and identification of two components from a given algal mixture and comments on their economic importance.
4. Camera-lucida diagrams of algae with their measurements and identification of the species.
5. Project work on a Seasonal variations in algal flora of

aquatic bodies, b. Influence of industrial effluents on growth and composition of algal flora, c. Maintenance of culture and mass culture of selected algae, d. Report on excursion trips for fresh water or marine algal forms.

IX d):- Environmental Science:

1. An Analysis of physicochemical parameters of environmental quality (air, water and soil) with reference to selected parameter.
2. Biological examination of polluted water: 1.Microscopic examination, 2.Microbial examination.
3. Project work on the allotted topic which shall involve collection of information, data, related to the local problems of environment, wildlife and its conservation.
4. Comparative study of floristic/morphological/anatomical characteristics of vegetation/plants from polluted and localities.
5. Seasonal variations in the biological/physicochemical quality of water from different localities.
6. Study of air microflora and particulate material in different seasons of the year.

BOOKS SUGGESTED FOR M.Sc. Part II.

Annonymous 1997, National Gene Bank. Indian Heritage on Plant Genetic Resources (Booklet). National Bureau of Plant Genetic Resources, New Delhi.

Annonymous, 1993, The Plant Cell. Special Issue on Reproductive Biology of Plants. The American society of Plant Physiologists, Rockville, Maryland, USA.

Arora R.K., Nayer E.R., 1984, Wild relatives of crop plants in India, NBPGR science Monographs No.7

Asthana D.K. and Asthana M., 2001, Environment: Problems and Solutions. 2nd Edition, S.Chand and Co. New Delhi.

Atwell B.J., Kriedermann P.E., Turnbull C.G.N. (Eds), 1999, Plants in Action: Adaptation in Nature, Performance in Cultivation. McMillan Education, Sydney Australia.

Bajracharya D., 1999, Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.

Baker H.G., 1978, Plants and Civilization (3rd Ed.) C.A.Wadsworth, Belmont.

Begon M., Harper J.L., Townsend C.R., 1996, Ecology. Blackwell Scientific Publications, Cambridge, USA.

Bewley J.D., Black M., 1994, Seeds: Physiology of Development and germination. Plenum Press, NY.

Bhojwani S.S., Bhatnagar S.P., 2000, The Embryology of Angiosperms (4th Ed.), Vikas Publishing House, New Delhi.

Bhojwani S.S., Razdan M.K., 1996, Plant Tissue culture: Theory and Practice (Revised Ed.) Elsevier Science Publishers, NY, USA.

Bole P.V., Vagham Y., 1986, Field guide to common Indian Trees. Oxford University Press, Mumbai.

Brady N.C., 1998, The Nature and Properties of Soils. MacMillan.

Brown T.A., Genomes. John Wiley & Sons (Asia) Pvt. Ltd. Singapore.

Buchanan B.B., Gruissem W., Jones R.L., 2000, Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.

Burgess J., 1985, An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.

Chandel K.P.S., Shukla G., Sharma N., 1996, Biodiversity in Medicinal and Aromatic Plants in India: conservation and Utilization. Natiom Bureau of Plant Genetic Resources, New Delhi.

Chopra V.L., 2001, Plant Breeding: Field Crops. Oxford IBH Pvt. Ltd. New Delhi.

Chopra V.L., 2001, Plant Breeding: Theory and Practice. Oxford IBH Pvt. Ltd. New Delhi

Chrispeels M.J., Sadava D., 1977, Plants Food and People. W.H.Freeman and Co. San Francisco.

Cole A.J., 1969, Numerical Taxonomy, academic Press, London

Conway G., 1999, The Doubly Green Revolution: Food for all in 21st Century. Penguin Books.

Conway G., Barbier E., 1994, Plant, Genes and Agriculture Jones and Bartlett Publishers, Boston.

Cooper T.G., 1977, Tools in Biochemistry. John Wiley, New York, USA.

Davis P.H., Heywood V.H., 1973, Principles of Angiosperm Taxonomy. Robert E. Kreiger Pub. Co., NY

Dennis D.T., Turpin D.H., Lefebvre D.D., Layzell D.B. (Eds.) 1997, Plant Metabolism (2nd Edn.) Longman, Essex, London

Devi P. 2000, Principles and Methods of Plant Molecualar Biology, Biochemistry and Genetics. Agrobios Jodhpur India.

Dryer R.L., Lata G.F., 1989, Experimental Biochemistry. Oxford University Press, NY.

Faegri K., Van der P.J.J. L., 1979, Principles of Pollination Ecology.
Pergamon Press, Oxford

Fahn A. 1982, Plant Anatomy (3rd Edn). Pergamon Press, Oxford

Fosket D.E., 1994, Plant Growth and Development - A molecular Approach. Academic Press San Diago

Frankel O.H., Brown A.H.D., Burdon J.J., 1995, The Conservation of Plant Diversity. Cambridge University Press, Cambridge.

Galston A.W., 1989, Life Processes in Plants. Scientific American Library, Springer-Verlag, NY. USA.

Grant V., 1971, Plant Speciation. Columbia University Press, NY

Grant W.F., 1984, Plant Biosystematics. Academic Press, London

Harrison H. J., New Concepts in Flowering Plant Taxonomy. Heinman Educational Books Ltd., London.

Hanlop-Harrison J., 1967. Plant Taxonomy. English Language Book Soc. & Edward Arnold Pub. Ltd. UK.

Heywood V.H., Moore D.M., 1984, Current concepts in Plant Taxonomy. Academic Press London

Heywood V.H., Watson R.T., 1995, Global Biodiversity Assessment. Cambridge University Press.

Hill M.K., 1997, Understanding Environmental Pollution. Cambridge University Press, Cambridge.

Horvakaas P.J.J., Hall M.A., Lebbbenga K.R.(Eds.), 1999, Biochemistry and Molecular Biology of Plant Harmones. Elsevier, Amsterdam, The Netherlands.

Hopkins W.G., 1995, Introduction to Plant Physiology. John Wiley & Sons Inc. NY,USA

Howell S.H., 1998, Molecular Genetics of Plant Development Cambridge University Press, Cambridge

Jones A.D, Wilbins A.D., 1971, Variations and Adaptations in Plant Species. Heinmann & Co., Eucational Books Ltd. London

Jones S.B.Jr., Luchsinger, A.E., 1986, Plant Systematics (2nd Edn.), McGraw-Hill Book Co. NY.

Kormondy J.L., 1996, Concepts of Ecology. Prentice-Hall of India Pvt. Ltd. New Delhi

Kothari A., 1997, Understanding Biodiversity: Life sustainability and equity. Orient Longman

Krebs C.J., 1989, Ecological Methodology. Harper and Row, NY

Lona P., Tucker S.C., Endress P.K., 1988, Aspects of Floral Development. J.Cramer, Germany.

Lodish H., Berk A., Zipursky S.L., Matsudaira P., Baltimore D., Darnell J., 2000, Molecular Cell Biology. Freeman and Co., NY.

Lyndon R.F., 1990, Plant Development: The Cellular Basis. Unwin Hyman, London.

Magurran A.E. 1988, Ecological diversity and its measurement. Chapman and Hall, London.

Mason C.F., 1991, Biology of Freshwater Pollution. Longman.

Misra R. 1968. Ecology Workbook. Oxford & IBH, New Delhi.

Mohlen B., Bilfhartz S., 1997, Sustainability Indicators. John Wiley & sons, NY.

Moore P.W., Chapman S.B., 1986, Methods in Plant Ecology. Blackwell Scientific Publications.

Moore T.C., 1974, Research Experiments in Plant Physiology: A Laboratory Manual. Springer Verlag, Berlin.

Moore T.C., 1989, Biochemistry and Physiology of Plant Harmones (2nd Edn.) Springer Verlag, NY.

Muller-Dombois D., Ellenberg H., 1974, Aims and Methods of vegetation ecology. Wiley, New York.

Murphy T.M., Thompson W.F., 1988, Molecular Plant Development, Prentice Hall, New Jersey.

Nobel P.S., 1999, Physiochemical and Environmental Plant Physiology. (2nd Edn.), Academic Press.

Nordenstam B., El Gazally G., Kanssas M., 2000, Plant Systematics for 21st Century. Portland Press Ltd. London.

Odum E.P., 1971, Fundamentals of ecology. Saunders, Philadelphia.

Odum E.P., 1983, Basic Ecology. Saunders, Philadelphia.

Pielou E.C. 1984, The Interpretation of ecological data. Wiley, New York.

Plummer D.T., 1988. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co Ltd. New Delhi.

Proctor M., Yeo P., 1973, The Pollination of Flowers. William Collins Sons, London.

Purohit S.S., 2002, Agricultural Biotechnology. (2nd Edn.) Agrobios, Jodhpur.

Radford A.E., 1986, 1986, Fundamentals of Plant Systematics. Harper & Row Publications, USA.

Raghavan V., 1997, Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.

Raghavan V., 1999, Developmental Biology of Flowering Plants (5th Edn). Worth, New York.

Salisbury F.B. and Ross C.W., 1992, Plant Physiology. 4th Edn. Wadsworth Publishing Co California. San Diago, USA.

Sedgely M., Griffin A.R., 1989, Sexual Reproduction of Tree Crops. Academic Press, London.

Shivanna K.R., Johri B.M., 1985, The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd. NY.

Shivanna K.R., Rangaswamy N.S., 1992, Pollen Biology: A laboratory Manual. Springer-Verlag, Berlin.

Shivanna K.R., Sawhney V.K.(Eds), 1997, Pollen Biotechnology for crop production and improvement. Cambridge University Press, Cambridge.

Singh H., 1978, Embryology of Gymnosperms. In Encyclopaedia of Plant Anatomy X. Gebruder Bortraeger, Berlin.

Singhal G.S., Renger G., Sopor S.K., Irrgang K.D., Govindji, 1999, Concepts in Photobiology:Photosynthesis and Photomorphogenesis,. Narosa Publishing House. New Delhi.

Smith R.H., 2000, Plant Tissue Culture, Techniques and Experiments. Academic press NY.

Smith R.L., 1996, Ecology and Field Biology. Harper Collins, NY.

Solbrig O.T., Solbrig D.J., 1979, Population Biology and Evolution. Addison-Wesley Publicating Co. Inc. USA.

Stace C.A. 1989, Plant Taxonomy and Biosystematics (2nd Edn.) Edward Arnold Ltd. London.

Stebbins G.L., 1974, Flowering plant - Evolution above species level. Edward Arnold Ltd. London

Steeves T.A., Sussex I.M., 1989, Patterns in Plant Development (2nd Edn.) Cambridge University Press Cambridge

Taiz L., Zeiger E., 1998. Plant Physiology (2nd Edn.) Sinauer associates Inc. Publishers. Massachusetts.

Takhtajan A.L., 1997, Diversity and Classification of Flowering plants. Columbia University Press, NY

Thomas B., Vince-Prue D. 1997, Photoperiodism in Plants (2nd Edn.) Academic Press, San Diago, USA.

Treshow M., 1985, Air Pollution and Plant Life. Wiley Interscience.

Waisel Y., Eshel A., Kafkaki U. (Eds.), 1996, Plant Roots: The Hidden Half (2nd Edn.) Marcel Dekker NY

Walter K.S., Gillet H.J. 1998, 1997 IUCN Red List of Threatened Plants. IUCN. The world Conservation Union. Gland Switzerland and Cambridge, UK.

Westhoff P., 1998, Molecular Plant Development: From Genes to Plant. Oxford University Press, Oxford, UK

Wilson K., Walker J., 1994, Practical Biochemistry. Principles and Techniques (4th Edn.) Cambridge University Press, Cambridge, UK.

Woodland D.W., 1991, Contemporary Plant Systematics. Prentice Hall, New Jersey

C.S.J.M. UNIVERSITY, KANPUR

M.Sc. Pre. - Zoology

ZOOLOGY

PAPER I	Structure and function of invertebrates	80 marks
PAPER II	Tools & Techniques for Biology, and Biotechnology	80 marks
PAPER III	Molecular Biology and Molecular Cytogenetics	80 marks.
PAPER IV	Animal behaviour and Wildlife Conservation and Management	80 marks
PAPER - V	Biostatistics and Population Ecology	80 Marks
PRATICAL EXAMINATION		200 marks

PAPER - I Structures and functions of Invertebrates.

Note: Attempt any four questions. All questions carry equal marks.

1. **Principles of Animal Taxonomy.**
   - (i) Species concept, international code of Zoological nomenclature.
   - (ii) Taxonomic procedures, new trends in taxonomy
   - (iii) Animal collection, handling & preservation

2. **Organization of coelom**
   - (i) Acoelomates
   - (ii) Pseudocoelomates
   - (iii) Coelomates, protostomia & Deuterostomia

3. **Locomotion**
   - (i) Flagella & ciliary movement in Protozoa

(iii) Hydrostatic movement in Coelenterate, Annelid & Echinoderm

4. **Nutrition & Digestion**
   (i) Patterns of feeding & digestion in lower metazoan
   (ii) Filter feeding in Polychaeta, Mollusca & Echinoderm.

5. **Respiration**
   (i) Organs of respiration; Gills, Lungs & trachea
   (ii) Respiratory pigments
   (iii) Mechanism of Respiration.

6. **Excretion**
   (i) Organs of excretion; coelom, coelomoducts, nephridia & Malpighian tubules.
   (ii) Mechanism of excretion.
   (iii) Excretion & osmoregulation

7. **Nervous system**
   (i) Primitive nervous system; coelenterate and Echinodermata
   (ii) Advanced nervous system: Annelids, Arthropods (crustaceans & insects) & mollusks (cephalopod)
   (iii) Trends in neural evolution

8. **Invertebrate Larvae**
   (i) Larval forms of free living invertebrates.
   (ii) Larval forms of parasites.
   (iii) Strategies and evolutionary significance of Larval forms.

9. **Minor Phyla**
   (i) Concept and significance.
   (ii) Organization & General Characters

Recommended Books

Hyman, L.H. The invertebrates. Vol. I Protozoa through ctenophora. McGraw Hill Book Co. New York .

The invertebrates. Vols. II, V and VIII. McGraw Hill Book Co. New York

Barrington, E.J.W. Invertebrate structure and function, Thomas Nelson and Sons Ltd. London

Jargenstern, G. Evolution of metazoan life cycle. Academic Press, New York and London

Barnes, R.D. Invertebrate Zoology. IIEedition. W.B.Saunders Co., Philadelphia.

Russel - Hunter, W.D. A biology of higher invertebrates, MacMillan Co. Ltd., London

Read, C.P. Animal Parasitism, Prentice Hall

Parker, T.J. and Haswell, W.A. Text Book of Zoology, Vol. I

PAPER - II: Techniques & Tools for Biology, and Biotechnology.

Note: Attempt four questions in all, two questions from each section, each question carries equal marks.

Unit I. Techniques and Tools for Biology

1 Principle of spectrophotometers, both UV and visible (Beer Lambert Law), pH meter and GM counter.

2 Microscopy : Light, phase contrast, transmission and scanning electron microscope, fluorescence microscopy

3 Histological techniques : Fixation, tissue processing, various embedding techniques Microtomes and their application in routine wax section cutting Principle and practice of double and triple staining

5 Photomicrography, its application and utility in biological research

4. Microbiology - General precautions in preparation of microbiologic media; Inoculation and growth curve of bacteria, Biological mutants and their significance
5. Cryotechniques - Principle of cryopreservation
6. Separation techniques - High speed and ultracentrifugation

   Analytical and preparative centrifugation

   Chromatography - Ion exchange, gel filtration, affinity chromatography.

   Electrophoresis

   Flow cytometry
7. Autoradiography, liquid scintillation counter, and Cerenkov radiation, RIA ELISA

Biotechnology Unit - II

1. Scope and importance of biotechnology.
2. Tools of genetic engineering in health & medicine
3. Hyb - doma technology
4. DNA recombination and expression in bacterial cell cloning, finger prints
5. Cell and tissue culture in animals - cell line, primary culture, cell colonies.

Books recommended

John R.W. Masters (ed) Animal cell culture - A practical approach, Ed. IRL Press

Robert Braun, Introduction to instrumental analysis. Mac Graw Hill International Edition

K. Wilson and K.G. Goulding A biologists guide to principals and techniques of practical biochemistry, ELBS ed

R.W. Old and S.B. Primrose. Principles of gene manipulation: an introduction to genetic engineering

R.A.Meyers (Ed.), Molecular biology and biotechnology. VCH Publishers

Glick, Molecular biotechnology

M.D.Trevan et al. Biotechnology : The biological Principle. Tata MacGraw - Hill Co. Ltd, New Delhi

John E. Smith Biotechnology, III ed. Cambridge University Press

PAPER - III : Molecular Biology & Molecular cytogenetics

Note: Attempt four questions in all, two questions from each section; each question carries equal marks.

Unit-I (Molecular Biology)

1. Structure of DNA - A, B and Z DNA
2. 3 -D Structure of tRNA
3. DNA replication, emphasizing on role of various enzymes involved, in prokaryotic cells and its differences from eukaryotic cells; plasmids.
4. Prokaryotic transcription with special reference to lac operon
5. Post transcriptional modifications - 5' capping, 3-polyadenylation, splicing
6. Genetic code and Wobble's hypothesis
7. Mechanism of initiation, elongation and termination of transcription
8. Translation in prokaryotes and translational machinery.
9. Post transcriptional modification, molecular chaperones
10. DNA damage and repair, Xeroderma pigmentosum, mismatch repair and base excision repair.

Unit II - Molecular Cytogenetics

10. Organisation of DNA in chromosome, chromatin organisation, solenoid organization
11. Structure of metaphase chromosome with special reference to importance of kinetochore and telomere
12. Heterochromatin - facultative and constitutive
13. Euchromatin and C - value paradox
14. Polytene chromosomes and lamp - brush chromosomes and their significance
15. Sex determination in insects and mammals, dosage compensation
16. Human chromosome karyotype
17. Banding in chromosomes : G, C, Q, R banding
18. Structural and numerical aberrations and their significance - nullisomy, trisomy, polyploidy and related syndromes.
19. Heritable diseases in humans viz haemophilia, colour blindness, albinism etc.
20. Human genome project and formation of genomic DNA library
21. Impact of ionising and non - ionising radiation on genes and chromosomes
22. Linkage, two point test cross
23. Cancer - protooncogenes and oncogenes

Books recommended

Atherly, A.G., J.R. Girlten, J.F. MacDonald. The science of Genetics. Saunders College Publishing. Harcourt Brace College Publishers, New York.

Brooker, R.J. Genetics: analysis and principles, Benjamin/Cummings, Longman, Inc

Gardener, E.J., M.J. Simmons and D.P. Snustad. Principles of genetics. John Wiley and Sons, New York.

Lewin, B. Genes VI. Oxford University Press, Oxford, New York, Tokyo

Watson J.D. et al. Molecular Biology of genes. The Benjamin/Cummings Publishing Co. Inc., Tokyo

J.Darnell, H.Lodish and D.Baltimore. Molecular Cell Biology. Scientific American Books, W.H.Freeman, N.Y.

Benjamin Lewin. Genes VI. Oxford University Press, New York

P.D. Dabre. Introduction to Practical Molecular Biology. John Wiley and Sons Ltd. New York

PAPER - IV : Animal behaviour & Wild life Conservation and Management

Note: Attempt four questions in all, two questions from each section; each question carries equal marks.

Unit I (Animal behaviour)

1. Ethology as a branch of biology, innate behaviour
2. Perception of the environment - Mechanical, Electrical, Chemical of factory, auditory and visual
3. Neural and hormonal control of behaviour
4. Genetic and environmental components of behaviour
5. Communication - chemical, visual, light, audio, species specificity of songs, evolution of language (Primates).
6. Ecological aspects of behaviour
   - 6.1 Habitat selection, food selection, optimal foraging theory anti predator defenses.
   - 6.2 Aggression, homing, territoriality, dispersal most parasite relations.
7. Social behaviour
   - 7.1 Aggregations - Schooling in fishes, flocking in birds, herding in mammals

7.2 Group selection, kin selection, altruism, and inclusive fitness

7.3 Social organization in insects and primates

Reproductive behaviour - Courtship, sexual selection, parental care

Biological rhythms -

9.1 Circadian and circannual rhythms

9.2 Orientation and navigation

9.3 Migration of fish, turtles and birds

Learning and memory - Conditioning, Habituation, insight learning, association learning, Reasoning

Unit II Wild life conservation and management

Wild life as a resource

Wild life action plan and its implementation.

Wild life conservation - In situ and ex-situ

Protected area classification (National parks, sanctuaries) and management

Management of endangered species

5.1 Project Tiger

5.2 Project Elephant

5.3 Project crocodile

5.4 Rhinoceros

Conservation strategies

IUCN - Criteria and technology

CITES, IBWL, WWF, WII

Wild life (Protection) Act 1972

7.1 Salient features.

7.2 Short comings of the Act

7.3 Amendments 1991

8. Administrative framework

8.1 Wild life advisory board

8.2 Chief wild life warden and power

8.3 Central zoo authority

Books recommended

Wilson, E.O. Sociobiology: the new synthesis. Harvard University Press, Cambridge, Massachusetts, USA

Hinde, R.A. Animal Behaviour: a synthesis of ethology and comparative psychology, McGraw-Hill, New York

Alcock, J. Animal Behaviour : An evolutionary approach. Sinauer Association, Sunderland, Mass. USA

Gadkar, Stategies for survival

Krebs, J.R. and N.B.Davies, Behavioural ecology, Blackwell, Oxford, U.K.

Saharia, Wild life of India

Dasmann, Wildlife biology

Paper V- Biostatistics and Population Ecology

Note: Attempt four questions in all, two questions from each section; each question carries equal marks.

Unit I Biostatistics

1 Definition of population sample, random sample presentation of data in form of graphs, line charts pie-charts, bar- graphs and histograms

2 Measure of Central Tendencies - Mean, Median & Mode.

3 Measure of dispersion - ranges, mean deviation, variance standard deviation, standard error, coefficient of variation, correlation.

4. Test of significance - T- test, Chi-square test
5. Probability distribution, and their properties
6 Hypotheses testing
7 Analysis of variance
8 Correlation

Unit II - Population Ecology.

1 Demography - Life tables, generation time, net reproductive rate, reproductive value.

2. Population growth.
   - 2.1 Growth of organisms with non-overlapping generations.
   - 2.2 Exponential growth, Verhist - Pearl logistic growth model
   - 2.3 Stochastic and time lag models of population growth.

3 Predation
   - 3.1 Models of prey-predatory dynamics.
   - 3.2 Rate of predation in nature.

4. Competition and Niche Theory
   - 4.1 Intraspecific and interspecific competition
   - 4.2 History of niche concepts.
   - 4.3 Theory of limiting similarity.

5. Mutualism
   - 5.1 Evolution of mutualism.
   - 5.2 Animal - animal interactions.
   - 5.3 Basic models.

6 Population regulation - Extrinsic and intrinsic mechanisms

Books Recommended

Sokal, R.R. and F.J. Rohlf. Biometry, Freeman, San Francisco, USA

Snedecor, G.W. and W.G. Cochran. Statistical Methods. Affiliated East - West Press, New Delhi

Began, M. et al. Ecology, Individuals, Populations and Communities. Blackwell Sci. Publi. Oxford, U.K.

Elseth, R.D. and K.M.Baumgartner. Population biology. Van Nostrand Co. New York

Krebs, C.J. Ecological methodology. Harper and Row, New York

M.Sc. Previous Zoology - Syllabus for Practical Examination

Note: The practical examination will be of 200 marks and the examination shall be spread over two days, with one session of five hours each day. Each candidate will submit a complete record of his practical work with collection, slides and preparations.

Both internal and external examiners will work in mutual consultation and cooperation during evaluation. The division of marks shall be as follows:

First Day Examination

1.	Dissection	20 marks
2.	Preparation of block of material provided in absolute alcohol/xylene	15 marks
3.	Section cutting and spreading	10 marks
4.	One permanent mount	05 marks
5	Ten spots (lower non chordates only) for identification and comments	20 marks
6.	One exercise on genetical problems	10 marks
7	One bio-statistic problem	10 marks
8	Viva voce test	10 marks
	TOTAL	100 marks

Second day Examination

1.	Dissection	15 marks
2.	Exercise on ecology / behavior	10 marks
3.	One cytological preparation	10 marks
4.	Staining of first days microtomic slide	05 marks
5.	Ten spots for identification and comments (higher non-chordates only)	20 marks
6.	Specific comments on any two instruments (tools, apparatus)	10 marks
7.	Viva voce test	10 marks
8.	Practical record	20 marks
	TOTAL	100 marks

Contents

Dissections - Nervous systems of Mytilus, Sepia, Loligo, Aplysia, Squilla Sea urchin (Aristotle'Es lantern), Holothuria (General anatomy)

Exercises on Methodology - a. Instructions on and practice of use of common biological instruments such as various light microscopes with sketching techniques, photomicrography, chromatography, electrophoresis,

pH meter, and colorimeter etc depending on availability

b. Culture methods

c. Methods of studying biometrics of living animals

d. Preparation of fixatives, stains and other reagents.

Microtomy - Preparation of blocks, section cutting by wax method and staining of vertebrate and invertebrate tissues.

Mounts - Preparation of permanent stained mounts of various preserved mounting materials (to be provided) and also from the material collected by the students.

Spotting - Study of important prepared slides, museum specimens including those prescribed for B.Sc., classification will follow as already taught in B.Sc.

Genetical problem - a. Test cross, b. back cross, c. dihybrid cross d. Multiple alleles, e. Sex linked inheritance, f. gene interaction.

Behavior - Orientation behaviour, phototaxis in earthworm and housefly, geotaxis in earthworm, chemotaxis, phototaxis in frog, olfactory behaviour in housefly.

Cytological Preparations i) Preparation of chromosomes from onion root tip, pollen mother cells (anther), testes of frog, and testes of grasshopper.

Biostatistics (Biometry) - a. Presentation of data in form of frequency table (direct variable continuous variable);

b. Measures of central tendencies (arithmetic mean, median mode, Standard deviation and numerical based on them).

c. Mean deviation, test of significance (t and χ^2 test) and numerical problems based on them and correlation coefficient

Books, as prescribed for related topics will apply here for assistance in M.Sc. practical as well

C.S.J.M. UNIVERSITY, KANPUR

ZOOLOGY

M.Sc. Final Zoology

PAPER - I Comparative Anatomy of vertebrates' (Compolsory)	80 marks
PAPER II Animal Physiology, Metabolic regulation and cell function (Compulsory)	80 marks
PAPER - III Gamete Biology and Developmental Biology (Compulsory)	80 marks
SPECIAL PAPERS (optional)	
PAPER - IV Special Paper	80 marks
PAPER - V Special Paper	80 marks
PRACTICAL EXAMINATION	200 marks

SPECIAL BRANCHES:

A Ichthyology
B Entomology
C Parasitology
D Cytogenetirs
E Endocrinology
F Environmental Biology & applied Ecology

PAPER - I: Comparative Anatomy of Vertebrates

Note: Attempt four questions in all, two questions from each section; each question carries equal marks.

1. Origin of chordates
   (i) Concept of protochordata
2. Origin and classification of vertebrates.
3. Vertebrate integument and its derivatives

   (i) Development general structure and function of skin and its derivatives.
   (ii) Glands, scales, horns, claws, nails, hoofs, feathers and hair.
4. General plan of circulation in various groups.
   (i) Blood (ii) Evolutions of heart (3) Evolution of aortic arches and portal systems.
5. Respiratory system
   (i) Characters of respiratory tissue
   (ii) Internal & External respiration
   (iii) Comparative account of respiratory organs.
6. Skeletal system:
   (i) Form, function, body size and skeletal elements of the body.
   (ii) Comparative account of jaw suspensorium, vertebral column.
   (iii) Limbs & girdles
7. Evolutions of urinogenital system in vertebrate services
8. Sense organs & function)
   (i) Simple receptors
   (ii) Organs of olfaction and taste
   (iii) Lateral line system.
   (iv) Electro reception.
9. Nervous system
   (i) Comparative anatomy of the brain in relation to its functions.
   (ii) Comparative anatomy of spinal cord.
   (iii) Cranial nerves, peripheral & autonomous nervous systems.

Books recommended

Alexander, R.M. The Chordata. Cambridge University Press, London

Barrington, E.J.W. The Biology of Hemichordata and Protochordata. Oliver and Boyd, Edinburgh

Kingsley, J.S. Outlines of comparative anatomy of vertebrates. Central Book Depot, Allahabad

Srivastava, MDL. Comparative anatomy of vertebrates, Central Book Depot, Allahabad

Milton Hilderbrand. Analysis of vertebrate structure. IV ed. J Wiley and Sons, New York.

Romer, A.S. Vertebrate Body. W.B.Saunders Co. Philadelphia

Young, J.Z. Life of vertebrates, Oxford University Press, London

Life of Mammals. ——————do——————

Colbert, E.h. Evolution of vertebrates. J.Wiley and Sons, NY

Montagna, W. Comparative anatomy. J.Wiley and Sons, NY

PAPER - II: Animal physiology, metabolic regulation and cell function

Note: Attempt four questions in all, two questions from each section; each question carries equal marks.

Unit - I, Animal Physiology.

1. Aims and scope of animal physiology.
2. Respiratory organs and respiratory pigments.
3. Patterns of nitrogen excretion among different animal groups
4. Osmoregulation in different animal groups
5. Thermoregulation
   (i) Homoeothermic animals
   (ii) Poikilotherms

   (iii) Hibernation.
6. Communication among animals
   (i) Bioluminescence
   (ii) Pheromones and other semiochemicals.
   (iii) Audio signals
7. Contractile elements, cells and tissues.
   (i) Muscle structure and function.
   (ii) Movements - amoeboid, ciliary and flagellar
8. Chromatophores and regulation of their function.

Unit - II

(Metabolic regulation and cell function)

1. Thermodynamics principles and steady - state conditions of living organisms.
2. Degradation of glucose, palmitic acid and amino acids.
3. Energy metabolism and high-energy compounds
   (i) Redox potentials
   (ii) Mitochrondrial electron transport chain
   (iii) Oxidative phosphorylation.
4. Biosynthesis of urea, aspartic acid, glucose, glycogen and prostaglandins.
5. Nature of Enzymes -
   (i) Classification and nomenclature of enzymes.
   (ii) Kinetic analysis of enzyme catalyzed reactions.
   (iii) Regulation of enzyme activity by non-genetic mechanisms.
   (iv) Half of enzymes intracellular degradation of proteins.
6. Biosynthesis of proteins and nucleic acids.
7. Site directed mutagenesis and enzyme engineering
8. Immobilized *enzymes and their applications*.

Books recommended

C.L. Prosser. Comparative animal physiology, W.B. Saunders

R. Eckert. Animal Physiology: mechanisms and adaptation W.H. Freeman

W.S. Hoar. General and comparative animal physiology, Prentice Hall, India

Schmidt Nielsen. Animal Physiology: Adaptation and Environment. Cambridge

D. Voet and J.G. Voet. Biochemistry. J.Wiley & Sons

De Robertis and De Robertis. Cell and Molecular biology

Paper III Gamete Biology and Developmental Biology

Unit I Gamete Biology

Note: Attempt four questions in all, two questions from each section; each question carries equal marks.

1. Heterogamy in eukaryotes
2. Comparative account of differentiation of gonads in a mammal and an invertebrate
3. Leydig cells
   a. Morphology
   b. Differentiation
   c. Function and its regulation
4. Spermatogenesis
   1. Morphological basis in Rodents
   2. Morphological basis in any invertebrate
   3. Gamete specific gene expression and genomics
5. Biochemistry of Semen
   1. Semen composition and formation
   2. Assessment of sperm functions
   3. Y-specific probes

6. Fertilization
   1. Pre-fertilization events.
   2. Biochemistry of fertilization
   3. Post-fertilization events.
10. Collection and cryopreservation of gametes and embryos
11. Ovarian follicular growth and differentiation
    1. Morphology
    2. Endocrinology
    3. Molecular Biology
    4. Oogenesis and vitellogenesis
    5. Ovulation and ovum transport in mammals.

Unit II Developmental Biology

1. Standard techniques and methods of experimental embryology namely - Vital dying, extirpation, isolation transplantation and grafting
2. Role of nucleus, cytoplasm & yolk
3. Multicellularity aggregation, differentiation, cell movement, contact inhibition, cell adhesives.
4. Cleavage, polarity, determination ingredients; cleavage and nuclear activity organizers- properties and physiology, embryonic induction primary and secondary competence heterogeneous inductions.
6. Metamorphosis, hormones and genes morphogenesis of vertebrates (the cyto differentiation with example of eye and limb)

Books recommended

Austen, C.R. and Short, R.V. Reproduction in animals.

Schatten and Schatten. Molecular biology of fertilization

F.T.Longo. Fertilization. Chapman and Hall

R.G Edwards. Human Reproduction

Balinsky. An Introduction to Embryology. CBS College Publishers

Gilbert. Developmental Biology. Sinauer

Berril, N.J. Developmental biology. TMH. India

M.Sc. Final

Zoology Practical Examination

Note: The practical examination shall carry 200 marks, 100 marks for first day (general examination) and 100 marks for second day (special paper). The examination shall be spread over two days, with one session of five hours each day.

Each student shall submit a brief report on excursion on special general papers (in the second day examination) along with the complete record of his / her practical work with collections, slides, and other preparations. Each student has to deliver at least one seminar lecture.

Both internal and external examiners shall work with mutual consultation and cooperation, during evaluation.

First day

1.	Major dissection	15 marks
2.	Minor dissection	10 marks
3.	Preparation of permanent mount	05 marks
4.	Ten spots for identification and comments	20 marks
5.	One physiology experiment	10 marks
6.	Comments in details on two embryological slides/models/specimens	10 marks
7.	One histological preparation/exercise	10 marks
8.	Viva voce test	10 marks
9.	Practical record, collection, slides and other preparations	10 marks
	TOTAL	100 marks

The second day practical will be held as per schedule provided for the concerned syllabi for special papers.

Contents of the Practical Exercises

Major Dissections - a. Fish: Cranial nerves of flat fish and Stingray, b. Mammal - Blood vascular system, cranial neck nerves.

Minor dissections - a. Fish: electric organs, b. Internal ear of Scoliodon; c. Reproductive organs of a mammal.

Mounts - WM of Salpa, Oikopleura, Squamous epithelium and ciliated epithelium of frog, filoplume of bird.

WM preparation of bird embryos.

Osteology - Endoskeleton of bony fish, reptiles, birds and mammals.

Palate in birds

Jaw suspension in vertebrates

Embryology - Study of various stages of embryos of representatives of different classes of vertebrates.
Study of different types of placentae (may be replaced by models) including their histological sections.
Sections of tadpole larvae through different regions of different stages.
Sections of various regions and stages of chick embryo and also their whole mounts.

Histology - Comparative histology of vertebrates organs including endocrine glands.

Museum Specimens - Models of extinct reptiles, human evolution, archaeopteryx, and other preserved specimens of chordates including those prescribed for B.Sc.

Physiology Experiments - a. Measurement of buffer action; b. Determination of osmotic concentration of a solution; c. To demonstrate the principle of dialysis; d. To determination of amount of dissolved oxygen in water; e. Effects of hormone on permeability of urinary bladder of frog; f. Oxygen consumption of an insect by ... improvised

spirometer; g Comparison of pulmonary and cutaneous respiration in frog; h any other modification of above exercises or additional one depending on facilities available.

M.Sc. Final Zoology

SPECIAL PAPER - Ichthyology and fisheries

Paper IV (Ichthyology)

Note: Attempt four questions in all; each question carries equal marks.

1. Classification - Evolutionary classification (Classification prepared by Berg and that by Romer), merits and demerits of Berg's classification. Cladistic classification (Modern approach); Ostracoderms, placoderms.
2. Origin and evolution of fishes (Elasmobranchs and bony fishes)
3. Identification - Technique, identification of local fish fauna.
4. Zoogeography - Spatial distribution of fishes; discontinuous distribution;
5. Local Fish fauna - Food fishes, forage fishes, predatory fishes and insectivorous fishes, wood fishes.
6. Migration - Type of migratory fishes; physiologic and applied aspects of migration, influencing factors, associated problems; migrations of eels, migration of Salmon, migration of Hilsa.
7. Adaptive radiation - Hill stream adaptations, deep-sea adaptations, adaptations in bony fishes and elasmobranchs.

8. Food and feeding habits - basic food, secondary food, incidental food, obligatory food and supplimentary food. Plankton feeders, herbivorous, carnivorous, omnivorous, monophagic and stenophagic fishes, euryphagic fishes. Surface feeders column feeders, bottom feeders, grazers, strainers.
9. Reproduction and development - Seasonality; Prolific breeders, Oviparity and viviparity; fecundity (methods of enumeration of eggs); endocrinal regulation; embryogenesis of any carp; parental care in fishes.
10. Abiotic factors and their influences on fish.
11. Maintenance and working freshwater and marine aquaria.

Paper V (A) - (Applied Fisheries)

Note: Attempt four questions in all; each question carries equal marks.

1. Type of fisheries - Marine fisheries (Costal fisheries, deep sea fisheries, off shore fisheries); Riverine fisheries (Major rivers systems of North India and their fisheries); reservoir fisheries; Lauritine fisheries; estuarine fisheries estuary types, ecologic features, principal estuaries and their fisheries).
2. Prawn Fisheries - Fishing methods, culture method, future of prawn fishery in India; pollution and prawn fishery and processing of prawns.
3. Fishing Methods - Sea water (crafts of east and west coast, tackles; other methods (electric fishing, light fishing, echo sounders; in in-land waters (fishing crafts and tackles);
4. Pond Culture (fish farming) - Types of fish farming, planning and construction fish farms, physiochemical and biological characteristic of fish farms; maintenance and improvement of fish farm.

5. Principal cultivable fishes - Brief account of indigenous and exotic species. Procurement of seed, collection, identification and transport of seed.

6. Induced breeding - Stripping, hypophysation technique, hand fisheries (dry and wet), indoor hatcheries and hapa techniques.

7. Other techniques of fish culture - Composite fish culture; fish culture in paddy fields; sewage fed fisheries.

8. Fish diseases and their control - fungal diseases, bacterial diseases, protozoan diseases, helminthes infections, and diseases induced by pollutants; prophylactic measures.

9. Fish decomposition and rigor mortis.

10. Fish preservation and processing - Causes of spoilage, methods of preservation and demerits of prevelent trivial methods.

11. Fish by-products.

12. Age and growth, length and weight relationship.

13. Tagging of fishes and population enumeration.

14. Transport of fish and marketing.

Syllabus for Practical examination to be held on second day

Note : The principal examination on second day will also extend for five hours; each student will maintain a record of the excursion and submit it at the time of this examination along with his collection and preparations.

The division of marks for practical examination on second day is as follows.

1.	Major Dissection	15 Marks
2.	Minor dissection	05 Marks
3.	Excursion report	20 Marks
4.	Ten spots for identification and comments	20 Marks

5.	Two local fresh water species for taxonomic identification with reasons up to species	10 Marks
6.	Comments on adaptive features of two fish species/two specimens for pathology/two models from applied fisheries.	10 Marks
7.	Viva voce test (on special paper only)	10 Marks
8.	Practical record, collections, slides and models.	10 Marks
	TOTAL	100

Syllabus for dissections and mountings: -

Major dissections - Cranial nerves of fresh water fish - Wallago attu, Mystus spe.

Weberian ossicles a fresh water fish

Exposure of pituitary a fresh water fish.

Minor dissections- Electric organs- Torpedo (Electric-ray)

Accessory respiratory organs- Heteropneustes, Anabas, Ophiocephalous.

Eye and eye muscles

Scroll valves.

Mountings - Different types of scales

Ampullae of Lorenzini

Hand section of olfactory organs

Nerve fibre

Blood film

Eggs

Books recommended for Special Papers(Ichthyology & Fisheries)

Lagler Ichthyology

Norma History of fishes.

Berg, L.S	Classification of fishes.
Francis Day	Fishes of India vol. I & II
K.C. Jayaram	The freshwater fishes of India, ZSI Calcutta.
P.K. Talwar	Commercial Marine fishes of India, ZSI Calcutta.
K.S. Misra	Fauna of India, Vol. I, II, III. Rec. of Indian Museum.
V.G. Jhingeran	Fish and Fisheries on India.
Parihar	Fish and Fisheries.
Chandy ,M.	Fish and fisheries. NBT, New Delhi
	Wealth of India Vol. III
C.V.Kurian and V.O.Sebastian	Prawns and Prawn Fisheries of India, Hindustan Publishing House, Ndelhi
C.L.Chunder	Breeding of Indian Major Carps, Rashtriya Art Printers, Agra
Lal	Nets and gears
Khanna S.S.	Fishes
Grover	Fishes
C.B.L. Srivastava	Biology of Fishes
Santosh Kumar	Anatomy and physiology of Fishes, Vikas Publication, N.Delhi

M.Sc. Final Zoology

Special paper - (IV B) - Entomology

Paper - III Morphology, anatomy, physiology, ecology and ebryology of insectd.

Note: Attempt four questions in all; each question carries equal marks.

1. Morphology of head thorax and abdomen, structure of the digestive, respirator, circulator, excretory, nervous receptor organs including second and light producing organs and reproductive system.
2. Physiology of the digestive, respirators, circulatory, excretory, nervous receptors organs including sound and light producing organs.
3. Metamorphosis, role of hormones in development.

Paper - V - (B) Insect taxonomy, economic entomology, and social insects.

Note: Attempt four questions in all, each question carries equal marks.

(1) Taxonomy : Detailed knowledge of the following orders and particularly of the families mentioned below -

1. Thynanure 2. Collembola 3. Orthoptera 4. Blatteria 5. Phasmida 6. Mantoidea 7. Dermaplera 8. Isopetra 9. Embiopetr 10. Corredenia 11. Mallphage 12. Anopleura 13. Ephemerida 14. Onnats 15. Thysanoptera 16. Neruoptera 17. Lecoptera. 18. Heteroptera - Pentotomidae, Coredae, Lygaeidae Hydrumetridae, Reostomatidae. 19.Homoptera - Fulgeriade, Oncadidae Cercopidae, Jassidate, Altyrodae, Aphididae. 20. Coleptera - Dytiscidae, Lampyridae, Cantharidae, Dermem,ade, Coccibellate, Scarabaeidae, Cerrmbycidae, Curculionidae. 21. Lepidoptera -

Pyraludiate, Nocurit, Spobgidae, Geometridae, Bombucidae, Saturnuiae, Papilionadar, Nymphaldae. 22. Strepsiptgera 23. Hymenuptera - Teuthrednae, Evanidae Iehne, umoidae, Chalici iade, Formicidae, Vespoino, Ecmeniade, Aniade. 24. Dipters - Mycropidae, Tipulidae, Psychodinae, Culcidae, Chtronomade, Asilidae, Syphidae, Muciade, Tuchiniade Hippoboscdae 25. Siphaopera

(2) Economic entomology economici importance of the weevil, locust honey bee, lac insect,pests of stored grains, cotton paddy, super cape, cattle, men, forest plants and frutis their life histarier, Nutrit of dusage and varioua types of control measures employed with special emphasis on insecticides.

(3) Social insects - their organization adaptations and behaviour.

(4) Soil insects and plant protection.

Books recommended.

Evig , D.. College Entomology.

Imm. A.D. : Text book of Entomology (9th ed. revited by Richard an Davis.

Icocot, A.D. : Recent Advances in Entomology.

Packward, A.S.: Text Book of Entomology.

Practical

Note : The practical examination on second day will also extend for five hours. Each student will maintain a record of the excursion and submit it at the time of this examination alongwith his/her practical record, collection and preparation.

The division of marks is as follows:

1.	Major dissection	15 marks
2.	Minor dissection	05 marks
3.	Ten spots for identification and comments	20 marks.

4.	Identification of two legal insects upto species leve	10 marks
5.	One biostatistical problem	10 marks.
6.	Excursum report	20 marks.
7.	Viva voce test	10 marks.
8.	Record, collection, and preparations.	10 marks.
	TOTAL.	100 marks.

Syllabus for M.Sc. (Final) Zoology (Entomology special paper) practical examination.

Major dissection:

Expose any one of the following systems and associated parts of any of the insects.

Nervous system, Alimentary canal, Reproductive system and Respiratory system of Grasshopper, Dysdercus (Red cotton bug), Danus (Plain tiger butter fly), Acherontia (Hawk moth), Musca (Housefly., Apis (Honey bee), Vespa (Wasp) and Mylabris (Blister beetle).

Ginor dissection:

Tentorium, Tympanum of Grasshopper, Spiracle of Grasshopper, Endocrine system of the Cockroach, Heart and blood vessels of Cockroach, Johnston's organ of Male mosquito, aristate antenna and modified hind wing (Haltere) f housefly, Sting apparatus of Honey bee and Wasp, Genitalia of Male and Female.

Study of the following prepared slides:

Type of Antenae; Mouth parts, Legs, Wings, Wign coupling apparatus, Eggs and Ovarioles. W.H. of Lepisma, Springtails, Pediculus, Cimex, Aphid, Kennpsylla, Bird louse, Culex Pule and Female, Anopheles male and female, kedes male and female, Thrip, Larva of Culex and Anopheles, Pupa of Culex

and Anopheles. T.S. Gizzard and Proventriculus of Cockroach, T.S. of ions gut, mid gut and hind gut alongwith cloaca, T.S. of Filter chamber, T.S. of Rectum, T.S. of Compound eye, T.S. of Flight muscle fibres, T.S. of Testis, Ovary, T.S. through an early embryo, T.S. of abdominal ganglia, L.S. of Spiracle alongwith trachea, L.S. of Brain, L.S. of the fore gut of Cockroach, MV.S. of the heaf of a Cicada; Gills of aquatic insects.

Study of the following museum specimens:

Mantis, Phyllium, Stick insect, Earwig, Queen termite, Belostoma, Cicada Male & Female , Nepa, Rhinoceros beetle, Types of Larvae and Pupae, Life History of Silk worm, Sand fly, Butterfly, Lac insect, Honey bee.

Study of the Specimens selected from the Orders of insects as per theory course for the purpose of id ntification.

Record of the exercises on growth and development of insects with the help of following biostatistical calculations, Dyar's law, Chi-square test, Growth index and Howe's index values, Critical difference, Standard error, Standard deviation, Transformed and Angular transformed values.

Histological preparations of the Grasshopper viscera exposed to easily available insecticides.

At least one Life History of a crop pest is to be included in the collection.

Books recommended for special paper

D.P. Tombhare: Insect, morphology, and physiology, S.Chand & Co.

H.Borsell: Insect physiology, Academic Press, NY

A Kumar and P.M.Nigam - Economic and applied entomology, Emkay Publishers, Delhi - 51

Nigam, P.M. and A.Kumar ü Agricultural entomology; do.

Kumar, A and P.N. Nigam- Crop pests of India do

M.Sc. Final Zoology

Special Paper - IV (C) - Parasitology

IV. General Parasitology

Note: Attempt four questions in all; each question carries equal marks.

(1) Morphology and systematics (including ultrastructure) of protozoans, trematodes, cestodes and nematodes in relation to man & domestic animals.

(2) Life cycle of the following :

Entamoeba historlytica, Trypanosoma, Leishmania, Schistosoma, Paragonimus westermani, Dicrocoelium dendriticum, Echinococcus granulosus, Diphyllobothrium latum, Dipylidium canimu, Hymenolepis nana, Wuchereria bancrofti, Brugia malayi, Dracunculus medinensis, Trichinella, spiralis, Strongyloides stercoralis.

(3) Different types of larvae of trematodes cestodes and nematodes.

(4) General account of parasitism, evolution and parasitic adaptation

(5) Arthopods as vectors.

Paper V (C) - Applied Parasitology

Note: Attempt four questions in all; each question carries equal marks.

1. Causes, symptoms, diagnosis, treatment and prevention of important pnastic protozoa,s trematodes, ceastdes & nematodes of man & domestic animals.
2. Physiology of nutrition, excretion and respiration of parasites.
3. Ecology of parasities

4. Immunology, immunity disorders and immunoprophylaxis.
5. Reproduction
6. Egg shell formation

Practical

1. Permanent preparation of rectal ciliates, Monocystis, Blood film of man for plasmodium - 15
2. Permanent stained preparation of trematodes & cestodes from the animal provided. - 10
3. Preparation of the material provided (Arthopoda) - 5
4. Identify and comment upon spots 1-10 -20
5. Two specimens for taxonomic identification upto species level -10
6. Viva-voce 10
7. Practical record & collection -30

TOTAL 100

Books Recommended

Read, C.P. Animal Parasitism, Prentice Hall, Inglewood, New Jersey, USA

Baker, J.R. The Parasitic Protozoa. Hutchinson, London

Cheng, T.C. The Biology of Animal Parasites, W.B.Saunders and Co. Philadelphia and London.

Chandler, A.C. Introduction to Parasitology, J Wiley and Sons

Cobb, N.A. Nematodes and their relationships, Year Book, U.S.Deptt. Of Agriculture, 1914, pp 457-5490

Corfton, H.B. Nematodes, Hutchinson University Library, London

Dawes, B. The Trematoda, Cambridge University Press

Hyman, L.H. The Invertebrates Vol. II and III, McGraw-Hill, N.Y.

Smyth, J.D. The Physiology of Trematodes, W.H.Freeman and Co.

Smyth. The Animal Parasitology, Cambridge University Press.

M.Sc. Final Zoology

Special Paper - (D) - Animal Cytology and Cytogenetics

Paper IV - (D) - GENERAL ANIMAL CYTOLOGY

Note: Attempt four questions in all, each question carries equal marks.

1. Cell cycle - cell divisions; mitosis and meiosis.
2. Chromosomes - Giant chromosomes, isochromosomes, heterochromatin, euchromatin, chromosome proteins, arrangement of chromatin in chromosomes. Nomenclature of mammalian chromosomes; C G banding and karyotypes.
3. Chromosomal aberrations - Deletion, duplication, translocation and and numerical abberation.
4. Sex determination - Primary and secondary sex characters, sex chromosome structure and mechanisms of sex determination; sex chromatin and Y body.
5. Protoplasm - Chemical and physical nature.
6. Cell metabolism - Energy metabolism and biosynthesis of carbohydrates, proteins, lipids, nucleic acids, and their catabolism.
7. Cell Membrane - modifications and physiology.
8. Nucleus - Ultrastructure, chemical composition and its significance.
9. Cell organelles - Detailed structure and functions of different organelles including lysosomes, centrosome and plastids.
10. Cilia, flagella, basal bodies and Parabasal apparatus.

Paper V (D) - Clinical Cytogenetics

Note: Attempt four questions in all, each question carries equal marks.

1 Linkage, and crossing over - types of linkage, linkage maps and groups, detection of linkage; cytologic basis of crossing over, crossing over between, three linked genes, gene conversion.

2 Chromosomal complments in human - nomenclature, morphology, karyotype and chemical composition; types of chromatin of different regions of the chromosomes. DV Praw model of human chromosome structure.

3 Lethal heriditary diseases in man - Sickle cell anemia, Phenyl - ketonuria, Huntgtn chores, albinism and Galactosemics.

4 Sex chromosomes and abnormalities, Klinfelter's syndrome, Turner's and Down syndrome, testicular feminisation and aged eggs.

5 Genetic and clinical aspect of Rh desease, A,B,O, n ompatibility and control, effect of IQ score and phenocopy.

6 Effect of environment on development of characters - external internal environment, effect of IQ score and phenocopy.

7 Population genetics - Factors affecting genen, gene frequencies, migration, mutations, selection, fitness, random drift, gene pool, Hardy Wienberg law.

8 Malagmoney - different & development.

Practical

M.Sc. Final Zoology

Special Paper - Cytogenetics Practical examination of second day

Note: The practical examination on second day will also extend for five hours. Each student will maintain a record of the excursion and submit it at the time of this examination alongwith his/her collection and preparations.

The division of marks is as follows:

		Max. Marks
1.	Major dissection (Somatic chromosome preparation from bone marrow of rat.	10
2.	Minor dissection (leptotene, zygotene, pachytene diplotene stages of Meiosis 1st from rat testes)	05
3	Slide preparation of sex chromatin of blood of female rat)	05
4	Ten spots for identification and comments	20
5.	Problem I	10
6	Problem II	10
7.	Excursion reports	20
8	Viva voce tests	10
9	Record, collection etc	10
	Total	100

Syllabus

1 Study of somatic chromosomes preparation from bone marrow of rat, or any other suitable satori 1.

2 Demonstration of insect salivary gland chromosomes.

3 Preparatum of polytene chromosomes from Drosophila or any other insect.

4 Squash preparation to show mitosis and meiosis.

5 Demonstration of mitochondria and other cell organelles.

6 Study of slides and photomicrographs showing ultra structures, cell types and cell organelles including prokaryotic cells from water and soil and E.coli and also animal eukaryotic cells.

7 Study of lethal hereditary syndromes in man (by chart).

Books Recommended

Problems relating to haemophilia, colour blindness, blood groups, sex determination, probability and population genetics

Atherly, A.G., J.R. Girtlan, J.F. MacDonald. The science of Genetics. Saunders College Publishing Harcourt

Brace College Publishers, New York

Brooker, R.J. Genetics: analysis and principles, Benjamin/Cummings, Longman, Inc.

Gardner, E.J., M.J.Simmons and D.P.Snustad, Principles of genetics. John Wiley and Sons, New York

Lewin, B. G. ies VI. Oxford University Press, Oxford, New York, Tokyo

Watson J.D. et al. Molecular Biology of genes. The Benjamin/Cummings Publishing Co. Inc., Tokyo

J Darnell, H Lodish and D Baltimore. Molecular Cell Biology Scientific American Books, W H Freeman, N.Y.

Benjamin Lewin. Genes VI. Oxford University Press, New York

P.D.Dabre. Introduction to Practical Molecular Biology. John Wiley and Sons Ltd. New York

Lewis C.D. and Levin, R. Biology of Gene McGraw - Hill Tejpaul Co. Ltd.

Gunther S Stent Molecular Genetics Macmillan Publishing Co. Inc.

Gooderaugh V. Genetics New York Holt Rinehart and Winston

Gardner Principles of Genetics Wiley Eastern Pvt. Ltd.

Winchesters, Genetics oxford IBM Publications

Stickberger, Genetics macmillan Publications

Pai A.C. Foundations of Genetics, McGraw Hill Publications.

Verma P.S. and J.K. Agarwal, Genetics S.Chand and Co New Delhi

Gupta P.K. Genetics Rastogi Publications Shivaji Road Meerut.

Sinnot, E.W., L.C. Dunn and T. Dobzhansky - Principles of Genetics McGraw Hill Book Company New York.

Stanafield, W.D. Theory and Problems of Genetics McGraw - Hill Book Company New York

Stent, G.S. Molecular Genetics W.H. Freeman and Company San Francisco.

Crick F.H.C. The genetic code

Lewin, Benjamin Gene Expression 2nd Ed. John Willey, London

M.Sc. Final Zoology

Endocrinology - The special papers

Paper IV (E) - Comparative endocrinology and peptide hormone systems of vertebrates

Note: Attempt four questions in all; each question carries equal marks.

1 History definition, characteristics and classification of hormones; Hormonal versus nervous integration; regulation of endocrine action.

2 Neurosecretion and neuroendocrines on invertebrates: Insect hormones (brain hormones, ecdysone, juvenile hormone, bursicon, diapaus, hormone relation, adipokinetic, proctolin, diuretic and heart beat accelerator hormones)

3. Vertebrate endocrine organs: Structural evolution of endocrine glands, Morphology, comparative anatomy and histology of pituitary, Thyroid, Parathyroid, adrenal, gonads and thymus.

4. Vertebrate neuroendocrine system: the nature of neurosecretory cells, hypothalamo-hypophysial system.

5. Adenohypophysis: cell types, hormones, their functions, deficiency and teratogenic effects.

6. General structure, histology and functions of pineal apparatus and the urophysial system.

7. Neurohypophysis: hormones, antidiuretic and oxytocic action, milk ejection.

8. Thyroid gland: Cytology, mode of secretion, cyclic architectural changes, functions of thyroid hormones, mechanism of action, hypo and hyperthyroidism and related abnormalities.

9. Parathyroid hormones: calcium and phosphorous, metabolism, action on bones, kidney function.

10. Gastro-intestinal hormones: endocrine regulation of gastric functions and role of gastrin, enterogastrone, secretin, pancreozyme, urogastrone, and cholecystokinin.

11. Pancreas: Histology, chemical nature of insulin and glucagons, action of insulin and control of the insulin and glucagons release.

Paper V (E) - Molecular Endocrinology

Note: Attempt four questions in all; each question carries equal marks.

1.0 Definition and scope of molecular endocrinology
- 1.1 Discovery of hormones and reductionist biology

2.0 Chemical nature of hormones

3.0 Purification and characterization of hormones

4.0 Production of hormones by biochemical and rDNA technologies

5.0 Structure of hormones
- 5.1 Structure-function relationship in hormones - comparative analysis and evolutionary perspectives

6.0 Nature of hormone action
- 6.1 Hormone receptors - identification, quantitation purification and physico-chemical properties.
- 6.2 Membrane receptors - structure and signal transduction mechanisms
- 6.3 G-proteins
- 6.4 Nuclear receptors - structure and function. Orphan receptors. Metabolic and developmental hormones.
- 6.5 Hormonal regulation of carbohydrate, lipid, Protein and nucleic and metabolism.
- 6.6 Hormonal regulation of growth, reproduction and development through differentiation gene expression.

7.0 Body fluids and hormones:
- 7.1 Reproductive cycles in vertebrates and hormonal concentrations in body fluids
- 7.2 Biosynthesis of hormones - molecular details
- 7.3 Transcriptional and post-translational regulation of hormone biosynthetic genes.
- 7.4 Hormone and receptor genes in population.

8 Genetic analyses of hormonal disorders

11. Hormones and evolution.

Suggested Reading Material

1. Benjamin Lewin, Genes VII, Oxford University Press.
2. Lodish et al. Molecular Cell Biology
3. Ethan Bier. The Coiled spring. Cold Spring Harbor Press.

4. L.P. Freedman. Molecular Biology of Steriod and Nuclear Hormone Receptors, *Birkhauser.*

5. G. Litwach. Bicohemical Actions of Hormones, Academic Press.

Practical

List of Suggested Practicals

1. Bioassay of any hormone involving target tissue growth/differentiation.
2. Radireceptor assay for any hormone.
3. RIA and ELISA for any hormone or second messenger.

Syllabus for practical examination of Endocrinology to be held on second day

Note: The practical examination on second day will also extend for five hours. Each student will maintain in record of the excursion and submit it at the time of this examination along with his/her collection and preparations.

1.	Dissection (any two endocrine glands)	15 marks.
2.	One microtomic slide preparation	10 marks.
3.	Ten spots for identification and comments (slides etc)	20 marks.
4.	Excursion reports	20 marks.
5.	Project report	15 marks.
6.	Viva voce test (on special paper only)	10 marks.
7.	Practical record, collections, preparations	10 marks.
	TOTAL	100marks.

Syllabus for Practical Examination:

Dissection - Endocrine gland of vertebrates: fish, amphibia, birds and mammals.

Microtomic Preparation - Examinees will be required to bring properly stretched slides of pituitary, thyroid, gonads, adrenal and thymus and shall suitably stain to demonstrate the histology of the gland.

Project - Each student shall be given a project involving experimental procedures. The candidate will keep complete record of his/her project including photographs, slide, data etc. and will submit the same at the time of the practical examination.

SUGGESTED READINGS:

Barrington, E.J.W (1975). General and comparative endocrinology. Oxford, Clarenden press

Barrington, E.J.W (1962) Hormones and evolution Oxford.

Call, Ed. (1971) An ABC of endocrinology. Little brown and Compalla Boston.

Frieden, E.H (1976). Chemical endrocrinology. Academic Press, *NY.*

__ and H Lapper (1971). Biochemical endocrinology of vertebrates, prentice hall, Englewood Cliffs, NJ.

Gorbman, A. and Howard. A. Born (1962). A text book of comparative Endocrinology. Wiley Eastern.

Sawin, C.T. (1969). The hormones. Little Brown & Co. Boston.

Tepperman, CT (1969). Metabolic and endocrine physiology (3rd ed.) near book Medical Publishers, Inc. Chicago,

Turner, CD and JT Bagnara (1976). General endocrinology. Saunders Philadelphia

Bentley, P.J. Comparative Vertebrate endocrinology, Cambridge University Press

R.H.Williams. Text Book of Endocrinology. W.B.Saunders

C.R.Martin. Endocrine Physiology. Oxford University Press

Gorbman, A. et al Comparative Endocrinology. J.Wiley and Sons

M.Sc. Final Zoology

Special Papers -Environmental Biology and Applied ecology

Paper IV (F) - (Environmental Biology)

Note: Attempt four questions in all, each question carries equal marks.

1. Scope major areas, historical background of environmental biology in India.
2. Tools and techniques - Population sampling techniques, methods of estimating primary and consumer production; measurement of environmental factors; remote sensing.
3. Statistical studies - Biometry and biological data; descriptive statistics and depiction of life patterns of animal with environmental effects by applying Boolean algebra.
4. The Environment- Elements and processes, interaction of environmental elements, dynamic environment.
5. The Atmosphere - Pressure, winds and air masses, moisture, temperature, and light.
6. Hydrospare- Realms of water; organisms in fresh and marine waters.
7. Lathosphere - Land forms, rocks, soil and soil erosion, underground water
8. Comparison of autecology and synecology.
9. Biosphere - Ecosystems, Diversity, kinds, structure and functional aspects
10. Community - Structure and dynamics; energy flow, biogeochemical cycles.

11. Population interactions- intra-and interspecific interactions; ecological genetics - Natural selection, adpatations and ecotypes, speciation, ecological indicators.

Paper V (F) - (Applied Ecology)

Note: Attempt four questions in all, each question carries equal marks.

1. Environmental aspects of human population - demography, growth, factors regulating human population; the impact on environmental imbalance.
2. Resources - Conservation with exploitation kinds - Terrestrial (soil, climate, climatic regions of India, forests, flora and fauna of India) deforestation and its impact various forestries, grasslands, flora fauna and their management, legal aspects, Govt. & Voluntry agencies for conservations,; mineral resources and their conservation).
3. Aquatic resources (Fish resource; land planning with fishery projects, freshwater irrigation, marine resources - minerals and conservation; economic utility, marine parks);
4. Urban water Management - Sources, water quality, criteria standards, Solid particle contents and their types; sewage and waste water treatment and disposal.
5. Pollution - A. Air - Gases, RPM, heavy metals and inorganic substances, Ozone erosion, prevention and control.

   B. Soil - Pesticides, synthetic fertilizers, fly ash, residual toxicity of persistant pesticides; Prevention and control.

   C. Water Industrial and urban wastes; various toxicants; Marine pollution; Eutrophication and related economic implications; prevention and control.
6. Toxicology - Branches; dose response relationship, LD_{50} and LC_{50}; local and systemic effects; commulative toxicity.

6. Factors effecting toxicity i.e. biological and chemical and route of administration.

7. Wildlife - Indian wildlife; endangered flora and fauna, management; preservation of wildlife (in situ and ex situ); planning and management of parks, sanctuaries, reserves, zoological gardens, and domestic wildlife attractants.

8. Energy - Types and sources; strategies for conservation.

9. Environmental Assessment - Biological monitoring; bioindicators; assessment of environmental alteration.

10. Environmental awarness and mass education - Principles and programmes of environmental education with special reference to India, UNCED on Earth Summit and SACEP, Deptt. of environment, forest and wildlife.

11. Preventive measures for conservation of resources and recycling of wastes.

Practical

Syllabus for Practical Examination to be held on second day

Note : The practical examination on second day will also extend for five hours; each student will maintain a record of the execusion and submit it at the time of this examination, alongwith his/her collections and preparations.

1.	One field excercise	15 marks.
	(Max. time one hour)	
2.	Estimation of Soil/water quality (chemical)	10 marks.
3.	Observations on abiotic (physical) factors	05 marks.
4.	Specific comments on an ecosystem model	
	(Including observations in field)	10 marks.
5.	One statistical problem	10 marks.
6.	Plankton number in a given sample	
	a. Quantitative	05 marks.
	b. Qualitative identification	05 marks.
7.	Excursion report	20 marks.
8.	Viva voce test	10 marks.
9.	Record, collections, preparations	10 marks.
	Total	100 marks.

1. Determination of minimum size of quadrate (species area curve).
2. Determination of minimum number of quadrates.
3. Determination of frequency of individual species, line transect method, point frame method.
4. Study of biomass of producers in the field.
5. Estimation of DO, free CO_2 Chlorides, dissolved organic matter in water.
6. Study of physical and chemical characteristics of soil.
7. Study of different ecosystems in field, including food chains and webs and to construct pyramids.
8. Exercises on population, toxicology and genetics on the basis of provided data.
9. Identification of Zooplanktons and phytoplanktons and estimation of numbers.
10. Study of domestic wild life attractants and preparation of at least one.
11. Observations and studies on planning and management of Zoological park, and forestry.

Books Recommended.

Began, M. et al. Ecology. Individuals, Populations and Communities. Blackwell Scr. Publi. Oxford, U.K.

Elseth, H.D. and K.M.Baumgartner. Population biology, Van Nostrand Co. New York.

Krebs, C.J. Ecological methodology. Harper and Row, New York
Odum : Ecology (Amerind)
Odum : Fundamentals of Ecology (W.B. Saunders)
Ricklefy : Ecology (W.H. Freeman
Turk & Turk Environmental Science (W.B. Saunders)
Cormondy, E.J. concepts of Ecology (Prentice Hall)

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KANPUR

M.A./M. Sc. (Previous)

MATHEMATICS

(Course Structure)

Applicable from July, 2002 (i.e. Academic Session 2003 -2004 and Onwards)

Note : There shall be five paper's of 100 marks each.

Paper -I to IV are Compulsory and Paper V is optional.

Paper - I : Real Analysis

Paper - II : Complex Analysis

Paper - III : Topology

Paper - IV : Mechanics

Paper - V : (Optional Papers) Any one of the following -

i. Programming in C (with ANSI features)

ii. Differential Equations

iii. Advanced Discrete Mathematics

iv. Differential Geometry of Manifolds

v. Mathematical Statistics

vi. Mechanics of Solids

vii. Operations Research

M.A./M. Sc. (Final)

MATHEMATICS

Applicable from July, 2004 (i.e. Academic Session 2004 -2005 and Onwards)

Note : There shall be five papers of 90 marks each and Viva - Voce test of 50 marks an entire Post - Graduate Syllabus. Paper I - IV are Compulsory and Paper V is optional

Paper - I : Advanced Abstract Algebra

Paper - II : Hydromechanics

Paper - III : Integration theory and Functional Analysis

Paper - IV : Integral Equations and Boundary Value Problems

Paper V : (Optional Papers) Any one of the following -

(i). Fundamentals of Computer Science

(ii). Partial Differential Equations and Mechanics

(iii). Space Dynamics

(iv). Non-Linear Programming

(v). Theory of Generalised Functions

(vi). General Relativity and Cosmology

(vii). Banach Algebras

(viii). Fuzzy Sets and Their Applications

(ix). Wavelets

(x). Non-Commutative Rings

(xi). Theory of Linear Operators

(xii). Biomechanics

(xiii). Analytic Number Theory

(xiv). Algebraic Number Theory

DETAILS OF SYLLABI

M. A. / M. Sc. (Previous)

MATHEMATICS

Paper I : Real Analysis

Definition and existence of Riemann-Stieltjes Integral, Properties of the Integral, Integration and Differentiation, The fundamental theorem of Calculus, Integration of vector-valued functions, Rectifiable curves.

Sequences and series of functions, pointwise and uniform convergence, Cauchy criterion for uniform convergence Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence; Uniform Convergence and continuity, uniform convergence and Riemann-Stieltjes integration uniform convergence and differentiation, Weierstrass approximation theorem, Power Series, Uniqueness theorem for power series, Abel's and Tauber's theorems.

Functions of Several variables, linear transformations, Derivatives in an open subsets of R^n, Chain Rule, Partial derivatives, interchange of the order of differentiation, Derivatives of higher orders, Taylor's Theorem, Inverse function theorem, Implicit function theorem, Jacobians, Extremum problems with constraints, Lagrange's multiplier method, Differentiation of integrals, Stoke's theorem.

Lebesgue outer measure, Measurable sets, Regularity, Measurable functions, Borel and Lebesgue measurability.

Integration of Non-negative functions, The General Integral, Integration of Series, Reimann and Lebesgue Integrals.

Functions of Bounded variation, Lebesgue Differentiation Theorem, Differentiation and Integration.

Measures and outer measures, Extension of a measure, Uniqueness of Extension, Completion of measure, Measure spaces, Integration with respect to a measure.

The L^p- spaces, Convex Functions, Jensen's inequality, Hölder and Minkowski inequalities, Completeness of L^p, Convergence in Measure, Almost uniform convergence.

References :

1. *Walter Rudin,* Principles of Mathematical Analysis (3rd edition) McGraw-Hill, Kogakusha, 1976, International Student edition.
2. *T.M. Apostol,* Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.
3. *I.P. Natanson,* Theory of Functions of a Real Variable, Vol. I, Frederick Ungar Publishing Co., 1961.
4. *H.L. Royden,* Real Analysis, Macmillan Pub. Co.Inc 4th Edition, New York, 1993.

Paper II : Complex Analysis

Complex integration, Cauchy-Goursat Theorem, Cauchy's Integral formula, Higher order derivatives, Morera's Theorem. Cauchy's inequality and Liouville's theorem. The fundamental theorem of algebra. Taylor's theorem. Maximum modulus principle. Schwarz lemma. Laurent's series. Isolated singularities. Meromorphic functions. The argument principle. Rouche's theorem , Inverse function theorem.

Residues, Cauchy's residue theorem, Evaluation of intergrals, Branches of many valued functions with special reference to arg z , log z and z^a.

Bilinear transformations, their properties and classifications. Definitions and examples of Conformal mappings.

Spaces of analytic functions. Hurwitz's theorem, Montel's theorem Riemann mapping theorem.

Weierstrass' factorisation theorem, Gamma function and its properties, Riemann Zeta function, Riemann's

Functional equation, Runge's theorem, Mittag-Leffler's theorem, Analytic Continuation, Uniqueness of direct Analytic continuation, Uniqueness of Analytic continuation along a curve,

Power series method of Analytic continuation, Schwarz Reflection principle, Monodromy theorem and its consequences, Harmonic functions on a disk, Harnack's inequality and theorem, Dirichlet problem, Green's function.

Canonical products, Jensen's formula, Poission formula, Hadamard's three circles theorem, Order of an entire function, Exponent of Convergence, Borel's theorem, Hadamard's factorization theorem.

The range of an analytic function,Univalent functions, Bieberbach's theorem (Statement only) and the "1/4- theorem.

References :

1. *H.A. Priestly,* Introduction to Complex Analysis, Clarendon Préss, Oxford 1990.
2. *L.V. Ahlfors,* Complex Analysis, McGraw-Hill, 1979.
3. *S.Lang,* Complex Analysis, Addison Wesley, 1977.
4. *Walter Rudin,* Real and Complex Analysis, McGraw-Hill Book Co., 1966.
5. *E.C. Titchmarsh,* The Theory of Functions, Oxford University Press, London.

Paper III : Topology

Definition and examples of metric spaces, Neighbourhoods, Limit points, Interior points, Open and Closed sets. Closure and interior, Boundary points, Sub-space of a metric space. Cauchy sequences, Completeness, Cantor's Intersection theorem, Dense subsets.Baire Category theorem, Separable, second countable and first countable spaces, Continuous functions, Extention theorem, Uniform continuity, Isometry and homeomorphism, Equivalent metrics, Compactness, Sequential Compactness, Total Bounded spaces, Finite intersection property, Continuous Functions and compact sets.

Countable and uncountable sets, Infinite sets and the Axiom of Choice, Cardinal numbers and its arithmetic,

Schroeder-Bernstein theorem, Cantor's theorem and the continuum hypothesis, Zorn's lemma, Well-ordering theorem.

Definition and examples of topological spaces, Closed sets, Closure, Dense Subsets, Neighbourhoods, Interior, exterior and boundary, Accumulation points and derived sets, Bases and sub-bases, Sub-spaces and relative topology.

Alternate methods of defining a topology in terms of Kuratowski Closure Operator and Neighbourhood Systems.

Continuous functions and homomorphism.

First and Second Countable spaces, Lendelof's theorems, Separable spaces, Second Countability and Separability.

Separation axioms T_0 , T_1 , T_2 , $T_{3½}$, T_4 ;their Characterizations and basic properties, Urysohn's lemma, Tietze extension theorem.

Compactness,Continuous functions and compact sets, Basic properties of compactness, Compactness and finite intersection property, Sequentially and countably compact sets.

Connected spaces, Connectedness on the real line, Components, Locally, Connected spaces.

Tychonoff product topology in terms of standard sub-base and its characterizations, Projection maps, Separation axioms and product spaces, Connectedness and product spaces, Compactness and product spaces (Tychonoff's theorem) Countability and product spaces.

Embedding and metrization, Embedding lemma and Tychonoff embedding, The Urysohn metrization theorem.

Nets and filters, Topology and Convergence of nets, Hausdorffness and nets, Compactness and nets, Filters and their convergence.

References

1. *George F. Simmons,* Introduction to Topology and Modern Analysis, McGraw-Hill Book Co., 1963.

2. *K.D. Joshi,* Introduction to General Topology, Wiley Eastern Ltd., 1983.

3. *J.L. Kelley,* General Topology, Van Nostrand, Reinhold, Co., New York, 1995.

4. *M.J. Mansfield,* Introduction to Topology, D. Van Nostrand Co. Inc. Princeton, N. J., 1963.

5. *K. K. Jha,* Advanced General Topology, Nav Bharat Prakashan, Delhi.

Paper- IV : Mechanics

Dynamics of Rigid Bodies (80 %)

Moments and products of Inertia, The Momental Ellipsoid, Equimomental Systems, Principal axes.

D'Alembert's principle, The general equations of motion of a rigid body, Motion of the Centre of inertia and motion relative to the Centre of Inertia.

Motion about a fixed axis,The compound pendulum, Centre of Percussion.

Motion of a rigid body in two dimensions under finite and impulsive forces.

Conservation of Monentum and Energy, Initial Motions, Lagrange's equation (D'Alembert's and Hamilton's approaches), Euler's equations of motion, Hamilton's principle, Hamilton's Equation of Motion.

Calculus of variations- (20%)

Variational problems with fixed boundaries - Euler's equation for functionals containing first order derivative and one independent variable, Extremals, Functionals dependent on higher order derivatives, Functionals dependent on more than one independent variable, Variational problems in parametric form, Invariance of Euler's equation under coordinates transformation.

Variational Problems with Moving Boundaries- Functionals dependent on one and two functions, One sided variations.

Sufficient Conditions for an Extremum- Jacobian and Legendre conditions, Second Variation, Variational principle of least action.

References :

1. *S.L. Loney,* An Elementary Treatise on the Dynamics of a Particle and Rigid bodies, Cambridge University Press, 1956.
2. *A.S. Gupta,* Calculus of Variations with-Applications, Prentice-Hall of India, 1997.
3. *I.M. Gelgand and S.V. Fomin,* Calculus of variations , Prentice-Hill, Englewood Cliffs (New Jersey), 1963.

Paper- V : (Optional Papers) - Any one of the following

(i). Programming in C (with ANSI features)

An overview of programming, Programming language, Classification.

C Essentials - Program Development, Functions, Anatomy of a C Functions, Variables and Constants, Expressions, Assignment Statements, Formatting Source Files, Continuation Character, The Preprocessor.

Scalar Data Types - Declarations, Different Types of Integers. Different kinds of integer constants, Floating-Point Types, Initialization, Mixing Types, Explicit Conversions-Casts, Enumeration Type, The Void Data Type, Type defs, Finding the Address of an object, Pointers.

Control Flow - Conditional Branching, The Switch Statement, Looping, Nested Loops, the break and continue Statements, The goto statement, Infinite Loops.

Operators and Expressions - Precedence and Associativity, Binary Plus and Minus operators. Binary

Arithmetic Operators, Arithmetic Assignment Operators, Increment and Decrement Operators, Comma Operators, Relational Operators, Logical Operators, Bit - Manipulation Operators, Bitwise Assignment operators, Cast Operator, Size of Operators, Conditional Operators, Memory Operators.

Arrays and Pointers- Declaring and Array, Arrays and Memory, Initilizing Arrays, Encryption and Decryption, Pointer Arithmetic, Passing Pointers as function Arguments, Accessing Array Elements through Pointers, Passing Arrays as Function Arguments, Sorting Algorithms, Strings, Multidimensional Arrays, Arrays of Pointers, Pointers to Pointers.

Storage Classes- Fixed vs Automatic Duration, Scope, Global variables, The register Specifier, ANSI rules For the syntax and Semantics of the storage-class keywords, Dynamic Memory Allocation.

Structure and Unions- Structures, Linked Lists, Unions, Enum Declarations.

Functions- Passing Arguments, Declarations and Calls, Pointers to Functions, Recursion, The main ( ) Function, Complex Declarations.

The C Preprocessor- Macro Substitution, Conditional-Compilation, Include Facility, Line Control.

Input and Output- Streams, Buffering, The <Stdio.h> Header File, Error Handling, Opening and Closing a File, Reading and Writing Data, Selecting an I/O Method, Unbuffered I/O Random Access, The standard library for Input / Output.

References

1. *Peter A. Darnell and Philip E. Margolis, C:* A Software Engineering Approach, Narosa Publishing House (Springer International Student Edition) 1993.
2. *Brian W. Kernighan & Dennis M. Ritchie,* The C Programming Language 2nd Edition (ANSI features), Prentice Hall 1989.

(iii). **Differential Equations**

Preliminaries- Initial value problem and the equivalent integral equation, nth order equation in n-dimensions as a first order system, concepts of local existence in the large and uniqueness of solutions with examples.

Basic Theorems- Ascoli-Arzela Theorem, A theorem on convergence of solutions of a family of initial value problems.

Ergos point and Lyapunov functions, Successive approximations.

Linear Differential Equations- Linear Systems, Variation of constants, Reduction to smaller systems, Basic inequalities, Constant coefficients, Floquest theory, Adjoint systems, High order equations.

Dependence on initial conditions and parameters; Preliminaries, Continuity, Differentiability, Higher Order Differentiability.

Poincare- Bendixson theory- Autonomous systems, Unianfsatz, Index of a Stationary point.

Poincare- Bendixson theorem, Stability of Periodic solutions, rotation points, foci, nodes and saddle point.

Linear second order equations- Preliminaries, Basic facts, Theorems of Sturm, Sturm-Liouille Boundary Value Problems, Number of zeros, Nonoscillatory equation and principal solutions, Nonoscillation theorems.

Use of Implicit function and fixed point theorems- Periodic solutions, Linear equations, Nonlinear problems.

Second order Boundary value problems- Linear problems, Nonlinear problems, Apriori bounds.

References

1	*P. Hartman.*	Ordinary Differential Equations, John Wiley (1964)
2.	*E. A. Coddington and N. Levinson.*	Theory of Ordinary Differential Equations, McGraw-Hill, NY (1965)

(iii). **Advanced Discrete Mathematics**

Formal Logic- Statements, Symbolic Representation and Tautologies, Quantifiers, Predicates and Validity, Propositional Logic.

Semigroups & Monoids- Definitions and Examples of Semigroups and Monoids (including those Pertaining to concatenation operation), Homomorphism of semigroups and monoids, Congruence relation and Quotient Semigroup, Subsemigroup and submonoids, Direct products, Basic homomorphism Theorem.

Lattices- Lattices as partial ordered sets, Their properties, Lattices as Algebraic systems, Sublattices, Direct Products, and Homomorphisms, Some Special Lattices e.g. Complete, Complemented and Distributive Lattices.

Boolean Algebras - Boolen Algebras as Lattices, Various Boolean Identities, The Switching Algebra example, Sub-algebras, Direct Products and Homomorphisms, Join-irreducible elements, Atoms and Minterms, Boolean forms and their equivalence, Minterm Boolean forms, Sum of Products, Canonical Forms, Minimization of the Boolean Functions, Applications of Boolean Algebra to switching theory (using AND, OR & NOT gates), The Karnaugh Map Method.

Graph Theory - Definition of (Undirected) Graphs, Paths, Circuits, Cycles, & Subgraphs, Induced Subgraphs, Degree of a vertex, Connectivity, Planar Graphs and their properties, Trees, Euler's Formula for connected Planar Graphs., Complete & Complete Bipartite Graphs, Kuratowski's Theorem (statement only) and its use, Spanning Trees, Cut-sets, Fundamental Cut-sets and Cycles, Minimal Spanning Trees and Kruskal's Algorithm, Matrix, Representation of Graphs, Euler's Theorem on the Existence of Eulerian Paths and Circuits, Directed Graphs, Indegree and Outdegree of vertex, Weighted undirected Graphs, Dijkstra's Algorithm, Strong Connectivity & Warshall's Algorithm, Directed Trees, Search Trees, Tree Traversals.

Introductory Computability Theory- Finite State Machines and their Transition Table Diagrams, Equivalence of

Finite State Machines, Reduced Machines, Homomorphism.Finite Automata, Acceptors, Non-deterministic Finite Automata and equivalence of its power to that of Deterministic Finite Automata, Moore and Mealy Machines. Turning Machine and Partial Recursive Functions.

References

1. *J. P. Tremblay & R. Manohar,* Discrete Mathematical Structures with Applications to Computer Science,McGraw-Hill Book Co. 1997.
2. *Seymour Lepschutz,* Finite Mathematics (International edition 1983), MCGraw-Hill Book Company, New York.
3. *C.L. Liu,* Elements of Discrete Mathematics, MC Graw-Hill Book Co.

(iv). Differential Geometry of Manifolds

Definition and examples of differentiable manifolds. Tangent spaces. Jacobian map. One parameter group of transformations. Lie derivatives. Immersions and imbeddings. Distributions. Exterior algebra. Exterior derivative.

Topological groups. Lie groups and lie algebras. Product of two Liegroups. One parameter subgroups and exponential maps. Examples of Liegroups. Homomorphism and Isomorphism. Lie transformation groups. General linear groups. Principal fibre bundle. Linear frame bundle. Associated fibre bundle. Vector bundle. Tangent bundle. Induced bundle. Bundle homomorphisms.

Riemannian manifolds. Reimannian connection. Curvature tensors. Sectional Curvature. Schur's theorem. Geodesics in a Riemannian manifolds. Projective curvature tensor. Conformal curvature tensor.

Submanifolds & Hypersurfaces. Normals. Gauss' formulae. Weingarten equations. Lines of curvature. Generalized Gauss and Minardi-Codazzi equations.

Almost Complex manifolds. Nijenhuis tensor. Contravariant and covariant almost analytic vector fields. F-connection.

References:

1. *R.S. Mishra,* A course in tensors with applications to Reimannian Geometry, Pothishala (Pvt.) Ltd. 1965.
2. *R.S. Mishra,* Structures on a differentiable manifold and their applications, Chandrama Prakashan, Allahabad, 1984.
3. *K. Yano and M. Kon,* Structure of Manifolds, World Scientific Publishing Co. Pvt. Ltd. 1984.

(v). Mathematical Stastistics

(Theory Paper - 70 Marks)

Moments, Method of least Squares and curve fitting. Moments of bivariate distribution, correlation coefficient and regression, Partial & multiple correlation for three variables.

Probability : Axiomatic definition of probability, Independent events, Baye's Theorem, discrete and continuous random variables.

Distribution Functions: Probability mass function (pmf) and probability density function (pdf), Mathematical Expectation of random variables, joint distribution function of two random variables, conditional and marginal pdf and pmf, conditional expectation, Chebyshev's and Markov's inequalities, Central Limit Theorem.

Moment Generting function : Characteristic function, cumulant generating function, MGF of Binomial, Poisson's and Normal distribution, Continuous distribution, Gamma Distribution, Beta Distribution of first and second kinds, Rectangular distribution, Moments in terms of Cumulants.

Continuous Bivariate probability Distribution, Bivariate Normal Distribution, Marginal and conditional bivariate distribution.

Sampling theory: Simple Random sampling with and without replacement, Stratified random sampling, Neyman

allocation; proportional allocation; Ratio Method of estimation

χ^2 – Chi square distribution, t, F and z distributions, distributions of function of random variables (for two random variable only).

Analysis of the variance and design of experiment : One way and two way classification, Principles of design, CRD, RBD and Latin Square Design.

Estimation and testing : Definition of statistic, Unbiased estimator, Consistant estimator, Sufficient estimator, Method of maximum likelyhood estimation, Minimum variance estimator, Sufficient statistic, two types of error, Neyman - pearson (NP) lemma, Problems based on NP lemma.

Practical Examination (30 Marks) ,

03 - Hours Duration

Distribution of marks	10 marks for major Experiment
	05 marks for minor Experiment
	05 marks - record of practical work
	10 marks - Viva
Total :	30 marks

References

1. Mayer : Introduction to Mathematical Statistics
2. Gupta Gupta & Dasgupta: Fundamentals of Statistics (Vol - I, II, III - World Press)
3. M Ray & H. S. Sharma: Mathematical Statistics, Ram Prashad & Sons.
4. Goyal, J. K. & J. N. Sharma Mathematical Statistics

(vii). Mechanics of Solids

Analysis of Strain- Affine transformations. Infinite simal affine deformation. Geometrical interpretation of the components of strain. Strain quadric of Cauchy. Principal strains and invariants. General infinite simal deformation. Saint Venant's equations of Compatibility. Finite deformations.

Analysis of Stress- Stress tensor. Equations of equilibrium. Transformation of coordinates. Stress quadric of Cauchy. Principal stress and invariants. Maximum normal and shear stresses.

Equations of Elasticity - Generalised Hooke's law. Homogeneous isotropic media. Elasticity moduli for isotropc media. Equilibrium and dynamic equations for an isotropic elastic solid. Strain energy function and its connection with Hooke's law. Uniqueness of solution. Beltrami - Michell compatibility equations. Saint-Venant's principle.

Torsion - Torsion of cylindrical bars. Tortional rigidity. Torsion and stress functions. Lines of shearing stress. Simple problems related to circle, ellipse and equilateral triangle.

Two-dimensional Problems - Plane stress. Generalized plane stress. Arry stress function, General solution of Biharmonic equation. Stresses and displacements in terms of complex potentials. Simple problems. Stress function appropriate to problems of plane stress. Problems of semi-infinite solids with displacements or stresses prescribed on the plane boundary.

Waves- Propogation of waves in an isotropic elastic solid medium. Waves of dilatation and distortion. Plane waves. Elastic surface waves such as Rayleigh and Lowe waves.

Variational methods - Theorems of minimum potential energy Theorems of minimum complementary energy. Reciprocal theorem of Betti and Rayleigh. Deflection of elastic string, central line of a beam and elastic membrane. Torsion of cylinders. Variational problem related to biharmonic equation. Solution of Euler's equation by Ritz, Galerkin and Kantorovich methods.

References:

1. *I.S. Sokolnikoff,* Mathematical Theory of Elasticity, Tata McGraw Hill Publishing company Ltd., New Delbi, 1977.
2. *A.E. Love,* A Treatise on the Mathematical Theory of Elasticity, Cambridge University Press, London, 1963.

3. *Y.C. Fung.* Foundations of Solid Mechanics, Prentice Hall, New Delhi, 1965

4. *S. Timoshenko and N. Goodier* Theory of Elasticity, McGraw Hill, New York, 1970

(viii). **OPERATIONS RESEARCH:**

Operations Research and its Scope. Necessity of Operations Research in Industry.

Linear Programming- Simplex Method, Theory of the Simplex Method, Duality and Sensitivity Analysis.

Other Algorithms for Linear Programming- Dual Simplex Method, Parametric Linear Programming, Upper Bound Technique, Interior Point Algorithm, Linear Goal Programming.

Transportation and Assignment Problems.

Network Analysis- Shortest Path Problem, Minimum Spanning Tree Problem, Maximum Flow Problem, Minimum Cost Flow Problem, Network Simplex Method, Project Planning and Control with PERT-CPM.

Dynamic Programming- Deterministic and Probabilistic Dynamic programming.

Game Theory- Two- Person, Zero-Sum Games, Games with Mixed Strategies, Graphical Solution, Solution by Linear Programming.

Integer Programming- Branch and Bound Technique.

Applications to Industrial Problems- Optimal product mix and activity levels, Petroleum-refinery operations, Blending problems, Economic interpretation of dual linear programming problems, Input-output analysis, Leontief system, Indecomposable and Decomposable economics.

Nonlinear Programming- One and Multi-Variable Unconstrained Optimization, Kuhn-Tucker Conditions for Constrained Optimization, Quadratic Programming, Separable Programming, Convex Programming, Non-convex Programming.

References:

1. *F.S. Hiller and G.J. Lieberman.* Introduction to Operations Research (Sixth Edition), McGraw Hill International Edition, Industrial Engineering Series, 1995. (This book comes with a CD containing tutorial software).

2. *G. Hadley, Linear Programming.* Narosa Publishing House, 1995.

3. *H.A. Taha, Operations Research* An introduction, Macmillan Publishing Co. Inc., New York.

4. *Kanti Swarup, P.K. Gupta and Man Mohan.* Operations Research, Sultan Chand & Sons, New Delhi.

5. *Prem Kumar Gupta and D.S. Hira,* Operations Research-An Introduction, S. Chand & Company Ltd., New Delhi.

DETAILS OF SYLLABI

M.A./M.Sc. (Final)

MATHEMATICS

Paper -I: Advanced Abstract Algebra:

Groups- Normal and subnormal series. Composition series. Jordan-Holder theorem. Solvable groups. Nilpotent groups p-Sylow subgroup. Cauchy's theorem. Sylow's theorems. Direct product. Structure theorem for finite abelian groups.

Canonical Forms - Similarity of linear transformations. Invariant subspaces. Reduction to triangular forms. Nilpotent transformations. Index of nilpotency. Invariants of a nilpotent transformation. The primary decomposition theorem. Jordan blocks and Jordan forms.

Integral domain, imbedding theorem, prime and maximal ideals, quotient rings, Euclidean rings, polynomial rings, Gaussian ring, unique factorization theorem.

Cyclic modules: Simple modules. Semi-simple modules. Schuler's Lemma. Free modules.

Field theory - Extension fields. Algebraic and transcendental extensions. Separable and inseparable extensions. Normal extensions. Perfect fields. Finite fields. Primitive elements. Algebraically closed fields. Automorphisms of extensions. Galois extensions. Fundamental theorem of Galois theory. Solution of polynomial equations by radicals.

Noetherian and artinian modules and rings- Hilbert basis theorem. Wedderburn - Artin theorem. Uniform modules, primary modules, and Noether-Lasker theorem.

References:

1. *I.N. Herstein.* Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. *N. Jacobson.* Basic Algebra Vols. I & II, W.H. Freeman, 1980 (also published by Hindustan Publishing Company)
3. *I. Stewart.* Galois Theory, 2nd edition, Chapman and Hall, 1989.
4. *T.Y. Lam.* Lectures on Modules and Rings, GTM Vol. 189, Springer-Verlag, 1999.

Paper - II: Hydromechanics:

Hydrodynamics (70%):

Kinematics- Lagrangian and Eulerian methods. Equation of continuity. Boundary surfaces. Stream lines. Path lines. Velocity potential. Irrotational and rotational motions.

Equations of Motion - Lagrange's and Euler's equations of motion. Bernoulli's theorem. Equation of motion by flux method. Equations referred to moving axes. Impulsive actions. Stream function. Irrotational motion in two-dimensions. Complex velocity potential. Sources, sinks, doublets and their images.

Two-dimensional irrotational motion produced by motion of circular, co-axial and elliptic cylinders in an infinite mass of liquid. Kinetic energy of liquid. Theorem of Blasius. Motion of a sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere. Equation of motion of a sphere. Stoke's stream function.

Vertex motion and its elementary properties: Kelvin's proof of permanency. Motions due to circular and rectilinear vortices. Wave motion in a gas. Speed of Sound. Equation of motion of a gas. Subsonic, sonic and supersonic flows of a gas. Isentropic gas flows. Flow through a nozzle. Normal and oblique shocks.

Stress components in a real fluid: Relations between rectangular components of stress. Connection between stresses and gradients of velocity. Navier-stoke's equations of motion. Plane Poiseuille and Couette flows between two parallel plates. Theory of Lubrication. Flow through tubes of uniform cross

section in form of circle, annulus, ellipse and equilateral triangle under constant pressure gradient. Unsteady flow over a flat plate.

Hydrostatics (30%):

Pressure equation: Condition of equilibrium. Lines of force. Homogeneous and heterogeneous fluids. Elastic fluids. Surface of Equal pressure. Fluid at rest under action of gravity. Rotating fluids.

Fluid Pressure on plane surface: Centre of pressure. Resultant pressure on curved surfaces.

Equilibrium of floating bodies: Curves of buoyancy. Surface of buoyancy. Stability of equilibrium of floating bodies. Meta centre. Work done in producing a displacement. Vessel containing liquid.

Gas laws: Mixture of gases. Internal Energy. Adiabatic expansion. Work done in compressing a gas. Isothermal Atmosphere. Convective equilibrium.

References:

1. *W.H. Besant and A.S. Ramsey.* — A Treatise on Hydromechanics, CBS Publishers, Delhi, 1988.
2. *R.K. Rathy.* — An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
3. *A.D. Young, Boundary Layers.* — AIAA Education Series, Washington DC, 1989.

Paper-III: Integration Theory and Functional Analysis.

Integration Theory (30%):

Signed measure. Hahn decomposition theorem, mutually singular measures. Radon-Nikodym theorem. Lebesgue decomposition. Riesz representation theorem. Extension theorem (Caratheodory). Lebesgue - Stieltjes integral, product measures, Fubini's theorem. Differentiation and Integration. Decomposition into absolutely continuous and singular parts.

Functional Analysis (70%):

Normed linear spaces. Banach spaces and examples. Quotient space of normed linear spaces and its completeness, equivalent norms. Riesz Lemma, basic properties of finite dimensional normed linear spaces and compactness. Weak convergence and bounded linear transformations, normed linear spaces of bounded linear transformations, dual spaces with examples. Uniform boundedness theorem and some of its consequences. Open mapping and closed graph theorems. Hahn-Banach theorem for real linear spaces, complex linear spaces and normed linear spaces. Reflexive spaces. Weak Sequential Compactness. Compact Operators.

Inner product spaces. Hilbert spaces. Orthonormal Sets. Bessel's inequality. Complete orthonormal sets and Parseval's identity. Structure of Hilbert spaces. Projection theorem. Riesz representation theorem. Adjoint of an operator on a Hilbert space. Reflexivity of Hilbert spaces. Self-adjoint operators, Positive, projection, normal and unitary operators.

References:

1. *P.R. Halmos,* — Measure Theory, Van Nostrand, Princeton, 1950.
2. *K.R. Parthasarathy,* — Introduction to Probability and Measure, Macmillan Company of India Ltd., Delhi, 1977.
3. *G. Bachman and L. Narici,* — Functional Analysis, Academic Press, 1966.
4. *G.F. Simmons,* — Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, New York, 1963.
5. *A.E. Taylor,* — Introduction to Functional Analysis, John Wiley and Sons, New York, 1958.
6. *A.H. Siddiqui,* — Functional Analysis with Applications, Tata McGraw-Hill Publishing Company Ltd, New Delhi.

Paper-IV Integral Equations and Boundary Value Problems.

Definitions of Integral Equations and their classifications: Eigen values and Eigen functions. Fredholm integral equations of second kind with separable kernels. Reduction to a system of algebraic equations. An Approximate Method. Method of Successive Approximations. Interative Scheme for Fredholm Integral equations of the second kind. Conditions of uniform convergence and uniqueness of series solution. Resolvent kernel and its results. Application of interactive Scheme to Volterra integral equations of the Second kind.

Classical Fredholm Theory: Fredholm Theorems. Integral Transform Methods. Fourier Transform. Laplace Transform. Convolution integral. Application to Volterra integral equations with convolution-type kernels. Abel's equations. Inversion formula for singular integral equation with kernel of the type $(t/s-t)^{1-\alpha}$, $0<\alpha<1$. Cauchy's Principal Value of singular integrals. Solution of the Cauchy-type singular integral equation. The Hilbert kernel. Solution of the Hilbert-Type singular integral equation.

Symmetric kernels: Complex Hilbert Space. Orthonormal system of functions. Fundamental properties of eigen values and eigen functions for symmetric kernels. Expansion in eigen function and bilinear form. Hilbert Schmidt Theorem and some immediate consequences. Solutions of integral equations with symmetric kernels.

Definition of a boundary value problem for an ordinary differential equation of the second order and its reduction to a Fredholm integral equation of the second kind. Dirac Delta Function. Green's function approach to reduce boundary value problems of a self-adjoint differential equation with homogeneous boundary conditions to integral equation forms. Auxiliary problem satisfied by Green's function. Integral equation formulations of boundary value problems with more general and inhomogeneous boundary conditions. Modified Green's function.

Integral representation formulas for the solution of the Laplace's and Poisson's equations. Newtonian single-layer and double layer potentials. Interior and exterior Dirichlet and Neumann boundary value problems for laplace's equation. Green's function for Laplace's equation in a free space as well as in a space bounded by a ground vessel. Integral equation formulation of boundary value problems for Laplace's equation.

Poisson's integral formula., Green's function for the space bounded by grounded two parallel plates or an infinite circular cylinder.

Perturbation techniques and its applications to mixed boundary value problems. Two-part and three-part boundary value problems.

Solutions of electrostatic problems involving a charged circular disk and annular circular disk, a spherical cap, an annular spherical cap in a free space or a bounded space.

References:

1. *R.P. Kanwal,* Linear Integral Equation Theory and Techniques, Academic Press, New York, 1971.
2. *S.G. Mikhlin,* Linear Integral Equations (translated from Russian), Hindustan Book Agency, 1960.
3. *I.N. Sneddon,* Mixed boundary value problems in potential theory, North Holland, 1966.
4. *I. Stakgold,* Boundary value problems of Mathematical Physics, Vol I, II, Mac Millan, 1969.

Paper-V: (Optional Papers) Any one of the following-

(i). Fundamental of Computer Science

Object Oriented Programming- Classes and Scope, nested classes, pointer class members; Class intialization, assignment and destruction; Overloaded functions and operators; Templates including class templates; class inheritance and

subtyping: multiple and virtual inheritance.

Data Strucure- Analysis of Algorithms, η, W, Θ, o, w notations, Lists, Stacks, and queues, Sequential and linked representations, Trees, Binary tree - search tree implementation, B-tree (concept only), Hashing - open and closed, Sorting, Insertion sort, shell sort, quick - sort, head sort and their analysis.

Database Systems - Role of database systems, database system, architecture, Introduction to relational, algebra and relational calculus, SQL - basic features including views, Integrity constraints, Database, design - normalization upto BCNF.

Operating Systems - User interface, Processor, management, I/O management, memory management, concurrency and security, network and distributed systems.

References:

1. *S. B. Lipman J. Lajoi:* C++ Primer, Addison, Wesley.
2. *B. Stroustrup,* The C++ Programming Language Addison Wesley
3. *C. J. Date :* Introduction to Database System, Addison wesley.

(iii). Partial Differential Equations and Mechanics

Partial Differential Equations

Example of PDE, Classification.

Transport Equation - Initial value Problem, Non Homogeneous Equation

Laplace's Equation - Fundamental Solution , Mean Value Formula, Properties of Harmonic Functions, Green's Function, Energy Methods.

Heat Equation - Fundamental Solution, Mean Value Formula, Properties of Solutions Energy Methods.

Wave Equation - Solution by Spherical Means, Non homogeneous Equations, Energy Methods.

Nonlinear First Order PDE - Complete Integrals, Envelopes, Characteristics.

Mechanics (Analytical Dynamics)

Generalized coordinates, Holonomic and Non - holonomic systems, Scleronomic and Rheonomic systems, Generalized potential, Lagrange's Equations of first kind, Lagrange's equations of second kind, Uniqueness of solution, Energy equation for conservative fields.

Hamilton's variables, Donkin's Theorem, Hamilton canonical equations, Cycle coordinates, Routh's equations, Poisson's Bracket, Poisson's Identity, Jacobi-Poisson Theorem, Shortest Distance, Minimum surface of revolution Brachistochrone problem, Isoprimetric problems, Geodesic.

Hamilton's Principle, Principle of least action, Poincare-Cartan Integral Invariant, Whittaker's equations, Jacobi's Equations, Statement of Lee Hwa Chung's theorem.

Hamilton - Jacobi equation, Jacobi theorem, Method of seperation of variables, Lagrange's Brackets, Condition of canonical character of a transformation in terms of lagrange brackets and Poisson Brackets, Ivariance of Lagrange's brackets and Poisson brackets under canonical transformations.

References :

1. *L. C. Evans,* Partial Differential Equations, Graduate Studies in Mathematics, Vol - 19, AMS, 1998.
2. *F. Gantmacher,* Lectures in Analytic Mechanics, MIR Publishers, Moscow, 1975.
3. *N. C. Rana & P. S. C. Joag,* Classical Mecahnics, Tata MacGraw Hill, 1991
4. *L. N. Hand and J. D. Finch,* Analytical Mechanics, Cambridge University Press, 1998.

(iii). **Space Dynamics**

Basic Formulae of a Spherical triangle - The Two-body Problem, The Motion of the Centre of Mass, The relative motion, Kepler's equation, Solution by, Hamilton Jacobi an theory.

The Determination of Orbits - Laplace's Gauss Methods.

The Three-Body problem - General Theory Problem, Restricted Three Body Problem, Jacobi an Integral, Curves of Zero velocity, Stationary solutions and their stability.

The n-Body Problem - The motion of centre of mass, Classical integrals.

Perturbation - Osculating orbit, Perturbing forces, Secular & Periodic perturbations, Lagrange's Planetory Equations in terms of Perturbing forces and it terms of perturbed Hamiltonian.

Motion of the Moon - The perturbing forces, Perturbations of Keplerian elements of the Moon by the Sun.

Flight Mechanics - Rocket Performance in a Vacuum, Vertically ascending paths, Gravity Twin trajectories, Multi stage rocket in Vacuum, Definitions Pertinent to single stage rocket Performance limitations of single stage rockets, Definitions pertinent to multi stage rockets, Analysis of multi stage rockets neglecting gravity, Analysis of multi stage rocket including gravity.

Rocket Performance with Aerodynamic forces.

Short range non-lifting missiles, Ascent of a sounding rocket, Some approximate performance of rocket-powered air-craft.

References:

1. *J. M. A. Danby.* Fundamentals of Celestial Mechanics, The Macmillan Company, 1962.
2. *E. Finlay, Freundech,* Celestial Mechanics, The Macmillan Company, 1958.

(iv). **Non-Linear Programming**

The non-linear Programming problem and its fundamental integredients

Linear inequalities and theorems of the alternative- Kapler's Theorem, The Optimality criteria of linear programming, Tucker's lemma and existence theorems, Theorems of the alternative

Convex sets - Separation theorems

Convex and Concave functions - Basic properties and some fundamental theorems for Convex functions, Generalised Gordan theorem, Bohnenblust - Karlin - Shapley theorem.

Saddlepoint Optimality criteria without differentiability - The minimization and the local minimiration problems and some basic results, Sufficient Optimality theorem, Fritz John saddlepoint necessary Optimality theorem, Slater's and Karlin's Constraint qualifications and their equivalence, The strict constraint qualification, Kuhn - Tucker Saddlepoint necessary optimality theorems.

Differentiatiable Convex and Concave functions - Some basic properties, Twice-differentiable convex and concave functions, Theorems in cases of strict convexity and concavity of function.

Optimality criteria with differentiability - Sufficient Optimality theorems, Fritz John Stationary-point necessary Optimality theorem, The Arrow - Hurwic - Uzawa Constraint qualification Kuhn - Tucker stationary - point necessary Optimality theorem.

Duality in non - linear programming - Weak duality theorem, Wolfe's duality theorem, Strict Converse duality theorem, the Hanson - Huard strict converse duality theorem, Unbounded dual theorem, Duality in quadratic and linear programmings

Quasiconvex, Strictly quasiconvex functions- Differentibility properties, Strictly quasiconvex and strictly quasiconcave functions, Karamardian theorem, Global minimum (maximum).

Pseudoconvex and pseudoconcave functions, Relationship between pseudoconvex functions and strictly quasiconvex functions and pseudoconvex functions.

Optimality, and duality for generalized convex and concave functions - Sufficient optimality theorem, Generalized Kuhn - Tucker Sufficient Optimality theorem, Generalized Fritz john Stationary point necessary for optimality theorem, Kuhn - Tucker necessary optimality conditions under the weak constrain: qualifications, Duality.

Optimality and duality in the presence of nonlinear equality constraints - Sufficient Optimality criteria, Minimum principle necessary optimality criteria : X^0 not open, Minimum principle necessary optimality theorem, Fritz John and Kuhn - Tucker Stationary - point necessary optimality criteria : X^0 Open, Duality with nonlinear equality Constraints.

References :

1. *O. L. Mangasarian,* Non linear Programming, McGraw Hill, New York.
2. *Mokhtar S. Bazaraa and C. M. Shetty,* Non - linear Programming, Theory and Algorithms, Willy, New York.

(vi). Theory of Generalized Functions

Analytical study of Beta and Gamma Functions with complex arguments, Hypergeometric Functions, Generalized Hypergeometric Functions and Confluent Hypergeometric functions, Legendre and Bessel Functions with Complex arguments.

Laguerre Polynomials, Hermite Polynomials, Orthogonal Sets of Functions, Elliptic Functions of Weierstrass and Jacobian including Theta functions, Jacobian Polynomials,The Dirac -Delta Function, Chebyshev Polynomials.

Testing Function Spaces D , Z , S and their dual spaces.

References:

1. Rainville, E.D.: Special Functions.
2. Saran, N ,S.D. Sharma & Trivedi T.N.: Special Functions,Pragati Prakashan, Meerut.

(vii). General Relativity and Cosmology.

Reimannian metric Parallel transport Intrinsic derivative and geodesics Riemann Christoffel curvature tensor and its symmetry properties Bianchi identities and Einstein tensor.

Review of the special theory of relativity and the Newtonian Theory of gravitation. Principle of equivalence and general covariance.Geodesic principle.Newtonian approximation of relativistic equations of motion. Einstein's field equations and its Newtonian approximation.

Schwarzschild external solution and its isotropic form, Planetary orbits and analogues of Kepler's Laws in general relativity, Advance of perihelion of a planet, Bending of light rays in a Gravitational field. Gravitational redshifts of spectral lines, Radar echo delay.

Energy - momentum tensor of a perfect fluid, Schwarzschild internal solution, Boundary conditions, Energy momentum tensor of an electromagnetic field, Einstein - Maxwell equations, Reissner - Nordstrom solution.

Cosmology - Mach's principle, Einstein modified field equations with cosmological term, Static Cosmological models of Einstein and De-Sitter, their derivation properties and comparison with the actual universe.

Hubble's Law Cosmological principles, Weyl's postulate. Derivation of Robertson - Walker metric, Hubble and deacceleration parameters, Redshifts, Redshift versus distance relation, Angular size versus redshift relation and source counts in Robertson - Walker space - time.

Friedmann models, Fundamental equation of dynamical cosmology, Critical density, Closed and open Universe, Age of the

Universes Matter dominated era of the Universe, Einstein - de Sitter model, Particle and even horizons.

Eddington - Lamaitre models with Λ-term, Perfect cosmological principle, Steady state cosmology.

Refrences :

1. *A. S. Eddington,* The Mathematical Theory of Relativity, Cambridge University Press, 1965.
2. *J. V. Narlikar,* General Relativity and Cosmology, The Macmillan Company of India Limited, 1978.
3. *B.F. Shutz,* A first course in general relativity, Cambridge University Press, 1990.

(vii). Banach Algebras

Definition of Banach Algebra and examples. Singular and Non-singular elements, The abstract index, The spetrum of an element, The spectral radius, Gelfand formula, Multiplicative linear functionals & the maximum ideal space, Gleason - Kahane - Zelazko Theorem.

The Gelfand Transforms, The Spectral Mapping Theorem, Isometric Gelfand Transform, Maximal ideal spaces for Disc Algebra and the algebra $l_1(z)$.

C^*-algebras - Definition and examples, Self adjoint, unitary, normal positive and projection elements in C^* algebra, Commutative C^* - algebras, C^* - Homomorphisms, Representation of Commutative C^* - algebras, Subalgebras and the spectrum, The spectral theorem, The continuous functional calculus, Positive linear functionals amd states in C^*- algebras, The GNS construction.

Strong and Weak operator topologies, Von Neumann Algebras, Monotone Sequence of Operators, Range Projections, The Commutant, The Double Commutant theorem, The Keplansky Density Theorem, L^2 as Von Neumann Algebra, *Maximal Abelian Algebras.*

Abelian Von Neumann Algebras, Cyclic and Separating vectors, Representation of Abelian Von Neumann Algebras, The L^1 functional calculus, Connectedness of the unitary Group, The Projection lattice, Keplansky's formula, The centre of Von Neumann Algebra, Various types of projections, Centrally Orthogonal projections, Type Decomposition.

References

1. *T.W. Palmer, Banach,* Algebra Vol. I, Cambridge University Press, 1964.
2. *C.E. Reckart,* General Theory of Banach Algebras Von Nostrand, 1960.

(viii) Fuzzy Sets and Their Applications

Fuzzy Sets-Basic definitions, α - level sets., Convex fuzzy sets, Basic operation on fuzzy sets, Type of fuzzy sets, Cartesian products, Algebraic products, Bounded sum and difference , t-norms and t - conorms.

The Extension Principle - The Zedeh's extention principle, Image and inverse image of fuzzy sets, Fuzzy numbers, Elements of fuzzy arithmetic.

Fuzzy Relations and Fuzzy Graphs - Fuzzy relations on fuzzy sets, Composition of Fuzzy relations Min Max composition and its properties, Fuzzy equivalence relations, Fuzzy compatibility relations, Fuzzy relation equations, Fuzzy graphs, Similarity relation.

Possibility theory - Fuzzy measures, Evidence theory, Necessity measure, Possibility measure, Posibility distribution, Possibility theory, and fuzzy sets, Possibility theory versus, probability theory.

Fuzzy Logic - An overview of classical logic, Multivalued logics, Fuzzy propositions, Fuzy quantifiers, Linguistic variables and hedges, Inference, form conditionnal fuzzy propositions, the compositional rule of inference.

Approximate Reasoning - An overview of Fuzzy expert system, Fuzzy implications and their selection, Multiconditional approximate reasoning, The role of fuzzy relation equation.

An introduction to Fuzzy Control- Fuzzy controllers. Fuzzy rule base. Fuzzy inference engine. Fuzzification. Defuzzification and the various defuzzification methods (the centre of area,the centre of maxima and the mean of maxima methods).

Decision making in fuzzy Environment- Individual decision making. Multiperson decision making. Multicriteria decision making. Multistage decision making. Fuzzy ranking methods. Fuzzy linear programming.

Reference:

1. *H.J. Zimmermann*, Fuzzy set theory and its Applications. Allied Publishers Ltd., New Delhi, 1991.
2. *G.J. Klir and B. Yuan*, Fuzzy sets and fuzzy logic, Prentice-Hall of India, New Delhi 1995.

(ix) Wavelets

Preliminaries.

Different ways of constructing wavelets- Orthonormal bases generated by a single function, the Balian-Low theorem. Smooth projection on $L^2(R)$. Local sine and cosine bases and the construction of some wavelets. The unitary folding operators and the smooth projections. Multiresolution analysis and contruction of wavelets. Construction of compactly supported wavelets and estimates for its smoothness. Band limited wavelets. Orthonormality. Completeness. Characterization of Lemarie-Meyer wavelets and some other characterizations. Franklin wavelets and Spline wavelets on the real line. Orthonormal bases of piecewise linear continuous functions for $L^2(T)$. Orthonormal bases of periodic splines. Periodization of wavelets defined on the real line.

Characterization in the theory of wavelets- The basic equations and some of its applications. Characterizations of MRA wavelets, low pass filters and scaling functions. Non existence of smooth wavelets in $H^1(R)$.

Frames- The reconstruction formula and the Balian-Low theorem for frames. Frames from translations and dilations. Smooth frames for $H^1(R)$.

Discrete transforms and algorithms- The discrete and the fast Fourier transforms. The discrete and the fast cosine transforms. The discrete version of the local sine and cosine bases. Decomposition and reconstruction algorithms for wavelets.

References:

1. Eugenio Hernandez and Guido Weiss, A First Course on Wavelets, CRC, Press, New York, 1996.
2. C. K. Chui, An Introduction to Wavelets, Academic Press, [illegible]
3. I. Daubechies, Ten Lectures on Wavelets, CBS-NSF Regional Conferences in Applied Mathematics, 61, SIAM, 1992.

(x) Non-Commutative Rings

Tensor Products, Chain Conditions, Semisimplicity and Structure of semisimple rings, (Wedderburn Artin Theory) Jacobson Radical, Prime radical, Prime and semiprime rings, Structure of primitive rings and Density Theorem, Direct products, Subdirect sums and Commutativity Theorems.

Division rings, Maximal subfields, Polynomials over division rings, Local Rings, Semi Local Rings and idempotents, Perfect and semi-perfect rings.

References:

1. *T.Y. Lam*, Non Commutative Ring, Springer Verlag, 1991.
2. *I.N. Herstein*, Non Commutative Rings, Carus Monographs of AMS, 1968.
3. *N. Jacobson*, Basic Algebra II, W.H. Freeman, 1980.

(xi) Theory of Linear Operators

Spectral theory in normed linear spaces, resolvent set and spectrum, spectral properties of bounded linear operators. Properties of resolvent and spectrum. Spectral mapping theorem for polynomials. Spectral radius of a bounded linear operator on a complex Banach space. Elementary theory of Banach algebras.

General properties of compact linear operators. Spectral properties of compact linear operators on normed spaces. Behaviours of Compact linear operators with respect to solvability of operator equations. Fredholm type theorems. Fredholm alternative theorem. Fredholm alternative for integral equations.

Spectral properties of bounded self- adjoint linear operators on a complex Hilbert space. Positive operators. Monotone sequence theorem for bounded self-adjoint operators on a complex Hilbert space. Square roots of a positive operator. Projection operators. Spectral family of a bounded self-adjoint linear operator and its properties. Spectral representation of bounded self-adjoint linear operators. Spectral theorem.

Spectral measures. Spectral Integrals. Regular Spectral Measures. Real and Complex Spectral Measures. Complex Spectral Integrals. Description of the Spectral Subspaces. Characterization of the Spectral Subspaces. The Spectral theorem for bounded Normal Operators.

Unbounded linear operators in Hilbert space. Hellinger-Toeplitz theorem. Hilbert adjoint operators. Symmetric and self adjoint linear operators. Closed linear operators and closures. Spectrum of an unbounded self adjoint linear operator. Spectral theorem for unitary and self adjoint linear operators. Multiplication operator and Differentiation Operator.

References :

1. *P.R.Halmos.* Introduction to Hilbert Space and the Theory of Spectral multiplicity, Second-Edition. Chelsea Publishing Co., N.Y. 1957.
2. *N.Dunford and J.T. Schwartz.* Linear Operators-3 parts, Interscience/Wiley, New York, 1958-71.

3. *Akhiezer, N.I. and I.M. Glazman.* Theory of Linear operators in Hilbert Space, Frederick Ungar Pub. Co. N.Y. Vol I (1961), Vol. II (1963).
4. *P.R.Halmos.* A Hilbert Space Problem Book, D.Van Nostrand Company Inc. 1967.

(xii) Biomechanics

(Prerequisite: Fluid Mechanics)

Newton's equations of motion. Mathematical modelling. Continuum approach. Segmental Movement and Vibrations.

External Flow: Fluid Dynamic Forces Acting on Moving Bodies.

Flying and Swimming.

Blood Flow in Heart, Lung, Arteries, and Veins.

Micro-and Macrocirculation.

Respiratory Gas Flow.

The Laws of Thermodynamics. Molecular Diffusion, Mechanisms in Membranes, and Multiphasic Structure.

Mass Transport in Capillaries, Tissues, Interstitial Space, Lymphatics, Indicator Dilution Method, and Peristalsis.

Description of External Deformation and Forces.

Stress, Strain, and Stability of Organs.

Strength, Trauma, and Tolerance.

Biomechanical Aspects of Growth. Engineering of Blood Vessels. Tissue Engineering of Skin.

Reference :

1. *Y.C. Fung.* Biomechanics, Springer-Verlag, New York Inc. 1990.

(xiii) Analytic Number Theory.

(Prerequisite: Elementary Number Theory and Complex Analysis)

Riemann Zeta function, functional equation, prime number theorem, arithmetical functions, Mobious inversion, introduction to modular forms.

References:

1. *T.M.Apostol,* Introduction to Analytic Number Theory, Narosa Publishing House, 1980.
2. *J.P.Serre,* A Course in Arithmetic, GTM Vol.7, Springer-Verlag 1973.

(xiv) Algebraic Number Theory

(Prerequisite: Elementary Algebra & Number Theory)

Algebraic number fields and their rings of integers; calculations for quadratic and cubic cases. Localization, Galois extensions, Dedekind rings, discrete valuation rings, completion, unramified and ramified extensions, different, discriminant, cyclotomic fields, roots of unity. Class group and the finiteness of the class number. Dirichlet unit theorem, Pell'equation, Dedekind and Riemann zeta functions, analytic class number formula.

References:

1. *S.Lang, Algebraic Number Theory,* GTM Vol.110 Springer-Verlag 1994.
2. *J.Esmonde, and M. Ram Murty,* Problems in Algebraic Number Theory, GTM Vol. 190 Springer-Verlag 1999.

C.S.J.M. UNIVERSITY KANPUR

Syllabus for M.Sc. (Previous)

PHYSICS

Paper No.	Title	Total no. of Teaching	Total no. of hours per year	Max. Marks
	Tutorial hours per year			
I	Mathematical Physics and Computational Methods and Programming	90	26	100
II	Classical Mechanics and Statistical Mechanics	90	26	100
III	Quantum Mechanics	90	26	100
IV	Electronic Devices and Condensed Matter Physics	90	26	100
	Practical	264	52	200
	Total	**624**	**156**	**600**

M.Sc PHYSICS (Previous)

Max. Marks - 100

Ist - Paper

Mathematical Physics And Computational Methods and Programming

Mathematical Physics Vector Spaces and Matrices, Linear Independence; Bases, Dimensionality type Inner product, Linear transformations, Matrices, Inverses; Orthogonal and Unitary Matrices; Independent elements of a Matrix; Eigenvalues and eigenvectors, Digonalization, Complete orthonormal sets of functions. Differential Equations and Speacial functions, Second order linear ODEs with varriable coefficients;

Solution by series expansion; Legendre, Bessel, Hermite and Lagaurre equations;

Physical applications; Generating functions; recursion relations;

Integral Transforms, Laplace transform; First and second shifting theorems, Inverse LT by partial fractions, LT of derivative and integral of a function; Fourier series, FS or arbitrary period, Half wave expansions, Partial sums, Fourier integral and transforms, FT of delta function

Computational Methods

Methods of determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, convergence of solutions

Solution of simultaneous linear equation, Gaussian elimination, Pivoting, Interative method, Matrix inversion

Eigenvalues and eigenvectors of Matrices, Power and Jacobi Method.

Finite differences, interpolation with equally spaced and unevenly spaced points, Curve fitting, Polynomial least squares and cubic Spline fitting

Numerical differentiation and integration, Newton-Cotes formulae, error estimates, Gauss method.

Random variate, Monte Carlo evaluation of integrals Methods of importance sampling, Random walk and Metropolis method.

Numerical solution of ordinary differential equations, Euler and Runga-Kutta methods, Predictor and corrector method. Elementary ideas of solutions of partial differential equations.

Programming

i **Computer background :**

Brief history of computer developments, computer system components, computers generators, computer classification -Micro computers, Mini computers, Mainframe computers and Super computers, their characteristics, common business applications, computers impact on society.

II **Hardware Component :**

Binary, Octal, Decimal, Hexadecimal system of numbers and their interconversion. Representing information in Computers, internal representation of data, Various type of memories and their storage system, Secondary Storage, Data communication Concepts and application, Communication processors, Data transmission, Channels (DTC), Data transmission Techniques (DTT), Local area networking: Micro to Main frame links, real time system, Time sharing system and remote computing networking.

III **Software packages**

Importance of Software its classification, world processor DTP Graphical packages, Data communication packages Integrated packages

IV Information System

Information system analysis & Design Programming languages Features of some high level langugages like FORTRAN or C++ and their applications in programming software piracy & Computer virus

Text and Reference Books

1. Mathematical Methods for Physics, by G. Arfken
2. Matrices and Tensors for Physicists, by A. W. Joshi.
3. Advanced Engineering Mathematics, by E. Kreyszig
4. Special Functions, by E. D. Rainville
5. Special Functions, by W. W. Bell
6. Mathematical Method for Physicists and Engineers by K. F Reily, M. P. Hobson and S. J. Bence
7. Mathematics for Physicists, by Mary L. Boas.
8. S. S Sastry: Introductory Methods of Numerical Analysis Prentice Hall of India Pvt. Ltd. New Delhi - 110.001
9. Rajaraman: Numerical Analysis
10. Rajaraman: Fortran Programming
11. Vetterming, Teukolsky, Press and Flannery: Numerical Recipes.
12. Stanton, R. G. Numerical Methods for Science and Engineering Prentice Hall of India Pvt. Ltd. New Delhi - 110.001
13. Francis Scheid, Numerical Analysis (Schaum's outline series) Mc. Graw Hill Book Co. New Delhi
14. B. Dharmadayalu "Computer Science (A Primer) Tata Mc-Graw Hill Pub. Comp. Ltd. Delhi
15. S. Michael, G. Weingart seven, W. Periman "An Introduction to Programming and problem solving" 3rd ed. Wiley Eastern Pub.
16. Sanders Donald. H. "Computers today" 3rd ed. Mc. Graw Hill Nx 1988.
17. V. Rajaraman "Fortran Programming".

Tutorial:-

MATHMATICAL PHYSICS

Exercises on linear dependence and independence of a set of vectors, obtaining inverse of a matrix; Generating the most general matrix of a certain type; Eigen values and Eigen vectors.

Potential due to a discrete of continuous charge distribution; Vibrations of a circular membrane Solving the 1-D harmonic oscillator Schrodinger equation; Relation of the hydrogen atom Schrodinger equation with Laguerre equation and solution.

Solution of initial value problems by using Laplace Transform, LT & inverse LT of various functions; Solution of time - dependent problems by fourier transform; FT of Gaussian; function; Applications of FT of Dirac delta function.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

Tutorial:-

COMPUTATIONAL METHODS AND PROGRAMMING

1. Write a FORTAN program to obtain the roots of a quadratic equation with the provision that if the roots are complex, the execution should stops.
2. Invert and diagonalize 3x3 and 4x4 symmetric matrices for example

$$\begin{vmatrix} 2 & 0.5 & 0.1 \\ 0.5 & 3 & 0.1 \\ 0.1 & 0.1 & 1 \end{vmatrix} \qquad \begin{vmatrix} 3 & 1 & 1 & 0.5 \\ 1 & 4 & 1 & 1 \\ 1 & 1 & 5 & 1 \\ 0.5 & 1 & 1 & 6 \end{vmatrix}$$

3. Explain how arrays are transferred between a main programme and its subprogrammes using common blocks and arguments.

4. Explain the use of sequential formatted files What are Random Access files ?

5. What are the different types of (i) If statements and (ii) Go To statements.

6. Distinguish between a Do Loop and an implied Do Loop What restrictions are associated with Do loops ?

7. Describe briefly the Newton Raphson iteratise method for the solution of non-linear equations. Show that the procedure is second order convergent.

8. Use the Lagrange form to find the quadratic interpolation polynomial to the function f(x) having values.

x	:	1	2	3
F(x)	:	2	3	7

9. Find the condition involving coefficients a_{ij} so that Gauss - Seidel iterative method to solve the Equations

$A_{11}x + a_{12}y = c$

$A_{21}x + a_{22}y = d$

Will converge.

10. Find equations for the co-efficients a and b of the curve $y = ae^{-bx}$ by the least squares method.

11. What is meant by numerical integration? Derive trapezoidal rule for numerical integration.

12. Give an outline of the fourth order Range Kutta method of solving the differential equation

$dy/dx = f(x,y)$

illustrate your answer graphically.

13. Find out c_0, c_1, x_0 and x_1 such that the Gaussian quadrature rule

$$\int_{-1}^{+1} f(x)\,dx = c_0 f(x_0) + c_1 (x_1)$$

is exact for polynomials of degree upto three. Hence evaluate, the integral of exp(x) over x from x=0 to x=2.

14. What are the methods to solve partial differential equations ? Write down the finite difference analogue of the Laplace equation

$Uxx + Uyy = 0$

M.Sc.(Prev.) Physics

Paper - II **Max Marks - 100**

CLASSICAL MECHANICS AND STATISTICAL MECHANICS

CLASSICAL MECHANICS

1. Preliminaries, Newtonian mechanics of one and many particle systems; conservation laws, work - energy theorem, open systems (with variable mass).

2. Constraints; their classification; D' Alembert's principle' generalized coordinates.

3. Lagrange's equations; gyroscopic forces; dissipative systems; Jacobi integral; gauge invariance; generalized coordinates and momenta; integrals of motion; symmetries of space and time with conservation laws; invariance under Galilean transformations.

4. Central force, definition and characteristics; Two-body problem; closure and stability of circular orbits; general analysis of orbits, Kepler's laws and equation; artificial satellites; Rutherford scattering.

5. Principle of least action; derivation of equations of motion; variation and end points; Hamilton;s principle and characteristic functions; Hamilton- Jacobi equation.

6. Canonical transformation, generating functions; Properties; group property, examples; infinitesimal generators; Poisson bracket; Poisson theorems, angular momentum PBr; small oscillations; normal modes and coordinates

STATISTICAL MECHANICS

1. Foundations of statistical mechanics; specification of states of a system, contact between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox.
2. Microcanonical ensomble, phase space, trajectories and density of states, Liouvitle's theorem, canonical and grand canonical ensembles; partition function, calculation of statistical quantities, Energy and density fluctuations.
3. Density matrix, statistics of ensembles, statistics of indistinguishable particles, Maxwell- Boltzman, Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein condensation.
4. Cluster expansion for a classical gas, Virial equation of state, ising model, mean field theories of the Ising model in three, two and one dimensions Exact solutions of one-dimension.
5. Landau theory of phase transition, critical indices, scale transformation and dimensional analysis.
6. Correlation of space-time dependent fluctuations, fluctuations and transport phenomena, Brownian motion Langevin theory, fluctuation dissipation theorem. The Fokker-Planck equation.

Text and Reference Books

1. Classical Mechanics, by N. C. Rana and P. S. Joag (Tata McGraw-Hill, 1991).
2. Classical Mechanics, by H. Goldstein (Addison Wesley, 1980).
3. Mechanics, by A Sommerfeld (Academic Press, 1952).
4. Introduction to Dynamics, by I Perceival and D Richards (Cambridge Univ. Press. 1982).
5. Classical Mechanics, by J. C. Upadhyaya (Himalaya Publishing House, 1999).

6. Statistical and Thermal Physics, by F Reif.
7. Statistical Mechanics, by K. Huang.
8. Statistical Mechanics, R. K. Pathria
9. Statistical Mechanics, R. Kubo.
10. Statistical Physics, Landau and Lifshitz.

Tutorial:

Classical Mechanics

Simple Pendulum with rigid support, and with variable length, two connected masses with string passing over a pulley; virtual work, rolling mass inside or outside a circular ring.

Rotating frames; electromagnetic analogy of inertial forces; Foucault's pendulum.

Stability of orbits under a central force; orbital elements of planetary orbits; launching of artificial satellites.

Various Poisson brackets; their relation with PBS in quantum mechanics.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

Statistical Mechanics

1. Calculation of number of states and density of states (i) free-particle in box
2. Linear harmonic and harmonic oscillators
3. Statistics of occupation number calculation of thermodynamic quantities.
4. Black body radiation and Photon statistics
5. Evaluation of second virial coefficient
6. Fluctuations of thermodynamic variables.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc.(Prev.) Physics

Paper - III **Max Marks - 100**

QUANTUM MECHANICS - I

1. What is QM? Revision; Inadequacy of classical mechanics; Admissible wave functions; Stationary states.
2. One-dimensional problems, wells and barriers, Harmonic oscillator, by operator method
3. Uncertainty relation of x and p, States with minimum uncertainty product, General formalism of wave mechanics, Commutation relations; Representation of states and dynamical variables; Completeness of eigenfunctions; Dirac delta function; bra and ket notation, Matrix representation of an operator; Unitary transformation.
4. Angular momentum in QM; Central force problem Solution of Schrodinger equation for spherically symmetric potentials; Hydrogen atom.
5. Time-independent perturbation theory; Non-degenerate and degenerate cases; Applications such as Stark effect.
6. Variational method; EKB approximation; Time dependent perturbation theory; Harmonic perturbation; Fermi's golden rule; Adiabatic and sudden approximations
7. Collision in 3-D and scattering; Laboratory and CM reference frames; Scattering amplitude differential scattering cross section and total scattering cross section, Scattering by spherically symmetric potentials; Partial waves and phase shifts; Scattering by a perfectly rigid sphere and by square well potential; Complex potential and absorption.
8. Identical particles, Symmetric and antisymmetric wave functions; Collision of identical particles, Spin angular momentum; Spin functions for a many-electron system

9. Semiclassical theory of radiation; Transition probability for absorption and induced emission; Electric dipole and forbidden transitions; Selection rules
10. Klein Gordan Equation, Interpretation and Free Particle solution; Dirac equation, Alpha and Beta matrices, Free Particle Dirac equation and plane wave Solution; Gamma matrices and their properties, Dirac equation in covariant form
11. Quantization of non-relativistic Schrodinger equation, The number representation creation and annihilation operators

Text and Reference Books

1. L. I. Schiff, Quantum Mechanics (McGraw-Hill)
2. S. Gasiorowicz, Quantum Physics (Wiley)
3. B. Craseman and J. D. Powell, Quantum Mechanics (Addison Wesley)
4. A. P. Messiah, Quantum Mechanics
5. J. J. Sakurai, Modern Quantum Mechanics
6. Mathews and Venkatesan Quantum Mechanics
7. L. I Schiff, Quantum Mechanics (McGraw-Hill)
8. S. Gasiorowicz, Quantum Physics (Wiley)
9. B. Craseman and J.D.Powell, Quantum Mechanics (Addison Wesley)
10. A. P. Messiah, Quantum Mechanics
11. J. J. Sakurai, Modern Quantum Mechanics
12. Mathews and Venkatesan Quantum Mechanics

Tutorial:-

A Black body radiation and Planck's hypothesis; Insignificance of De Broglie hypothesis in macro-physics, Hamilton's and Fermat's principles. One-dimensional

step, barrier, well Particle energy below and above barrier height Similarly for well. Plotting of harmonic oscillator wave functions, problems involving matrix representations of an operator.

Commutation relations, uncertainty; Transformations

Angular momentum states, Addition of angular momenta; L, S, J values for various atoms in the periodic table

Anharmonic perturbation of the form x_3 and x_4 Various other time independent perturbations

Helium atom and hydrogen molecule; Various time dependent perturbations; Density of continuous states; Transition probabilities

Partial wave analysis of scattering from standard simple potentials; Scattering cross section; Optical theorem.

Slater determinants, spin and statistics; Difference in collision process between classical and quantum identical particles. Magnetic dipole transitions. Stimulated emission. Higher order transitions

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. (Prev.) Physics

Paper IV **Max. Marks - 100**

Electronic Devices and Condensed Matter Physics

ELECTRONIC DEVICES:-

Transistors: JEET, BJT, MOSFET and MESFET Structure, Working, Derivations of the equations for I-V characteristics under different conditions High Frequency Limits.

Microwave Devicese Tunnel diode, transfer for electron devices (Gunn diode) Avalanche transit time devices, Impatt diodes, and parametric devices

Photonic Devices: Radiative and non-radiative transitions. Optical Absorption, Bulk and Thin film Photoconductive devices (LDR). Diode photodetectors, solar cell- (open circuit voltage and short circuit current, fill factor) LED (high frequency limit, effect of surface and indirect recombination current, operation of LED), diode lasers (conditions for population inversion, in active region, light confinement factor. Optical gain and threshold current for lasing, Fabry-Perrot Cavity Length for lasing and the separation.

Memory Devices: Static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, non-volatile - NMOS, magnetic, optical and ferroelectric memories, charge coupled devices (CCD).

Other Electronic Devices: Electro-Optic, Magneto-Optic and Acousto-Optic Effects. Material Properties related to get those effects. Important Ferro electric, Liquid Crystal and Polymeric materials for these devices. Piezoelectric, electrostrictive and magneto strictive Effects, Important materials exhibiting these properties, and their applications in sensors and actuator devices. Acoustic Delay lines, piezoelectric resonators and filters. High frequency piezoelectric devices-Surface Acoustic Wave Devices.

CONDENSED MATTER PHYSICS :

Crystal Physics and Defects in Crystals

Crystalline solids, unit cells and direct lattice, two and three dimensional Bravais Lattices, closed packed structures.

Interaction of X-ray with matter, absorption of X-rays. Elastic scattering from a perfect lattice. The reciprocal lattice and its applications to diffraction techniques. The Laue, powder and rotating crystal methods, crystal structure factor and intensity of diffraction maxima.

point defects, line defects and planer (stacking) faults. The role of dislocations in plastic deformation and crystal growth. The observation of imperfections in crystals. X-ray and electro microscopic techniques.

Electronic Properties of Solids

Electronic in a periodic lattice: Bloch theorem, band theory, classification of solids, effective mass. Tight-binding, cellular and pseudopotential methods. Fermi surface, De Haas Van Alfen effect, cyclotron resonance, magnetoresistance, quantum Hall effect. Layered materials and its applications.

Weiss theory of ferromagnetism. Heisenberg model and molecular field theory. Spin waves and magnons. Curie-Weiss law for susceptibility. Ferri and antiferro-magnetic order. Domains and Bloch - wall energy.

Text and Reference Books

1. Semiconductor Devices - Physics and Technology, by SM Sze Wiley (1985)
2. Introduction to semiconductor devices, M. S. Tyagi, John Wiley & Sons
3. Measurement, Instrumentation and Experimental Design in Physics and Engineering by M. Sayer and A. Mansingh, Prentice Hall, India (2000)
4. Optical electronics by Ajoy Ghatak and K. Thyagarajan, Cambridge Univ. Press.
5. Verma and Srivastava: Crystallography for Solid State Physics
6. Azaroff: Introduction to Solids
7. Omar: Elementary Solid State Physics
8. Aschroft & Mermin: Solid State Physics
9. Kittel: Solid State Physics

10. Chaikin and Lubensky: Principles of Condensed Matter Physics
11. Robert A. Levy, Principles of solid State Physics, Academic Press

Tutorial:-

ELECTRONIC DEVICE

The problems given in the Text and Reference books will form tutorial course

CONDENSED MATTER PHYSICS

1. Given that the primitive basis vectors of a lattice a=(a/2)(i+j), b=(a/2)(j+k) and c=(a/2)(k+j), where i, j, and k are usual three unit vectors along Cartesian coordinates, what is the Bravais lattice ?
2. Show that in an Ideal hexagonal-close-packed (hcp) structure, where the atomic spheres touch each other, the ratio c/a is given by

$$\frac{c}{a} = \sqrt{\left(\frac{8}{3}\right)} = 1.633$$

3. The packing ratio is defined as the fraction of the total volume of the cell that is filled by atoms. Determine the maximum values of this ratio for equal spheres located at the points of simple-cubic, body-centered-cubic, and face-centered-cubic crystals.
4. Consider a face-centered-cubic cell. Construct a primitive cell within this larger cell, and compare the two. How many atoms are in the primitive cell, and how does this compare with the number in the original cell ?
5. a. Determine which planes in an fcc structure have the highest density of atoms.

   b. Evaluate this density in atoms/cm^2 for Cu.

6. a. Show for a simple square lattice (two dimensions) that the kinetic energy of free electron at a corner of the first zone is higher than that of an electron at midpoint of a side face of the zone by a factor of 2.

b. What is the corresponding factor for a simple cubic lattice (three dimensions)?

c. What bearing might the result of (b) have on the conductivity of divalent metals ?

7. Consider the free electron energy bands of an fcc crystal lattice in the approximation of an empty lattice, but in the reduced zone scheme in which all k's are transformed to lie in the first Brillouin zone. Plot roughly in the (111) direction the energies of all bands up to six times to lowest band energy at the zone boundary at $k = (2\pi/a)(1/2, 1/2, 1/2)$. Let this be the unit of energy. This problem shows why band edges need not necessarily be at the zone center. Several of the degeneracies (band crossings) will be removed when account is taken on the crystal potential

8. a. For the delta function potential and with $P < 1$, find at $k=0$ the energy of the lowest energy band.

(b) For the same problem find the band gap at $k = \pi/a$.

9. Consider a square lattice in two dimensions with the crystal potential $U(x, y) = -4U \cos(\pi x/a) \cos(\pi y/a)$

Apply the central equation to find approximately the energy gap at the corner point $(\pi/a, \pi/a)$ of the Brillouin zone. It will suffice to solve a 2×2 determinantal equation.

10 Explain qualitatively why the Hall constant RH is inversely proportional to the electron concentration N.

Demonstrate qualitatively that the Hall constant for a current of positive charges is positive.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. (Prev.) Physics

Max. Marks - 200

LABORATORY/PRACTICAL COURSE

1. Design of a Regulated power Supply
2. Design of a Common Emitter Transistor Amplifier
3. Experiment on Bias Stability
4. Negative Feedback (Voltage series /shunt and current series/shunt)
5. A stable, Monostable and Bistable Multivibrator.
6. Characteristics and applications of Silicon Controlled Rectifier.
7. Testing goodness of fit of Poission distribution to cosmic ray bursts by chi-square test.
8. Determination of Half Life of 'In'
9. Determination of range of Bata - rays from Ra and Cs.
10. X-rays diffraction by Telexometer.
11. Determination of Ionization Potential of Lithium.
12. Determination of e/m of electron by Normal Zeeman Effect using Febry parrot Etalon.
13. Determination of Dissociation Energy of Iodine (I) Molecule by photography the absorption band of in the visible region.
    (a) Measurement of wavelength of He - Ne Laser using ruler.
    (b) Measurement of thickness of thin wire with laser.
14. Experiment on FET and MOSFET characterization and application as an amplifier.
15. Experiment on Uni - Junction Transistor and its application
16. Digital I: Basic Logic Gates, TTL, NAND and NOR.
17. Digital II: Combinational Logic

18. Flip - Flops
19. Operational Amplifier (741)
20. Differential Amplifier.
21. Measurement of resistivity of a semiconductor by four probe method at different temperatures and Determination of band gap.
22. Determination of Lande's factor of DPPH using Electron - Spin resonance (E.S.R.) Spectrometer.
23. Measurement of Hall coefficient of given semiconductor. Identification of type of semiconductor and estimation of charge carrier concentration.
24. To study the fluorescence spectrum of DCM dye and to determine the quantum yield of fluorescence maxima and full width at half maxima for this dye using monochromator.

Tutorial

1. Network Analysis - Thevenin and Norton's equivalent circuits
2. Basics of p-n junction - Diffusion current, Drift current, Junction width, Forward and Reverse Biasing; Significance of Fermi level in stabilizing the junction
3. Zener diode - characteristics and voltage regulation
4. Transistor biasing and stability
5. Wein's bridge and phase shift
6. Solving Boolean expressions
7. Mechanism and production of electrical pulse through absorption of nuclear radiation in medium
8. Deadtime efficiency, counting techniques, energy resolution
9. Lattice extinctions in X-ray diffraction
10. Atomic scattering power and geometrical structure factor

11. Effect of capacitance and load resistance on output of an amplifier
12. Integrated circuit timer familiarization
13. Op-amp differentiator
14. Multiplexers and Demultiplexers
15. Resistors and counters
16. Radiation level and activity measurement
17. Shielding, mass absorption coefficient
18. Coincidence circuits, counters, timers
19. Coherence and it's relevance in diffraction
20. Identification of charge type by Hall voltage measurement
21. How does four probe method solve the problem of contact resistance ?

C.S.J.M. University Kanpur

Syllabus for M.Sc. (Final)

PHYSICS

Paper No.	Title	Total no. of Teaching hours per year	Total no. of Tutorial	Max. Marks
I	Atomic, Molecular, Nuclear and Particle Physics	90	26	100
II	Special Paper I	90	26	100
III	Special Paper II	90	26	100
IV	Electrodynamics and Plasma Physics	45	13	50
V	Elective Paper	45	13	50
Practical		132	26	100
Project		132	26	100
Total		624	156	600

The candidate may offer one of the following as special paper.

(1) Condensed Matter Physics.
(2) Electronics.
(3) Atomic and Molecular Physics.
(4) Nuclear and Particle Physics.
(5) Informatics.

Any one of the following electives papers is to be opted.

(1) Quantum Electrodynamics.
(2) Physics of Liquid Crystals.

(3) Science and Technology of Solar Hydrogen and other Renewable Energies.
(4) Reactor Physics.
(5) Numerical Methods and Programming.
(6) Physics of Lasers and Laser Application.
(7) Structures, Spectra and Properties of Biomolecules.
(8) Diagram Techniques.
(9) Physics of Electronics Devices & Fabrication of Integrated Circuits and Systems.
(10) Atmospheric Science.
(11) Plasma Physics.
(12) Quantum Many-Body Physics.
(13) Nonlinear Dynamics.
(14) Environmental Physics.
(15) Physics of Nanomaterials.

M.Sc. (Physics) (final year)

Ist Paper **Max Marks - 100**

Atomic, Molecular, Nuclear and Particle Physics

(1) ATOMIC AND MOLECULAR PHYSICS

Quantum states of one electron atoms-Atomic orbitals-Hydrogen spectrum-Pauli's principle-Spectra of alkali elements-Spin orbit interaction and fine structure in alkali Spectra-Equivalent and non-equivalent electrons-Normal and anomalous Zeeman effect-Paschen Back effect-Stark effect-Two electron systems-interaction energy in LS and JJ coupling-Hyperfine structure (qualitative)-Line broadening mechanisms (general ideas)

Types of molecules- Diatomic linear symmetric top, asymmetric top and spherical top molecules-Rotational spectra of diatomic molecules as a rigid rotor-Energy levels and spectra of non rigid rotor-intensity of rotational lines-Stark modulated microwave spectrometer (qualitative)

Vibration energy of diatomic molecule- Diatomic molecule as a simple harmonic oscillator-Energy levels and spectrum-Morse potential energy curve-Molecules as vibrating rotator-Vibration spectrum of diatomic molecule-POR branches IR spectrometer (qualitative)

(2) NUCLEAR AND PARTICLE PHYSICS

Nuclear Interactions and Nuclear Reactions

Nucleon - nucleon interaction - Exchange forces and tensor forces - meson theory of nuclear forces - Nucleon - nucleon scattering - Effective range theory - Spin dependence of nuclear forces - charge independence and charge symmetry of nuclear forces - Isospin formalism - Yukawa interaction. Quadrupole moment.

Direct and compound nuclear reaction mechanisms - Cross sections in terms of partial wave amplitudes

Compound nucleus - Scattering matrix - Reciprocity theorem - Breit - Wigner one - level formula - Resonance scattering. Reaction dynamics, Q value.

Nuclear Models

Liquid drop model - Bohr - Wheeler theory of fission - Experimental evidence for shell effects - Shell model - Spin - Orbit coupling. Magic numbers - Angular momenta and parities of nuclear ground states - Qualitative discussion and estimates of transition rates - Magnetic moments and Schmidt lines - Collective model of Bohr and Mottelson. Parity.

Nuclear Decay

Beta decay - Fermi theory of beta decay - Shape of the beta spectrum - Total decay rate - Angular momentum and parities selection rules - Comparative half - Lives - Allowed and forbidden transitions - Selection rules - Parity violation - Two - component theory of neutrino decay - Detection and properties of neutrino - Gamma decay - Multipole transitions in nucles - Angular momentum and parity selection rules - Internal conversion - Nuclear isomerism.

Elementary Particle Physics

Type of interaction between elementary particles - Hadrons and leptons - Symmetry and conservation laws - Elementary ideas of CP and CPT invariance - Classification of hadrons - Lie algebra, SU(2) - SU(3) multiplets - Quark model - Gell - Mann - Okubo mass formula for octet and decuplet hadrons - Charm, bottom and top quarks. G.M. courtesy

Text and Reference Books

1. Introduction to Atomic spectra - H.E. White (T)
2. Fundamentals of molecular spectroscopy - C.N.Banwell (T)

3. Spectroscopy Vol. I, II & III - Walker & Straughen
4. Introduction to Molecular spectroscopy - G.M. Barrow
5. Spectra of diatomic molecules - Herzberg
6. Molecular spectroscopy - Jeanne L McHale
7. Molecular spectroscopy - J.M.Brown
8. Spectra of atoms and molecules - P.F.Bernath
9. Modern spectroscopy - J.M.Holias
10. A.Bohr and B.R. Mottelson, Nuclear Structure, Vol. 1 (1969) and Vol. 2, Benjamin, Reading, A, 1975.
11. Kenneth S.Kiane, Introductory Nuclear Physics, Wiley, New Yark, 1988.
12. Ghoshal, Atomic and Nuclear Physics Vol.2.
13. P.H. Perkins, Introduction to High Energy Physics, Addison - Wesley, London, 1982.
14. Shirokov Yudin, Nuclear Physics Vo. 1 & 2, Mir Publishers, Moscow, 1982.
15. D. Griffiths, Introduction to Elementary Particles, Harper and Row, New Yark, 1987.
16. H.A.Enge, Introduction to Nuclear Physics, Addison - Wesley, 1975.
17. G. E. Brown and A.D. Jackson, Nucleon - Nucleon Interaction, North - Holland, Amsterdam, 1976.
18. S.de Benedetti, Nuclear interaction, John Wiley & Sons, New York, 1964.
19. M.K. Pal, Theory of Nuclear Structure, Affiliated East - West, Madras, 1982.
20. Y.R. Waghmare, Introductory Nuclear Physics, Oxford - IBH, Bombay, 1981.
21. J.M. Longo, Elementary Particles, Mc Graw - Hill, New York, 1971.
22. R.D.Evans, Atomic Nucleus, Mc Graw - Hill, New York, 1955.

23. I. Kaplan, Nuclear Physics, 2nd Ed., Narosa, Madras, 1989
24. B.L. Cohen, Concepts of Nuclear Physics, TMGH, Bombay,1971.
25. R.R. Roy and B.P. Nigam, Nuclear Physics, Wiley Eastern Ltd., 1983

Tutorial : Atomic and Molecular Physics

1. Write all possible term symbols for the following electron configuration (a) [Be]2p3p (b) [He] 2s2p (c) [Be] 2p3d
2. Helium atom has two forms: orthohelium and parahelium. Describe these two forms of helium and the term symbols for each state. Calculate the equilibrium ratio of the two forms of He at 300K. Explain why orthohelium is metastable?
3. Give that the bond dissociation energy of oxygen is 5.2eV and its vibrational frequency is 1580 cm^{-1}. Estimate maximum vibrational quantum number possible for oxygen?
4. Why is the harmonic oscillator model aphysical at long bond lengths? How is this model at short bond lengths ?

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

Tutorial : Nuclear and Particle Physics

1. Scattering Matrix
2. Nucleon-Nucleon phase shifts
3. Double Scattering Experiment to measure Polarization
4. General Properties of Nuclear forces
5. The Q Equation
6. Calculation of Absorption Cross Section
7. Resonance Reaction

8. Kurie Plot
9. Comparative Half-Lives
10. Selected Rules
11. Parity Violation Experiment
12. Neutrino Helicity
13. Isospin Symmetry
14. Lie Algebra

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. (Physics) (final year)

Special Paper - Ist Paper (IInd A)

Max. Marks - 100

Condensed Matter Physics

Crystal Physics and X-Ray Crystallography :

Crystalline solids, Bravais lattices, Crystal System Representation of directions and plains, External symmetry elements; point groups; Glide planes and screw axes, space groups, crystal structure, principle of X-ray diffraction, structure factor, The Powder method interpretation of X-ray powder photographs. Intensity of Ito/ks method, Accurate determination of lattice parameters, Applications of powder method, Intensity of powder diffraction rings, Laue oscillation.

Lattice Dynamics and optical properties of solids :

Interatomic forces and lattice dynamics of simple metals, Ionic and covalent crystals, optical photons and dielectric constants, Inelastic neutron scattering Debye Waller factor, Anharmonicity, thermal expansion and thermal conductivity Interaction of electrons and photons with photons. Direct and indirect transitions. Absorption in insulators, Polarisation, one photon absorption optical properties of metals, skin effect.

Electron - Photon Interaction :

Interaction of electrons and acoustic and optical photons, polarions Superconductivity, manifestations of energy gap. Cooper pairing due to photons, BCS theory of superconductivity, Ginzsburg-Landau theory and application to Josephson effect. Elements of high temperature superconductors

Exotic Solids :

Amorphous solids, liquid crystals, Aperiodic solids and quasi crystals. Fibonancy sequence, penrose lattices and their extension to 3 dimensions. Nm structural materials: Introduction, methods of synthesis and experimental characterization techniques, quantum size effect and its applications; Fullerences, side wall and multiwall carbon tubes, their formation and characterization. Carbon nanotubules based electronic devices.

References :

1. B. D. cullity, x-ray diffraction.
2. A.R. Verma and O.N. srivastava : crystallography for solid state physics.
3. Azaroff : X-ray crystallography.
4. Azaroff and Buerger : the powder method.
5. Henry, Lipson and Booster : Interpretation of X-ray diffraction photographs.
6. Buerger : Crystal structure analysis
7. M. Ali omar : elementary solid state physics.
8. Steinhard and sustland : The physics of quasi crystals.
9. Maleiung : Introduction to solid state theory.
10. Callaway : Quantum theory of solid state
11. Huang : theoreal solid state physics.
12. Kittle : Quantom theory of solid
13. Animal : Quantum theory of crystal solids
14. Chandrashekhar : Liquid crystals.
15. Hari Singh Nalwar (editer): Hand book of Nanostructured materials (vol 1-4)

Tutorial :

Crystal Physics and X-ray crystallography :

1. The powder diffraction pattern of a metal belonging to cubic system made with Cu K' Radiation contains ten lines whose sin values are 0.118, 0.1487, 0.2940, 0.403, 0.4391, 0.583, 0.691, 0.727, 0.872 and 0.981. Index these lines and find out the lattice type and calculate lattice parameter.

A powder diffraction pattern is made of a cubic substance with unfiltered chromium radiation. Then observed sin2? values (relative intensities) are 0.265 (m), 0.321 (vs), 0.528 (w), 0.638 (s), 0.793 (s) and 0.958 (vs). Index these lines and state which are due to K_{α} and which to K_{β} radiation. Determine the Brevis lattice and lattice parameter. Identify the substance based on ASTM chart (m = medium, v = very, s = strong, w = weak)

The following data were obtained from a Debey-scherrer ring pattern of a simple - Cubic substance recorded with Copper radiation. The given $\sin^2\theta$ values for the K_{α} only

$h_1^2+k_1^2+l_1^2$	$\sin^2\theta$
38	0.9114
40	0.9563
41	0.9761
42	0.9889

Determine the lattice parameter, accurate to four significant figures by graphical extrapolation of a against $\cos^2\theta$

The Bragg angle for reflection from (11^0) planes in bcc iron is 22^0 for x-ray wavelength of λ = 1.54 Å Compute the cube edge for iron. Do you see reflection from (111) plains justify your answer, Also calculate the density of bcc iron. The atomic weight of iron is 55.8

Show that if the crystal undergoes volume expansion, Then the refelection beam is rotated by angle

$$d\theta = -\frac{\gamma}{3}\tan\theta$$

θ = Bragg's angle, γ = volume expansion coeff.

6. Explain with the help of reciprocal lattice concept. The oscillation photograph. How can be the streaks be removed.

Exotic solids:

1. Distinguish between crystalline, amorphous solids and liquids.
2. What is the golden mean ratio. How is relevant quasicrystals?
3. Can periodicity and aperiodicity exist together in a structure ? Justify your answer.
4. What are rational approximations in quasicrystals ? Discus there relevance.
5. Band structure concept for crystals is not quite valid for nanostructure why ?
6. Carbon nanotubles can be both semiconductor and metallic why ?
7. What is the onion carbon structure ? How is it related to florevenes ?

In addition to other revalent problems as given by instructor based on text and reference books.

M.Sc. (Physics) (final year)

Special Paper - Ist Paper (IInd B)

Max Marks - 100

ELECTRONICS

Operational Amplifiers

Differential amplifier - circuit configurations - dual input, balanced Output differential amplifier - DC analysis - AC analysis, inverting and non inverting inputs CMRR - constant current bias level translator.

Block diagram of a typical Op-Amp-analysis. Open loop configuration inverting and non - inverting amplifiers Op - amp with negative feedback - voltage series feed back - effect of feed back on closed loop gain input persistence output resistance bandwidth and output offset voltage - voltage follower.

Practical op-amp input offset voltage - input bias current - input offset current, total output offset voltage, CMRR frequency response.

DC and AC amplifier summing scaling and averaging amplifiers instrumentation amplifier, integrator and differentiator.

Oscillator principles - oscillator types - frequency stability - response - the phase shift oscillator, Wein bridge oscillator - LC tunable oscillator - Multivibrators - Monostable and Astable - comparators - square wave and Triangle wave generators.

Voltage regulators - fixed regulator - adjustable voltage regulators switching regulators using regulated I.C.

Communication Electronics

Amplitude modulation - Generation of AM waves - Demodulation of AM waves - DSBSC modulation, Generation of DSBSC waves, Coherent detection of DSBSC waves, SSB modulation, Generation and detection of SSB waves, Vestigial sideband modulation. Frequency Division multiplexing (FDM). Discriminator, Ratio detector.

Digital Electronics

1. **Combinational Logic**

The transistor as a switch, OR, AND and NOT gates - NOR and NAND gates Boolean algebra - Demorgan's theorems - Exclusive OR gate, Decoder/Demultiplexer Data selector/multiplexer - encoder. Half and Full Adder.

2. Sequential Logic

Flip - Flops : AL - bit memory - The RS Flip - Flop, JK Flip - Flop - JK master slave Flip - Flop - T Flip - Flop - D Flip - Flop - Shift registers - synchronous and asynchronous counters - cascade counters. Module 5, 10, N counters.

Microprocessors

Introduction to microcomputers - memory - input/output - interfacing devices

8085 CPU - Architecture - BUS timings - Demultiplexing the address bus generating control signals - Introduction set - addressing modes - Illustrative programmes - writing assembly language programmes looping, counting and indexing - counters and timing delays - stack and subroutine.

Analog and Digital Systems

Analog computation, active filters, comparators, logarithmic and anti - logarithmic amplifiers, sample and hold amplifiers, waveform generators. Square and triangular wave generators, pulse generator.

Read - only Memory (ROM) and applications. Random Access Memory (RAM) and applications. Digital to - analog converters, ladder and weighted resistor types Analog to digital converters - counter type, successive approximation and dual slope converters, Application of DACs and ADCs.

Optoelectronics

Photo detectors : Photo detectors with external photo effect, photo detectors with internal photo effect, photo conductors and photo resistor, junction photo detectors. Circuits with Light Emitting Diodes, Diode tester. Polarity and voltage tester, measuring instruments with LED indication. LED, Numeric and alphanumeric display

units. Semiconductor switches and potential isolation. The phototransistor as a switch in the optocouplers, steady state performance, dynamic performance, use of optocouplers. Liquid crystal display (applications).

Microwave Devices

Klystrons, Magnetrons and Travelling Wave Tubes. Velocity modulation, Basic principles of two cavity Klystrons and Reflex, Klystrons, principles of operation of magnetrons. Helix Travelling Wave Tubes, Wave Modes. Power measurements at microwaves. Transferred electron devices, Gunn Effect, Principles of operation. Modes of operation, Read diode, IMPATT diode, TRAPATT Diode.

Microwave Communications

Advantage and disadvantage of microwave transmission, loss in free space, propagation of microwave, atmospheric effects on propagation, fresnel zone problem, ground reflection, fading sources, detectors, components, antennas, antennas used in MW communication systems.

Radar System

Radar block diagram an operation, radar frequencies, Pulse considerations. Radar range equation, derivation of radar range equation, minimum detectable signal, receiver noise, signal to noise ratio, Integration of radar pulses. Radar cross section . Pulse repetition frequency. Antenna parameters, system Losses and propagation losses. Radar transmitters, receivers. Antennas, Displays. Radar Aids to navigation, moving target Indicator.

Satellite Communication

Satellite communication : orbital satellites, geostationary satellites, orbital patterns, look angles, orbital spacing, satellite systems. Link modulas.

Text and Reference Books

1 "Electronic Devices and circuit theory" by Robert Boylestad and Louis Nashdsky PHI, New Delhi - 110001, 1991

2 "OP-Amps & Lancar integrated circuits," by Rmakanth A Gayakwad PHI, Second Edition, 1991

3. "Digital principles and applications" by A P. Malvino and Donald P. Leach, Tata Megraw - Hill company. New Delhi, 1993

4. "Microprocessor Architecture, programming and Application with 8085/8086" by Ramesh S. Gaonkar, Wiley - Eastern Ltd., 1987 (for unit v)

5. "Microelectronics" by Jacob Millman, Megraw - hill International book co., New Delhi 1990

6. "Optoelectronics: Theory and Practice", Edited by Alien Chappal. Mc GrawHill Boll co., New York.

7 "Microwaves" by K.L. Gupta, Wiley Eastern Ltd., New Delhi. 1983

8 "Advanced Electronics Communications System" by Wayne Tomasi., Phi. Edn.

Tutorial: ELECTRONICS

1 Operational Amplifiers

2. Design considerations of opamp oscillators

3. Design considerations of instrumentation amplifiers

4 Mathematical operation using opamps

5 Radiowave propagation in free space

6. Tropospheric & ionospheric propagation

7 Application of counters & shift registers

8 Dedicated systems using microprocessors

9 Sampling Theorem - sample and hold circuits

10 Second and higher order filter design concepts

11 A/D & D/A interfacing

12. Photo electric effect

13 Photo emissive cells

14 Microwave amplification

15. Klystron and Gunn Oscillator characteristics

16. Concepts of wave guides

17. Microwave propagation

18 Design considerations of microwave links

19 Different types of radar systems

20. (i) Weather Radars (ii) Cyclone detection radars (iii) Moving target indicators

21 Frequency considerations in satellite communications

In addition to above, the tutorial will also consist of solving problems given in the text and Reference books.

M.Sc. (Physics) (final year)

Special Paper - Ist Paper (IInd C)

Max Marks - 100

ATOMIC AND MOLECULAR PHYSICS

Basic principle of interaction of spin and applied magnetic field - Concepts of NMR spectroscopy - Concepts of 'spin spin' and 'spin lattice's relaxation - Chemical shift - Spin spin coupling between two and more nuclei (qualitative) experimental setup CW NMR Spectrometer Chemical analysis using NMR

Mossbauer effect - Recoil less emission of gamma rays - Chemical shift - Magnetic hyperfine interaction - Experimental setup

Electron spin resonance - Effects of L.S. coupling fine and hyperfine structure - G Values - Simple experimental setup

Time dependence in quantum mechanics - Time dependent perturbation theory - Rate expression for emission - Perturbation theory calculation of polarisability - Quantum mechanical expression for emission rate - Time correlation function and spectral Fourier transform pair - Properties of time correlation functions and spectral time shape - Fluctuation dissipation theorem - Rotational correlation functions and pure rotational spectra - Re orientational spectroscopy of liquids.

Raman effect - Quantum theory - Molecular polarisability - Pure rotational Raman spectra of diatomic molecules - Vibration rotation Raman spectrum of diatomic molecules - intensity alterations in Raman spectra of diatomic molecules - Experimental setup for Raman spectroscopy - Application of IR and Raman spectroscopy in the structure determination of simple molecules.

Electronic spectra of diatomic molecules - Born Oppenheimer approximation - Vibrational coarse structure of electronic bands - Progression and sequences - intensity of electronic bands - Franck Condon principle - Dissociation and pre dissociation - Dissociation energy - Rotational fine structure of electronic bands - Electronic structure of diatomic (base ideas only).

Test and Reference Books

1. Molecular spectroscopy - Jeane I. McHale
2. Molecular quantum mechanics - P.W Alkins & R.S. Friedman
3. Mossbauer spectroscopy - M.R.Bhide
4. NMR and chemistry - J.W.Akitt
5. Structural methods in inorgame chemistry - *E.A.V.Ebsworth, D.W.H Rankin & S.Cradock*

6. Introduction to Atomic spectra - H.E.White (T)
7. Fundamentals of molecular spectroscopy - C.B.Banwell (T)
8. Spectroscopy Vol. I, II, & III - Walker & Straughen
9. Introduction to Molecular spectroscopy - G.M.Barrow
10. Spectra of diatimic molecules - Herzberg
11. Molecular spectroscopy - Jeanne L. McHale
12. Molecular spectroscopy - J.M.Brown
13. Spectra of atoms and molecules - P.F.Bernath
14. Modern spectroscopy - J.M.Holkas

Tutorial :

ATOMIC AND MOLECULAR PHYSICS

1. Predict the appearance of high resolution (1H)NMI spectrum of the following compounds: I)- Acetaldehyde ii) Acetone iii) Acetic acid iv) n - Butanone v) Propionic acid vi) Benzene vii) Tolune viii) Ethyl benzene ix) Isobutane
2. The NMR spectrum of a certain organic compound containing a single atom of bromine is given. Identify the compound. (give the spectrum of Ethyl Bromide)
3. The NMR spectrum of a compound with empirical formula C_4H_8O. Identify the compound (give the spectrum of ehyl ketone)
4. Explain the splitting pattern of high resolution HNMR spectrum of: a) 1,1 dibromoethane b) ethane c) 1 - chloropropane
5. For HCN how many vibrational peaks do you expect its IR spectrum to have? What about its Raman spectrum?
6. Explain how you can have a $\Delta J = 1$ Absorption in an IR (vibrational - rotational) spectrum?
7. The rotational absorption peaks of HCL IR spectrum, the peaks are not of the same height. The peaks started off

(from the center of the spectrum) short and then get taller and then finally became short again. Why does this happen?

8. For the molecule CO ν (bar) =2170 cm^{-1} and Be=1.931cm^{-1}. Now answer the following questions pertaining to its IR (vibrational and rotational) spectrum.

a) Where will the center of the vibrational band be located? What vibrational transition does this correspond to? What rotational transition does this correspond to?

b) How far away (in wave numbers) will the first rotational absorption be from the center?

c) What is the spacing between rotational absorptions (in wavenumbers)?

d) Sketch the overall vibrational - rotational spectrum?

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. (Physics) (final year)

Special Paper Ist Paper (IInd D)

Max. Marks - 100

NUCLEAR AND PARTICLE PHYSICS

The Nucleon - Nucleon Interaction

Nucleon - Nucleon Interaction and Hadron Structure : Phenomenological Nucleon - Nucleon potentials - Meson theory - Derivation of Yukawa interaction - Electromagnetic properties of deuteron - Polarisation in nucleon - nucleon scattering - Scattering matrix - Probing charge distribution with electrons - Form factors - Proton form factors - Deep inelastic electron - proton scattering - Bjorken scaling and Partons - Quarks within the proton - Gluons as mediators of strong interaction.

Particle Phenomenology : Pion - Nucleon scattering - Isospin analysis - Phase shifts - Resonance and their quantum numbers - Production and formation experiments Relativistic kinematics and invariants - Mandelstam variables - Phase space - Decay of one particle into three particles - Dalitz Plot.

Nuclear Radiation Detectors

Ionizing radiations : Ionization and transport phenomena in gases - Avalanche multiplication.

Detector Properties : Detection - Energy measurement - Position measurement Time measurement.

Gas Counters : Ionization chambers, - Proportional counters - Multiwire proportional counters - Geiger - Muller counters - Neutron detectors.

Solid State Detectors : Semiconductor detectors - Integrating solid state devices - Surface barrier detectors.

Scintillation counters: Organic and inorganic scintillators - Theory, characteristics and detection efficiency.

High Energy Particle Detectors : General principles - Nuclear emulsions - Cloud chambers - Bubble chambers - Cerenkov counter

Nuclear Electronics : Analog and digital pulses - Signal pulses - Transient effects in an RC circuit - Pulse shaping - Linear amplifiers - Pulse height discriminators - Single channel analyzer - Multichannel analyser.

Nuclear Reactions and Nuclear Energy

Nuclear Reactions : Elementary approach to potential scattering theory - S-wave neutron scattering in the compound nuclear reaction model - Derivation and discussion of Breit - Wigner resonance formula - Single level single channel R-matrix (R-function) theory - Statistical model of compound nuclear reaction -

Pre-equilibrium reactions - Discussion of direct reactions - Ground state of deuteron - Magnetic moment - Quadrupole moment - S and D admixtures - Plane wave theory of deuteron - Stripping in zero range approximation - Spectroscopic factor and determination of nuclear level properties - Single nucleon transfer reactions - Theory of average cross sections - Properties of optical potentials, Heavy-ion collisions - Features of medium and low energy heavy ion elastic scattering - Diffraction models - Nuclear fission and extended liquid drop model

Nuclear Energy: The fission process-Neutrons released in the fission process Cross sections - The fission reactors - Fusion - Thermonuclear reactions -Energy production in stars.

Accelerators

Historical Developments: Different types of accelerators - Layout and components of accelerators - Accelerator applications.

Transverse Motion : Hamiltonian for Particle motion in accelerators - Hamiltonian in Frenet - Serret coordinate system - Magnetic field in Frenet - Serret coordinate system - Equation of betatron motion - Particle motion in dipole and quadrupole magnets - Linear betatron motion: Transfer matrix and stability of betatron motion - Courant - Snyder invariant and emittance - Stability of betatron motion - Symplectic condition - Effect of space - charge force on betatron motion.

Synchrotron Motion : Longitudinal equation of motion - The Synchrotron Hamiltonian - The synchrotron mapping equation - Evolution of synchrotron phase Space ellipse.

Linear Accelerators : Historical milestones - Fundamental properties of accelerating structures - Particle acceleration by EM waves - Longitudinal particle dynamics in Linac - Transverse beam dynamic in a Linac.

Principle and Design Details of Accelerators : Basic principle and design details of accelerators viz electrostatic, electrodynamic, resonant with special emphasis on microtron, pelletron and cyclotron - Synchrotron radiation sources - Spectrum of the emitted radiation and their applications.

Text and Reference Books

1. G. E. Brown and D. Jackson, Nucleon - Nucleon Interaction, North - Holland, Amsterdam, 1976.
2. S. de Benedetti, Nuclear Interaction, John Wiley and Sons, New York, 1964.
3. P. Marmier and E.Sheldon, Physics of Nuclei and Particles, Vol. I & II, Academic Press, New York, 1970.
4. H. A. Enge, Introduction to Nuclear Physics, Addison - Wesley, 1975.
5. S. S. Kapoor and V.S. Ramamurthy, Nuclear Radiation Detectors, Wiley - Eastern, New Delhi, 1986.
6. W. H. Tait, Radiation Detection, Butterworths, London, 1980
7. W. J. Price, Nuclear Radiation Detection, Mc Graw Hill, New York, 1964.
8. Satchler, Introduction to Nuclear Reactions
9. H. A. Enge, Introduction to Nuclear Physics, Addison - Wesley, 1975.
10. B. L. Cohen, Concepts of Nuclear Physics, Tata Mac Graw Hill, New Delhi, 1978.
11. P. Marmier and E. Sheldon, Physics of Nuclei and Particles, Vol. I & II Academic Press, 1969.
12. S. Y. Lee, Accelerator Physics, World Scientific, Singapore, 1999
13. J. J. Livingood, Principles of Cyclic Particle Accelerators, D. Van Nostrand Co., 1961

14. J. P. Blewett, Particle Accelerators, McGraw - Hill Book Co.

15. S. P. Kapitza and V. N. Melekhin, The Microtron, Harwood Academic Publishers.

16. W. Scharf, Particle Accelerators and Tbeir Uses, Harwood Academic Publishers.

17. I. M. Kapchinsky, Tbeory of Resonance Linear Accelerators, Harwood Academic Publishers.

18. P. Lapostole and A. Septier, Linear Accelerators, North Holland.

Tutorial :

NUCLEAR AND PARTICLE PHYSICS

1. Scattering Matrix
2. Electromagnetic Form Factors of the Deuteron
3. Comparison Between Experimental p-p Scattering Phase Parameters and Parameters Derived From a Pion Exchange Potential.
4. Nucleon - Nucleon Scattering at Elevated Energies and its Interpretation.
5. Numerical Solutions to the Lippman - Schwinger Equation.
6. Relation Between Various Sets of Invariants.
7. Nucleon - Nucleon Phase Shifts and Phenomenological Potentials.
8. Internal Conversion Electrons, Auger Electrons.
9. Energy Spectra of A, B and Y radiation.
10. Interaction of Radiation with Matter: Photoelectric Effect, Compton Scattering, Pair Production.
11. Calculation of Detector Efficiency and Resolution.
12. Pulse Height Spectrometry, Pulse Shape Discrimination.
13. Dead - Time Measurement.
14. Gas Quenching.

... Mass Attenuation Coefficient as a Function of Photon Energy for Sodium Iodide.

... Effect of RC Time Constant on Pulse Shape.

... The Q - Equation.

... Conservation of Energy and Momentum in Nuclear Reactions.

19. Threshold Energies.

20. Reaction Theory.

21. Cross sections in matrix formalism.

22. Calculation of Absolute Cross Section.

23. Calculation of Excitation Energy.

24. Resonance Reactions.

25. Necessity for High Energy Accelerators Classification of Accelerators.

26. Layout and Components of Accelerators.

27. Derivation of Betatron Equations of Motion.

28. Courant - Snyder Parametrization.

29. Experimental Tracking of Synchrotron Motion.

30. EM Waves in Cylindrical Wave Guide.

31. TM Modes in a Cylindrical Pillbox Cavity.

32. Design of a Cyclotron for a Given Energy of Protons.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. (Physics) (final year)

Special Paper Ist Paper (IInd E)

Max. Marks - 100

INFORMATICS

Semiconductor Quantum structures, Heterostructures, Mismatch Heterostructures, Coherently Strained

Structures, Partially Relaxed Strained Layer Structures, Methods of Formation Heterostructures some of the examples of heterostructures, Bandgap engineering, Strained Layer Epitaxy, Light emitting Diodes, Etched Well surface emitting LED, Continuous operation lasers Heteroquantum Lasers, CW Heteroquantum Laser, Stripe Geometry.

Fourier series and transforms and their applications to data communication.

Introduction to Probability and Random Variables. Introduction to Information Theory and Queuing Theory.

Introduction and Evolution of Telecommunication, Fundamentals of electronic communication Wired, Wireless, Satellite and optical Fibre, Analog/digital, Serial/parallel, Simplex/half and full duplex, Synchronous/Asynchronous, Bit/baud rates, Parity and error control (CRC, LRC, ARQ, etc.), Signal to Noise Ratio, etc.

Transmission types, codes, modes, speed and throughout. Modulation types, techniques and standards. Base band and carrier communication, Detection, Interference, Noise signals and their characterization, Phase Locked Loops.

Moderns, Transmission media (guided & unguided), Common Interface standards.

Introduction to Unix/Linux and shell scripting.

Conceptual framework of computer languages. Introduction to C/C++. Data Types and Operators, Statements and Control Flow, Functions and Program Structure, Strings, The Preprocessor, Pointers, Memory Allocation, Input and Output, Sub program, Recursion, File Access.

Object orientation concepts: classes, objects, methods and messages, encapsulation and inheritance, interface and implementation, reuse and extension of classes, *inheritance and polymorphism analysis* and design.

Notations for object-oriented analysis and design; Case studies and applications using some object oriented programming languages.

Introduction to web enabling technologies and authoring tools/languages: webcasting, database integration. (CGI, perl, java, HTML, C#,etc.)

Text and Reference Books

1. Data communication by Reid and Bartskor.
2. Data Networks by Gallager.
3. Data Communication by William Stalling.
4. Communication networks by Leon - Garcia and Widjaja
5. Introduction to communication systems by S. Haykins
6. Analog and Digital Communication by S. Haykins.
7. Bahrami A., Object Oriented Systems Development using the Unified Modeling Language. McGraw Hill International Edition, 1999.
8. Booch. G., Object - Oriented Analysis and Design with Applications, Addison - Wesley, 2nd Edition, 1994
9. Jesse Liberty, Beginning Object Oriented Analysis & Design Using C++, Wrox Press, 1998.
10. Timothy Budd, An Introduction to Object Oriented Programming, 2M Irst Ed., Addison Wesley, 1997.

Tutorial :

INFORMATICS

The tutorial will consist of problems solving from the Text and Reference books.

M.Sc. (Physics) (final year)

Special Paper - IInd Paper (IIIrd A)

Max. Marks - 100

CONDENSED MATTER PHYSICS

Imperfection In Crystals :

Point imperfection vacancies, interstitials, Schottky and Frenkil defect colour centres. Dislocation of Elastic and Plastic Deformation of solids, slip system, critical resolved sheer stress, elastic energy+ dislocation, Frank – Reed sources, steeking faults, observations of dislocations and other defects.

Electrons in solids and surface states :

Interacting electron gas : Hartree and Hartree-Fock approximation Landau's quasi particle theory fermi liquid. Elementry ideas of surface states in semiconductors. Localized vibrunational states.

Films and Surfaces :

Study of surface topography by multiple beam interferometry, determination of film thickness (Fizau, fringes FECO). Elementry concepts of surface crystallography SEM and ST Microscopy. Thin films, prepration methods. Boltzmannn transport eqn. for different scattering expression for Electrical conductivity.

Disordered System :

Disorder in condensed matter, substitutional, positional and topographical disorder. Sort and long range order. Atomic correlation functional and structural description of glass and liquids. Anderson models for random systems and electron localization. Mobility edge. Qulitative application and Hopping conduction.

References :

1. D. Hull / Introduction to dislocations ELBC edition 1971.
2. Weertman & Weertman : Elementry dislocation theory
3. Madelung : Introduction of solid state theory
4. Callaway : Quantom theory of solid state

5. Huang : Theortical solid state physics
6. Kittle : Quanton theory of solids
7. Heavens : Thinfilms
8. Chopra : Physics of Thinfilms
9. Tolansky : Multiple beam interferometry
10. Thomas : Transmission electron microscopy
11. Buerger : Crystal structure analysis
12. Azaroff and Buerger : Powder method
13. Verma and Srivastava : Cryctallography for solid state physics
14. Azaroff : X-Ray Crystallography
15. Kittle . Solid State physics
16. Heris etal : Electron microscopic thin crystals
17. Henery etal : The interpretation of x-ray diffraction and photographs

Tutorial :

Electrons in Solids and surface states

Find a canonical transformation whereby the electron-plasmon interection can be removed from the Hamiltonian (see equation 3.23 of Madlung's book). How do the effective electron mass and the plasmon frequency change?

Discus the renormalization terms in (see Equation 3.44 and 2.45 of Madelung's book) and show in particular that the renormalization of the fermion mass near the fermi surface ($k \rightarrow k_f$) leads to reduction in electron velocity (mass inhancement) and that the normalization of the boson frequency leads to a logrithmic divergence in the w(q) spectrum at $1\text{-}2k_f$ (kohan anomaly).

Calculate the 1s, 2s, and 2p states of a Wannier excitation in a semiconductor with an isotropic effective electron mass (m_e, m_h) and anisotropic dilectric constants (ε_0, ε_1) (example : CdS).

Disordered systems

Consider a one dimensional chain with one defect. Transfer the method used in connection Fig. 9.9 of Madlung's book to show the splitting-off an energy level from an energy band as in Fig. 9.1 of Madlung's book. Use the LCAO (tight binding) method treated in section 2.2.7 of Madlung's book.

How do the (2l+1) fold degenerate the energy levels of a free atom split up in a crystal field invariant to all proper rotations which transform a cube in to itself? The free atom is invariant to operations of the (infinite) rotation group. The character of the irreducible representation of this group are $\chi^{(l)}(\psi) = \sin(l + 1/2)\psi / \sin \psi/2$. The point group of crystal field has 24 elements in five class and hence also five irreducible representations. Set up character table for this group first.

Calculate the lifetimes of electrons and holes in a semiconductor with recombination centers (accepters with levels ER in a energy gap). Treat explicity the limits of large and small defect concentration Na. Discuss the recombination mechanism in both cases. Compare the two possible definitions : $\delta_n(t) \exp(-t/\lambda)$ (decay time) and ? $\delta_n = G\,\tau$ (steady state)

In addition to above, the tutorial will also consist of solving problems given in the Text and reference books.

Imperfection in crystals

Consider two parallel dislocations lying on the same slip plane. Their burgers vectors lie parallel to the slip plane but are not parallel to each other. Their magnitudes are equal. Find all possible orientations of the burgers vectors for which the component of the force between the dislocation that acts parallel to the slip plane is zero.

Prove that the stress σ_{zz} never exerts a force on a dislocation which burgers vector lies parallel to the x direction regardless of the orientation of the dislocation line.

Find the stress system that will turn an edge dislocation into a helix if a supersaturation of vacancies exists.

Prove that the presence of an excess point defect concentration produces a torque on any closed dislocation loop that turns the loop to such a position that every segment of the loop is a pure edge dislocation.

Prove that a tensile or compressive stress acting parallel to a straight screw dislocation can turn the straight screw dislocation into to helix. The point defect concentration is at its equilibrium value.

Consider two parallel dislocations that do not necessarily lie on a common slip plane. Let the Burgers vector of each dislocation have a random orientation. Let the magnitudes of the Burgers vectors be equal. Obtain the general condition under which the total force exerted by one dislocation on the other is zero. Obtain the condition under which the total force is a maximum.

Show that the force between two parallel screw dislocations lying on the same slip plane and moving in the same direction with the same velocity approaches zero as the velocity approaches the transverse sound velocity.

Calculate the elastic energy contained in the stress filed of moving screw dislocation. Show that it is equal to $\xi\left(1 - \frac{v^2}{2c^2}\right)\beta$, where ? is the self - energy of a stationary screw dislocation and $\beta^2\left(1 - \frac{v^2}{2c^2}\right)$, v is the velocity of dislocation and c is the velocity of sound.

Show that the energy of a screw dislocation is infinite at the transverse sound velocity.

Consider a screw dislocation with a hollow core of radius or (such dislocations actually have been observed). Calculate the self – energy of this dislocation. Include in your calculation the energy contributed by the surface energy γ per unit area of the surface of the core. Find the value of or for γ=1000 ergs/cm^2 and γ=10 ergs/cm^2 when μ=3x1011 dynes/cm^2.

Films and Surfaces

Bring out the essential differences between conventional

solid - bulk and films by taking the specific property of electrical conductivity.

What are thin and thick films? With reference to electronic conduction which films can be referred to as thin and which as thick taking into account the mean free path as a reference parameter..

Bring out the essential differences between diffuse and specular electron scattering from the film's surface.

Work out the approximations for the conductivity of a metallic film for p=0 and large and small values of k, where p is the fraction of electron specularly reflected and k is ratio of thickness of film and mean free path.

The temperature coefficient of resistance (TCR) of a thin metal film is positive! If you measure the TCR of a metal film and find it to be positive, does it necessarily follow that the film is continuous? In your answer utilize the fact that the resistivity between conduction islands has an activation energy associated with it.

What would you expect the Wiedemann - Franz ratio, $\frac{K}{\sigma T}$, to be equal to for a thin metal wire 100 angstroms in diameter? That is, compared to the bulk value. Give reasoning! (K=thermal conductivity, σ=electrical conductivity., and T=temperature).

Show that the change in thermoelectric power As from that of the bulk value So caused by thin - film size effects can be written as

Experimentally, what is the importance of this form for As? (α_0 and α are temperature coefficient of resistance for bulk and thin film, ko is Boltzmann constant and other symbols have their usual meaning).

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

Direct Memory Access : Basic DMA operation, 8237 DMA controller, Shared Bus operation, Disk memory systems. Video displays

M.Sc. (Physics) (final year)

Special Paper IInd Paper (IIIrd B)

Max Marks - 100

ELECTRONICS

Digital Communication

Pulse - Modulation Systems : Sampling theorem - Low - Pass and Band - pass signals, PAM, Channel BW for a PAM signal. Natural sampling. Flat - top sampling. Signal recovery through Holding. Quantization of signals, Quantization, Differential PCM, Delta Modulation. Adaptive Delta modulation, CVSD.

Digital Modulation Techniques :BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK.

Mathematical Representation of Noise : Sources of noise, Frequency domain representation of noise, Effect of filtering on the probability Density of Gaussian noise. Spectral component of noise, Effect of a filter on the power spectral density of noise. Superposition of noises. Mixing involving noise. Linear filtering, Noise Bandwidth. Quadrature Components of noise. Power spectral density of nc (t), ns (t) and their time derivatives.

Data Transmission : Baseband signal receiver, probability of error. Optimum filter. White noise. Matched filter and probability of error. Coherent reception, Correlation, PSK, FSK, Non - coherent detection of FSK, Differential PSK, QPSK, Calculation of error probability for BPSK, BFSK and QPSK.

Noise in pulse - Code and Delta - modulation systems. PCM transmission. Calculation of Quantization noise, output - signal power. Effect of thermal noise, output signal - to -noise ratio in PCM. DM, Quantization noise in DM, output signal power. DM output - signal - to quantization - noise ratio. Effect of thermal noise in Delta

modulation, output signal - to -noise ratio in DM.

Computer Communication Systems : Types of networks, Design features of a communication network, examples, TYMNET, ARPANET, ISDN, LAN.

Mobile Radio and Satellites : Time Division multiple Access (TDMA). Frequency Division Multiple Access (FDMA), ALOHA, Slotted ALOHA, Carrier Sense Multiple access (CSMA). Poisson distribution, Protocols.

Microprocessors & Micro Computers

Microprocessors and Architecture : Internal Microprocessor Architecture, Real mode and protected modes of memory addressing, memory paging.

Addressing modes : Data addressing modes, Program memory addressing modes, Stack memory addressing modes.

Instruction Set : Data movement instruction, Arithmetic and Logic instruction, Program control instruction. Assembler details.

Programming the Microprocessor : Module programming, using the keyboard and video display, data conversions. Disk files. Example programs.

Hardware Specifications : Pin - outs and the Pin functions, clock - generator (8284A), Bus buffering and Latching, Bus timing. Ready and wait state. Minimum mode versus maximum mode.

Memory Interface : memory devices, Address decoding. 8088 and 800188 (8-bit) memory interface, 8086, 80186, 80286 and 80386 (16-bit) memory interface, 80386DX and 80486 (32-bit) memory Interface, Dynamic RAM. **Basic I/O** Interface : Introduction to I/O interface, I/O port address decoding, 8255, 8279, 8254, 16550, ADC and DAC (excluding multiplexed display & keyboard display using 8255).

Interrupts : Basic interrupt processing, Hardware interrupts. Expanding the interrupt structure, 8259A PIC.

Direct Memory Access : Basic DMA operation, 8237 DMA controller, Shared Bus operation, Disk memory systems, Video displays.

Text and Reference Books

1. Barry B. Brey, "The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, 80486 Pentium and Pentium pro processor architecture, programming, and interfacing" Fourth Edition, PHI, 1999.
2. Douglas V. Hall, "Microprocessors and Interfacing. Programming and Hardware", second edition, McGraw Hill International Edition, 1992.
3. Muhammad Ali Mazidi and Janice Gillispie Mazidi, "The 80x86 IBM PC and Compatters (Volumes I & II), second edition, Prentice - Hall International, 1998.
4. Taub and Schilling, Principles of Communication System, Second Edition TMH, 1994.
5. Simon Haykin, Communication Systems, Third Edition, John Wiley & Sons, Inc. 1994.

Tutorial :

1. Digital Communications Theory Tutorials
2. Design of Digital filters using MATLAB
3. Cellular communications
4. Mobile communications via satellites
5. Bandwidth considerations in INTERNET
6. IS DN
7. Wide Area Network
8. Bus Interface : The ISA Bus, EISA and VESA local buses, PCI Bus

9. Advanced Microprocessors : 80186, 80188 and 80286 Microprocessors : 80186/80188 Architecture, Introduction to 80286

10 80386 and 80486 Microprocessors : 80386 Microprocessor, Special 80386 registers, 80386 memory management Protective mode Virtual mode, memory paging mechanism, 80486 Microprocessor.

11. Pentium and Pentium Pro Microprocessor : Introduction to Pentium microprocessor, special Pentium registers. Introduction to Pentium pro processors.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. (Physics) (final year)

Special Paper IInd Paper (IIIrd C)

Max. Marks - 100

ATOMIC AND MOLECULAR PHYSICS

Spontaneous and stimulated emission - Einstein coefficients -idea of light amplification - Threshold condition for laser oscillation - Pumping schemes - Role of resonant cavity - Three and four level systems - Ammonia MASER, ruby, He, Ne, CO_2, dye and diode lasers - Laser application - Holography, material processing, Fusion reaction, laser isotope separation, Pollution monitoring, Optical Communication

Saturation spectroscopy - Burning and detection of holes in Doppler broadened two level system - Experimental methods of saturation spectroscopy in laser - Ramsey fringes - Saturation techniques for condensed matter application.

Two photon absorption spectroscopy - Selection rules Expression for TPA cross section photo acoustic

spectroscopy - PAS in gaseous medium - Rosenewi\wig and Gresbow theory - Thermally thin, thick samples - Typical experimental setup-Application in spectroscopy-Stimulated Raman Scattering-Quantum mechanical treatment-Raman oscillation parametric instabilities - Electro magnetic theory of SRS.

Vibronic interaction, Herzberg Teller theory, Fluorescence spectroscopy, Kasha's rule, Quantum yield, Non - radiative transition, Jablonski diagram, Time resolved fluorescence and determination of excited state lifetime.

Light detectors, Single photon counting technique, Phase sensitive detectors

Laser optogalvanic spectroscopy, Matrix isolation spectroscopy, Fourier transform spectroscopy, Laser cooling.

Molecular symmetry and group theory, Matrix representation of symmetry elements of a point group, reducible and irreducible representations, character tables specially for $C_{2}v$ and $C_{3}v$ point groups, Normal coordinates and normal modes, Application of group theory to molecular vibrations.

Text and Reference Books

1. Quantum electron - A. Yariv
2. Introduction to non linear laser spectroscopy - M.D.Levenson
3. Photoacoustics and its application - Rosenewcig
4. J.M.Hollas, High Resolution Spectroscopy
5. Cotton, chemical Application of group theory
6. Herzberg, Molecular spectra and Molecular structure II & III
7. Demtroder, Laser spectroscopy and Instrumentation
8. King, Molecular Spectroscopy
9. Lakowicz, Principles of Fluorescence Spectroscopy.

Tutorial :

Illustrate the combined use of infra red and Raman spectroscopy in deducing molecular geometry for the following systems.

CO_2, 2) H_2O, 3) N_2O, 4) NO_2, 5) ClO_3, and 6) ClF_3

Correlate the Raman spectrum and molecular structure for the following systems

Carbon monoxide - 2155cm-1, b) Hydrogen cynide - two lines at 2062 cm-1 and 2094 cm-1, c) Sulphuric acid, d) CO_2, e) N_2O and f) H_2O

As a project work let the student study different types of UV - VIS absorption spectrometers having different geometries. Let the student prepare details of different types of sources, filters, monochromators, gratings, and detectors used in these instruments. Again let the student find out the difference between single beam and dual beam spectrometers

Similar studies can be done on IR, FTIR and NMR spectrometers.

Let the student do a project work on the study on Raman spectrometers and the present Laser Raman Spectrometers

The (0,0) band in the 260 nm band system of benzene does not appear in the spectrum. However (1,0) band appears quite intense. Give the reason

What is difference

CH_3Cl and CH_2DCl.

How can one obtain the number of molecular vibration of a given symmetry type in a molecule?

Illustrate your answer for a molecule with C_{2v} point group

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. (Physics) (final year)

Special Paper IInd Paper (IIIrd D)

Max. Marks - 100

NUCLEAR AND PARTICLE PHYSICS

Nuclear Models

Single Particle Shell Model : Determinantal wave functions of the nucleus - single particle operator and their expectation values.

Extended Single Particle Model : Classification of shells - Seniority and reduced I - spin - Configuration mixing - Pairing force theory - Gap equation and ground state properties - Idea of quasi particles - Simple description of two - Particle shell model spectroscopy.

Collective Model of Nucleus : Deformable liquid drop and nuclear fission - Shell effects on liquid drop energy - Collective vibrations and excited states - Permanent deformation and collective rotations - Energy levels - Electromagnetic properties of even -even, odd - odd A deformed nuclei - Nilsson model and equilibrium deformation - Behaviour of nucles at high spin - Back bending.

Nuclear Reactor Theory

Introduction : Fundamentals of nuclear fission - Fissum fuels - Neutron chain reaction - Multiplication factor - Condition for criticality - Breeding phenomena - Different types of reactors - Fusion - Nuclear fusion in stars.

The Diffusion of Neutrons : Neutron current density - The equation of continuity - Fick's law - The diffusion equation - Boundary conditions - Measurement of diffusion parameters.

Neutron Moderation : Moderation without absorption - Energy lost in elastic collisions - Collision and slowing - Down densities - Moderation - Space dependent slowing

down - Fermi's age theory - Moderation with absorption - NR and NRIM approximations - Temperature effects on resonance absorption.

Criticality : Criticality of an infinite homogeneous reactor - The one - region finite thermal reactor - The critical equation - Optimum reactor shapes - Multiregion Reactors - One group and two group methods of calculation of criticality - Reflector savings - Critical reactor parameters and their experimental determination.

Reactor Kinetics : Infinite reactor with and without delayed neutrons - The stable period - Reactivity and its determination - The prompt jump and prompt critical condition - Changes in reactivity - Temperature coefficients - Fuel depletion effects.

Reactor Control : Control - rod worth - One control rod - Modified one group and two -group theories.

Strong, Weak and Electromagnetic Interactions and QCD and Quark - Gluon Plasma

Strong, Weak and Electromagnetic interactions

Strong interactions and symmetries : Uses of symmetry - Space time and internal symmetries - Lie groups generators and Lie algebra - Casimir operators - SU(2) irreducible representation - Weight diagram - Diagonal generators - SU (3) generators - U and V spin - Raising and lowering operators - Root diagram - Weight diagram - Multiplets of SU (n) - Baryons and meson multiplets - Symmetry breaking - Gell-Mann-Okubo mass formula - Charm, bottom and top quarks and higher symmetry - Bag model for hadrons.

Weak and Electromagnetic interactions : Invariance of Dirac equation - Bilinear covariants - Properties of gamma matrices - Leptonic, semileptonic and nonleptonic weak decays - Selection rule for leptons - Current - current interaction and V - A theory - Universality - Abelian and non - Abelian gauge invariance - Spontaneous symmetry

breaking and Higgs mechanism - Standard model for electro weak unification.

QCD and Quark - Gluon Plasma

Perturbative QCD I : Colour gauge invariance and QCD Lagrangian - Deep inelastic scattering : The GLAP equations - an alternative approach to the GLAP equations - Common parametrizations of distribution functions - Structure Functions, The span - dependent structure functions and the MIT bag model.

Perturbative QCD II : The Drell - Yan process - Small X physics and the Gribov - Levin - Ryskin equation.

Nonperturbative QCD : QCD sum rules - The ground state of QCD - Equation of state of a quark - gluon plasma - Hadronization phase transition.

Text and Reference Books

1. M. A. Preston and R. K. Bhaduri, Structure of the Nucleus, Addison Wesley, 1975.
2. R. R. Roy and B. P. Nigam, Nuclear Physics, Wiley - Eastern Ltd., 1983.
3. M. K. Pal, Theory of Nuclear structure, Affiliated East West, Madras, 1982.
4. P. Marmier and E. Sheldon, Physics of Nuclei and Particles, Vol. II, Academic Press, New York, 1971.
5. H. A. Enge, Introduction to Nuclear Physics, Addison - Wesley, 1975.
6. J. R. Lamarsh, Introduction to Nuclear Reactor Theory, Addison Wesley, 1966.
7. P. F. Zweifel, Reactor Physics, Mc - Graw Hill Kogakusha Ltd., Tokyo, 1973.
8. S. Glasstone and M.C. Edlund, The Elements of Nuclear Reactor Theory, Van Nostrand Co., 1953.

9. A. M. Weinberg and E. P. Wigner, The Physical Theory of Neutron Chain Reactors, University of Chicago Press, 1958.

10. F. Halzen and A.D. Martin, Quarks and Leptons, John - Wiley & Sons, New York, 1984.

11. G. Kane, Modern Elementary Particle Physics, Addison - Wesley, 1987.

12. D. B. Lichtenberg, Unitary Symmetry and Elementary Particles, 2nd Edition, Academic Press, 1978.

13. R. K. Bhaduri, Models of Nucleon, Addison -Wesley, Reading, MA, 1988.

14. J. Mc. Emmerson, Symmetry Principles in Particle Physics, Clarendon Press, Oxford, 1972.

15. M. Leon, An introduction to Particle physics. Academic Press, New York, 1973.

16. I. J. R. Aitchison and A. J. G. Hey, Gauge Theories of Particle Physics, Adam Hilger, Bristol, 1989.

17. D. H. Perkins, Introduction to High Energy Physics, Addison - Wesley, London, 1982.

18. W. Greiner and A. Schafer, Quantum Chromodynamics, Springer, Berlin, 1983.

19. D. H. Perkins, Introduction to High Energy Physics, Addison - Wesley, London, IV Edition, 2000.

20. F. J. Yndurain, Quantum Chromodynamics - An Introduction to the Theory of Quarks and Gluons, Springer - Verlag, New York, 1983.

Tutorial

1. Shell Model Configuration and Configuration Mixing
2. Spin - Orbit Coupling
3. Nuclear Ground State and Angular Momenta
4. Magnetic Moments and the Shell Model - Schmidt Lines

5. Anisotropic Harmonic Oscillator Potential
6. Coupling of Particle and Collective Motion - Weak and Strong Couplings
7. Comparison of Nuclear Models
8. Thermal Neutron Cross Sections
9. Diffusion Equation in Plane, Spherical and Cylindrical Geometries
10. Criticality Calculations
11. Special Functions of Reactor Physics
12. The Reactor Transfer Function
13. Numerical Solution of the Multigroups Equation
14. The Collision Kernel
15. Reactor Stability Analysis
16. The Hadron Spectrum
17. Algebra of Gamma Matrices
18. The Neutrons Scattering Tensor with Weak Interaction
19. Higgs' Bosons and Spontaneous Symmetry Breaking
20. Gauge Invariance and Gauge Bosons
21. Lepton and Hadron Currents
22. Algebra of Gamma Matrices
23. Feynmen Rules for QCD
24. Kinematics, Cross Sections and Decay Rates
25. The Renormalized Coupling Constant of QCD
26. Asymptotic Freedom

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books

M.Sc. (Physics) (final year)

Special Paper IInd Paper (IIIrd E)

Max. Marks - 100

INFORMATICS

Multiplexing (FDM, TDM), switching paradigms (circuit, packet and cell switching), propagation delay, clock synchronization. Network access control (centralized, decentralized, distributed). Overview of Satellite Communication, Broadcast Channel and Optical Fibre Communication systems. Power and Energy spectra, Distortionless Transmission, Signal distortion over a channel.

Bandwidth and rate of transmission, Communication in Noisy channels, Optimum Signal Detection, Channel Capacity, Hartley Shannon Law, Error Correcting Codes, Error control, Line control, Rate control, Repeaters, Concentrators, Regenerators, Link behaviovr, Pe, Burst error, optimum Packet size, Error control, Elementary coding ideas, ATM as a transport mechanism, An overview of Telecom Network, ISDN.

Network types and architecture (broadcast, multicast, LAN, WAN, MAN, topology, token rings FDDI, Cabeling) Protocols, interfaces and services, X.25, ISDN, ATM, VPN, frame relay, wireless transmission, bridges. TCP/IP and ISO/OSI Models. Routing, congestion and flow control, tunneling, internetwork routing. Datalink protocol, Multiple access protocols, TCP, UDP, Transport layer error recovery, Application layer services and protocols. IP addressing, Network security.

Evolution of Internet, Internet architeture; goals and key issues related to Internetworking technologies. Internet connectivity (dial – up), dedicated lines, broadband, ISDN, radio, VSAT, etc); Domain Name Scheme, Technology and

tools relevant for web access (FTP, email, search tools, etc.) Internet security.

Multimedia, technique of data compression, voice, video, Mbone, and interactive video-on-demand over the internet. Mobile computing.

Fundamentals of network management (NM), Need for NM, Element of NM system (Manager, Agent and a protocol, SNMP), Functional areas of NM defined by ISO Fault management, Configuration management, Performance management, Security management, Accounting management, NM standards, TMN, Web based NM (introduction), case studies: HP Open-view, IBM Net-view, Sun Solaries Enterprise Manager.

Text and Reference Books

1. Data communication by Reid and Bartakur
2. Data network by Gallager
3. Data communication by William Stalling
4. Communication Network by Leon-Garcia and Widjaja
5. Introductim to communication system by S. Haykins
6. Analog and Digital communication by S. Haykins
7. Bohdan O Szuprowicz : Multimedia Networking, McGraw-Hill, Singapore (ISE)
8. Marille Ford et al Internetworking Technologies Hand book, Cisco press, 1997
9. Grady N, drew using SET for secure Eletronics commerce, PTR Prentice-Hall, 1998.
10. N Buchanan : Advanced Data communication and Networking, Chapman &Hall,in London, 1997
11. Dave konar : IP Multicasting : The complete guide to interactive corporates networks, John Willy & Sons, New York, 1998
12. Computer Networks by William Stalling, PHI.

13. Computer Networks by S. Keshav, Addition Wesley

Tutorial:

The Tutorial will consist of problems solving from the Text and Reference books

M.Sc. (Physics) (final year)

Special Paper IVth

Max. Marks - 50

ELECTRODYNAMICS AND PLASMA PHYSICS

1. Review of Four - Vector and Lorentz Transformation in Four Dimensional Space. Electromagnetic Field Tensor in Four Dimensions and Maxwell's Equations. Dual Field Tensor. Wave Equation for Vector and Scalar Potential and Solution Retarded Potential and Lienard - Wiechert Potential, Electric and Magnetic fields due to a Uniformly Moving Charge and An Accelerated Charge, Linear and Circular Acceleration and Angular Distribution of power Radiated, Bremsstrahlung, Synchrotron Radiation and Cerenkov Radiation, Reaction Force of Radiation

2. **Motion of charged particles in electromagnetic field:** Uniform E and B Fields, Nonuniform Fields, Diffusion Across Magnetic Fields, Time Varying E and B Fields, Adiabatic Invariants: First, Second Third Adiabatic Invariants

3. **Elementary Concepts:** Derivation of moment Equations from Boltzmann Equation, Plasma Oscillations, Debye Shielding, Plasma Parameters, Magnetoplasma, Plasma Confinement.

4. **Hydrodynamical Description of Plasma:** Fundamental equations, Hydromagnetic Waves Magnetosonic and Alfven Waves.

5. **Wave Phenomena in Magnetoplasma:** Polarization, Phase Velocity, Group Velocity, Cut - offs, Resonance for Electromagnetic Wave Propagating Parallel and Perpendicular to the Magnetic Field, Propation at Finite Angle and CMA Diagram, Appleton - Hartee Formula and Propagation through Ionosphere and Magnetosphere Helicon, Whistler, Faraday Rotation

Text and Reference Books

1. Panofsky & Phillips: Classical Electricity and Magnetism
2. Bittencourt: Plasma Physics
3. Chen: Plasma Physics
4. Jackson: Classical Electrodynamics

Tutorial:

1. The electric field vector E of an electromagnetic wave in free space is given by

   Ex = Ez = 0 and Ey = A cos w (t - z/c)

   Using Maxwell's equations, find the expressions for the components of magnetic field vector. Also Calculate the energy flow per unit area along

   A circular plate capacitor of radius R and separation d is being charged by an alternation current so that there is a uniform electric field inside the capacitor. Show that the energy flow within the capacitor is the same as given by the Poyntings vector

2. Starting from the equation for the conservation of linear momentum :

$$\frac{d}{dt}\int_{v}\left|\vec{P}_{mech.}+\vec{P}_{field}\right|=\oint_{s}\sum_{\beta}T_{\alpha\beta}n_{\beta}$$

Where P_{mech} is the mechanical momentum density of a system of particles inside a volume V and P_{field} is the field momentum density.

$$\vec{P}_{field} = \left[\frac{1}{4\pi c}\right](\vec{E} \times \vec{B})$$

and T_{ij} is the Maxwell stress tensor, deduce the equation for the conservation of angular momentum for a combined system of particles and fields. [Hint: Consider the field angular momentum density

$$\vec{L}_{field} = \vec{r} \times \vec{P}_{field} = \left[\frac{1}{4\pi c}\right] \vec{r} \times (\vec{E} \times \vec{B})$$

3. A linear accelerator accelerates protons to almost relativistic speeds. Determine the fraction of power radiated by the protons to the power supplied in terms of the gradient of the linear electric field.

$\vec{r} = \vec{r}_{max} (\omega t + \alpha)$

A charged particle oscillates according to the harmonic law. Determine the total average intensity of the emitted radiation.

4. From the definition of the dual tensor

$$G_{\mu\nu} = \frac{1}{2} \varepsilon_{\mu\nu\rho\sigma} F^{\rho\sigma}$$

Where $\varepsilon_{\mu\nu\rho\sigma}$ is a completely antisymmetric unit tensor of rank four, express $G_{\mu\nu} F^{\mu\nu}$ as a function of the fields and.

Hence show that $\vec{E} \cdot \vec{B}$ and $B^2 - E^2$ are Lorentz invariants.

5. Consider a magnetic field configuration that is cylindrically symmetric and a charged particle is injected into it. Use the adiabatic invariants of motion to describe conditions in which the injected particle would bounce back from the direction of increasing field gradient.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M. Sc. Physics (Final Year)

Elective Papers (Vth)

Max. Marks -50

Titles of Elective Papers

A. Quantum Electrodynamics

B. Physics of Liquid Crystals

C. Science and Technology of Solar Hydrogen and other Renewable Energies

D. Reactor Physics

E. Numerical Methods and Programming

F. Physics of Lasers and Lasers Application

G. Structures, Spectra and Properties of Biomolecules

H. Diagram Techniques

I. Physics of Electronic Devices & Fabrication of Integrated Circuits and systems

J. Atmospheric Science

K. Plasma physics

L. Quantum Many - body Physics

M. Nonlinear Dynamics

N. Environmental Physics

O. Physics of Nanomaterials

(Any one of the electives paper is to be opted in the final year. The full details of elective paper are annexed at the end of post graduate course paper details.)

M. Sc. Physics (Final Year)

Elective Paper (Vth, A)

QUANTUM ELECTRODYNAMICS

Dirac equation, properties of Dirac matrices. Projection operators, Traces, Feynman's theory of positron.

Second quantization of Klevin, Gordon Field, Creation and Annihilation operators, Commutation relations. Quantisation of electromagnetic field, creation and Annihilation operators, Commutation relations. Fock space representation, interacting fields, Dirac (interaction) picture, S-Matrix and its expansion. Ordering theorems, Feynman graph and Feynman rules. Application to some problems like Rutherford scattering and Compton scattering, calculation of cross - sections using Feynman graphs.

Text and Reference Books

1. Bjorken & Drell: Relativistic Quantum Fields
2. Muirmead: The Physics of Elementary Particles
3. Schweber, Bethe and Hoffmann: Mesons and Fields
4. Sakurai: Advanced Quantum Mechanics
5. Mandal: Introduction to Field Theory
6. Low: Particle Physics and Introduction to Field Theory

The problems given in the Text and Reference books will form tutorial course.

M. Sc. Physics (Final Year)

Elective Paper (Vth, B)

PHYSICS OF LIQUID CRYSTALS

Classification of Liquid Crystals

Symmetry, structure and classification of liquid Crystals, Polymorphism in thermotropics, Reentrant phenomena in liquid crystals. Blue phases, Polymer liquid crystals. Distribution functions and order parameters, macroscopic and microscopic order parameters. Measurement of order parameters, magnetic resonance, electron spin resonance, Raman Scattering and X-ray diffraction.

Theories of Liquid Crystalline Phase Transitions

Nature of phase transitions and critical phenomena in liquid crystals, hard particle, Maier - Saupe and Van der Waals theories for nematic - isotropic and nematic-smectic A transitions, Landau theory. Essential ingredients, application to nematic - isotropic, nematic - smectic A transitions and transitions involving smectic phases.

Continuum theory

Curvature elasticity in nematic and smetic A phases, distortions due to magnetic and electric fields, magnetic Coherence length, Freedericksz transition, field-induced cholesteric - nematic transition.

Dynamical Properties of Nematics

The equations of nematodynamics, Laminar flow, molecular motions.

Optical properties of Cholesterics

Optical properties of an ideal helix, agents influencing the pitch, liquid crystal displays.

Ferroelectric Liquid Crystals

The properties of smectic C continuum description, smectic C - smectic A transition.

Discotic Liquid Crystals

Symmetry and structure, mean-field description of discotic liquid crystals, continuum description Lyotropic liquid crystals and biological membrane. Applications of liquid crystals.

Text and Reference Books

1. Chandrasekhar: Liquid Crystals
2. Vertogen & de Jeu: Thermotropic Liquid Crystals: Fundamentals
3. De Gennes & Prost: The Physics of Liquid Crystals
4. Introduction to liquid crystals: Physics and Chemistry (1997. Taylor and Francis)
5. Elston & Sambles: The Optics of Thermotropic Liquid Crystal
6. Collyer: Liquid Crystal Polymers: From Structures to Applications
7. Goodby et al.: Ferroelectric Liquid Crustals : Principles, Properties & Applications

The problems given in the Text and Reference books will form tutorial course.

M. Sc. Physics (Final Year.)

Elective Paper (Vth,C)

SCIENCE AND TECHNOLOGY OF SOLAR HYDROGEN AND OTHER RENEWABLE ENERGIES

Solar Energy

Fundamentals of photovoltaic Energy Conversion Physics and Material Properties Basic to Photovoltaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

Types of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief descriptions of single crystal silicon and amorphous silicon solar cells, elementary ideas of advanced solar cells e.g. Tandem Solar Cells. Solid Liquid Junction Solar Cells, Nature of Semiconductor, Electrolyte Junction, Principles of Photoelectrochemical solar cells.

Hydrogen Energy

Relevance in relation to depletion of fossil fuels and enviormental considerations.

Hydrogen Production

Solar Hydrogen through Photoelectrolysis and Photocatalytic process. Physics of material characteristics for production of Solar Hydrogen.

Storage of Hydrogen

Brief discussion of various storage processes, special features of solid state hydrogen storage materials, structural and electronic characteristics of storage materials. New storage modes.

Safety and Utilisation of Hydrogen

Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel cells. Elementary concepts of other Hydrogen Based devices such as Air Conditioners and Hydride Batteries.

Other Renewable Clean Energies

Elements of Solar Thermal Energy, Wind Energy and Ocean Thermal Energy Conversion.

Text and Reference Books

1. Fonash: Solar Cell Devices - Physics
2. Fahrenbruch & Bube: Fundamentals of Solar Cells Photovoltaic solar Energy
3. Chandra: Photoelectrochemical Solar Cells
4. Winter & Nitch (Eds.): Hydrogen as an Energy Carrier Technologies Systems Economy

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (Final Yr.)

Elective paper (Vth, D)

REACTOR PHYSICS

Interaction of Neutrons with Matter in Bulk

Transport and diffusion equations, transport mean free path, solution of diffusion equation for a point source in an infinite medium and for an infinite plane source in a finite medium, extrapolation length and diffusion length - the albedo concept.

Moderation of Neutron

Mechanics of elastic scattering, average logarithmic energy decrement, slowing down power and moderating ratio of a medium. Fermi's age theory. Solution of age equation for a point source of fast neutrons in an infinite medium. Slowing down length. Fermi age.

Theory of Homogeneous Bare Thermal Reactor

Critical equation, material and geometric bulkings, Neutron balance in a thermal reactor, four factor formula, typical calculations of critical size and composition in simple cases.

Heterogeneous Natural Uranium Maintenance

Advantage and disadvantages of heterogeneous assemblies, various types of reactors and a brief discussion of their design features.

Problems of Reactor Control and Maintenance

Role of delayed neutrons, Inhour formula, temperature effects, fission product poisoning, use of coolants and control rods.

Power Reactors

Fast breeder reactors, dual purpose reactors, concepts of fusion reactors.

Text and Reference Books

1. Glasstone & Edlund: The Elements of Nuclear Reactor Theory
2. Murray: Introductions of Nuclear Engineering

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (Final Year)

Elective paper (Vth, E)

NUMERICAL METHODS AND PROGRAMMING

Numerical Methods

Methods for determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, convergence of solutions.

Solution of simultaneous linear equations, Gaussian elimination, Pivoting, interative Method Matrix Inversion. Eigenvalues and eigenvectors of matrices, Power and Jacobi Method.

Finite differences, interpolation with equally spaced and unevenly spaced points. Curve fitting, Polynomial least squares and cubic Spline fitting.

Numerical differentiation and integration, Newton Cotes formulae, error estimates, Gauss method.

Random variate, Monte Carlo evaluation of Integrals, Methods of importance sampling, Random, walk and Metropolis method

Numerical solution of ordinary differential equations, Euler and Runge Kutta methods, Predictor and corrector methods. Elementary ideas of solutions of partial differential equation.

Fortran Programming

Digital Computer Principles, Compilers, Interpreters, Operating Systems, Fortran programming, Flow Charts, Integer and Floating Point Arithmetic, Expressions, built-in functions, executable and non-executable statements, assignment, control and input-output elements, Subroutines and functions, Operation with files.

Text and References Books

1. Sastry: Introductory Methods of Numerical Analysis
2. Rajaraman: Numerical Analysis
3. Rjaraman: Fortran Programming
4. Vetterming Teukolsky, Press and Flannery: Numerical Recipes

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (Final Year)

Elective paper (Vth, F)

PHYSICS OF LASERS AND LASER APPLICATIONS

Laser Characteristics

Gaussian beam and its properties. Stable Two-Mirror Resonators, Longitudinal and Transverse Modes of Laser Cavity. Mode Selection, Gain in a Regenerative Laser Cavity. Threshold for 3 and 4 level Laser Systems. Mode Locking Pulse Shortening - Picosecond & formosecond operation, Spectral Narrowing and Stabilisation.

Laser Systems

Ruby Laser, Nd-YAG Laser, Semi Conductor Lasers, Diode-Pumped Solid State Lasers, Nitrogen Laser, Carbon-dioxide Laser, Excimer Laser, Dye Laser, High Power Laser Systems

Laser Spectroscopic Techniques and Other Applications

Laser Fluorescence and Raman Scattering and their use in pollution studies, Non-Linear interaction of Light with

matter, Laser induced multiphoton processess and their applications, Ultrahigh resolution Spectroscopy with lasers and its applications, Propagation of light in a medium with variable refractive index. Optical Fibres. Light wave communication. Qualitative treatment of Medical and Engineering applications of Lasers.

Text and Reference Book

1. Svelto: Lasers
2. Yariv. Optical Electronics
3. Demtroder: Laser Spectroscopy
4. Letokhov: Non-Linear Spectroscopy

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (Final Year)

Elective paper (Vth, G)

STRUCTURES, SPECTRA AND PROPERTIES OF BIOMOLECULES

Structural Aspectes of Biomolecules

Conformational Principles, Conformation and Configuration Isomers and Derivatives. Structure of Polynucleotides, Structure of Polypeptides. Primary, Secondary, Tertiary and Quaternary Structures of Proteins, Structure of Polysaccharides.

Theoretical Techniques and Their Application to Biomolecules

Hard Sphere Approximation, Ramachandran, Plot, Potential Energy Surfaces, Outline of Molecular Mechanics Method, Charge Brief Ideas about Semi -

empirical and ab Initio Quantum Theoretical methods, molecular charge distribution, Molecular Electrostatic Potential Field and their Uses.

Spectroscopic Techniques and Their Application to Biomolecules

Use of NMR in Elucidation of Molecular Structure Absorption and Fluorescence Spectroscopy. Circular Dichroism. Laser Raman Spectroscopy. IR Spectroscopy. Photoelectron Spectroscopy. Photo- biological Aspects of Nucleic Acids.

Structure - Function Relationship and Modeling

Molecular Recognition: hydrogen bonding, hypophilic pockets on Receptors, Drugs and Their principles of Action, Lock and Key Model and Induced fit Model.

Text and Reference Books

1. Srinivasan & Pattabi : Structural Aspects of Biomolecules
2. Geval & Hosur : Conformations of Biological Molecules
3. Prince : Basic Molecular Biology
4. Pullman : Quantum Mechanics of Molecular Conformations
5. Lehninger Biochemistry
6. Mehler & Cortes Biological Chemistry
7. Smith and Hanawalt : Molecular Photobiology, Inactivation & Recovery

The problems given in the text and reference books will form tutorial course.

M.Sc. Physics (Final Year.)

Elective paper (Vth, II)

DIAGRAM TECHNIQUES

Formalism of Second Quantization

Quantum mechanical of many body problem, boson and fermion system, Creation and Annihilation operators, Commutation Relations, Vacuum state. The Hamiltonian in terms of creation and annihilation operators and its matrix elements for the simple cases of one -and two - particle systems.

Time Dependent Opecotors Schrodinger, heisenberg and interaction picture Time development operator (TDO), its properties and equation of motion. The integral equation for TDO and formal solution by interative method, Dyson chronological operator, S - matrix expansion, Universality of S - matrix Transition matrix. The adiabatic hypothesis and correspondence with usual perturbation theory.

Introduction to Graphs

Creation and destruction operator in the interaction picture, Particle and hole operators. Reduction of chronological products Normal product, Contraction of operators and Wick's theorem, Graphical representation of the expansion First order graphs, Higher order graphs. The interaction term and ground state energy. Evaluation of the contributions of various graphs to the perturbation series, Linked and unlinked diagrams.

Introduction to Green's Function Differential equation and their Green's functions Examples of time independent Schrodinger equation Resolvent operators. The single particle Green's function. Physical interpretation. Fourier transform of the Green's functions. Lehmann Representation and Kramer - Kronig

relationship. Analytic properties and physical meaning of the poles, Relation between Green's function and the properties of the ground state. Its relation with elementary excitations. Concept of quasi particles.

Text and Reference Books

1. Raimes: Many Election Theory
2. Mandel: Introduction to Quantum Field Theory
3. Fretter & Walecha: Quantum Theory of Many - particle Systems
4. Match, Young & Sampantha: The Many Body Problems in Quantum Mechanics
5. Mattuch: Feynman Diagram Techniques

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (Final Year)

Elective paper (Vth, I)

PHYSICS OF ELECTRONIC DEVICES & FABRICATION OF INTEGRATED CIRCUITS AND SYSTEMS

Semiconductor Materials

Energy Bands, Intrinsic carrier concentration. Donars and Acceptors. Direct and Indirect band semiconductors. Degenerate and compensated semiconductors. Element (Si) and compound semiconductors (GaAs). Replacement of group IIIrd element and Group Vth elements to get tertiary alloys such as Al x Ga (1-x) As or GaP y As (1-y) and quaternary In x Ga (1-x) PyAs (1-y) alloys and their important properties such as band gap and refractive index changes with x and y. Doping of Si (Group III (n) and Group V(p) compounds) and GaAs (group II -IV, IV (n p

and VI (b compounds). Diffusion of Impurities. Thermal Diffusion, Constant Surface Concentration, Constant Total Dopant Diffusion, Ion Implantation.

Carrier Transport in Semiconductors

Carrier Drift under low and high fields in (Si and GaAs) saturation of drift velocity, High field effects in two valley semiconductors. Carrier Diffusion, Carrier Injection, Generation Recombination Processes. Direct, Indirect bandgap semiconductors. Minority Carrier Life Time, Drift and Diffusion of Minority Carriers (Haynes Shockley Experiment) Determination of Conductivity (a) four probe and (b) Vander will techniques. Hall Coefficient, Minority Carrier Life Time, Junction Devices. (i) p-n junction. Energy band diagrams for homo and hetro junctions, Current flow mechanism in p-n junction, effect of (minority and surface) recombination currents on the forward biased diffusion current, p-n junction diodes - rectifiers (high frequency limit), (ii) Metal - semiconductor (Schottky junction) Energy band diagram, current flow mechanisms in forward and reverse bias, effect of interface states. Applications of Schottky diodes, (iii) Metal - Oxide - semiconductor (MOS) diodes Energy band diagram, depletion and inversion layer. High and low frequency Capacitance Voltage (C-V) characteristics. Smearing of C-V curve, flat band shift. Applications of MOS diode.

Transistors

JFET, BJT, MOSFET and MESFET: Structure, Working, Derivations of the equations for I-V characteristics under different conditions. High Frequency limits.

Microwave Devices

Tunnel diode, transfer electron devices (Gunn diode) Avalanche Transit time devices (Read, Impatt diodes, and Parametric devices).

Photonic Devices

Radiative and non-radiative transitions. Optical Absorption. Bulk and Thin film Photo conductive devices (LDR), diode photodetectors, solar cell (spectral circuit voltage and short circuit current, fill factor). LED (high frequency limit, effect of surface and indirect recombination current, operation of LED), diode lasers (conditions for population inversion, in active region, light confinement factor. Optical gain and threshold current for lasing. Fabry-Perrot Cavity Length for lasing and the separation between modes).

OVER VIEW AND BASIC PRINCIPLE OF THE FOLLOWING

Memory Devices

Static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, non-volatile NMOS, magnetic, optical and ferroelectric memories, charge coupled devices (CCD).

Other Electronic Devices

Electro-Optic, Magneto-Optic and Acousto-Optic Effects, Material Properties related to get these effects. Important Ferroelectric, Liquid Crystal and Polymeric materials for these devices. Piezoelectric, Electrostrictive and magnet strictive Effects, Important materials exhibiting these properties, and their applications in sensors and actuator devices. Acoustic Delay lines, Piezoelectric resonators and filters. High frequency Piezoelectric devices - Surface Acoustic Wave Devices. Pyroelectric effect, Inorganic oxide and Polymer pyroelectric materials and their applications.

Fabrication of Integrated Devices

Thin film Deposition Techniques. Vacuum Pumps and gauges - pumping speed, throughput. Effective conductance control. Chemical Vapour Deposition (CVD),

MOCVD, PEMOCVD (Plasma enhanced chemical vapour deposition), Physical Vapour Deposition, Thermal Evaporation, Molecular Beam Epitaxy (MBE), Scattering and Laser Ablation. Lithography, Etching and Micro-machining of Silicon, Fabrication of Integrated Circuits and Integrated Micro-Electro-Mechanical Systems (MEMS).

Text and Reference Books

1. The Physics of Semiconductor Devices by D.A. Fraser, Oxford Physics Series (1986).
2. Semiconductor Devices – Physics and Technology, by SM Sze Wiley (1985).
3. Introduction to semiconductor devices, M. S. Tyagi, John Wiley & Sons
4. Measurement, Instrumentation and Experimental Design in Physics and Engineering by M.Sayer and A. Mansingh, Prentice Hall, India (2000)
5. Thin film phenomena by K.L.Chopra
6. The material science of thin films, Milton S. Ohring
7. Optical electronics by Ajoy Ghatak and K. Thyagarajan, Cambridge Univ. Press
8. Material Science for Engineers, by James F. Shackelford, Prentice Hall
9. Deposition technique for films and coatings, R.F Bunshah (Noyes publications)
10. Solid state electronics, Ben G. Streetman

The problems given in the Text and Reference books will form tutorial course

M.Sc. Physics (Final Year)

Elective paper (Vth, d)

ATMOSPHERIC SCIENCE

1. **Physical Meteorology**

Atmospheric composition, laws of thermodynamics of the atmosphere. Adiabatic process, potential temperature, The clausius Clapeyron equation, laws of black body radiation, solar and terrestrial radiation, Albedo, Green house effect, Heat balance of earth atmosphere system.

2. **Dynamic Meteorology**

Fundamental forces, non -inertial reference frames and apparent forces, structure of static atmosphere.

Momentum, continuity and energy equations. Thermodynamics of the dry atmosphere, elementary applications of the basic equations.

The circulation theorem, vorticity, potential vorticity, vorticity and potential vorticity equations.

3. **Monsoon Dynamics**

Wind, temperature and pressure distribution over India in the lower, middle and upper atmosphere during pre, post and mid-monsoon season. Monsoon circulation in the meridional (Y-Z) and zonal (X-Y) planes, energy cycle of monsoon. Dynamics of monsoon depressions and easterly waves. Intra seasonal and interannual variability of monsoon. Quasi-bi weekly and 30-60 day oscillations. ENSO and dynamical mechanism for their existence.

4. **Numerical Methods for atmospheric Models**

Filtering of sound and gravity waves, filtered forecast equations, basic concepts of quasi-geostrophic and primitive equation models, one level and multi-level

models. Basic concepts of initialization and objective analysis for wave equation, advection equation and diffusion equation

5. Atmospheric Pollution

Role of meteorology on atmospheric pollution, atmospheric boundary layer, air stability, local wind structure, Ekman spiral, turbulence boundary layer scaling

Residence time and reaction rates of pollutants, sulphur compounds, nitrogen compounds, carbon compounds, organic compounds, aerosols, toxic gases and radio active particles trance gases

6. Atmospheric Instrumentation Systems

Ground based instruments for the measurement of Temperature, Pressure, Humidity, Wind and Rainfall Rate

Air borne instruments – Radiosonde, Rawinsonde, Rocketsonde-satellite instrumentation (space borne instruments)

7. Radar Meteorology

Basic meteorology radar principles and technology-radar processing and display-weather, radar observation of precipitating, systems-estimation of precipitation-radar observation of tropical cyclones, use of weather radar in aviation-clear air radars-observation of clear air phenomena-other radar systems and applications

Text and Reference Books

1. The Atmosphere by Frederick K. Lutgens and Edward J. Tarbuk (for chapter and VI)
2. Dynamic Meteorology by Holton, J.R.,3rd Edition, Academic Press N. Yl. 1992) The Physics of Monsoons, By R.N.Keshvamurthy and M.Shankar Rao, Allied Publishers, 1992 (for chapter 3)

3. Numerical Weather Prediction, by G.J.Haltiner and R.T.Williams, John Wiley and sons, 1980 (for chapter 4)
4. Principles of Air pollution meteorology by Tom Lyons and Peilscott, CBS publishers & Distributors (P) Ltd.
5. Radar Meteorology by Henry Sauggeot

The problems given in the Text and Reference books will form tutorial course

M.Sc. Physics (Final Year)

Elective paper (Vth, K)

PLASMA PHYSICS

Introduction to the plasma state, elementary concepts and definitions of temperature and other plasma parameters, occurrence and importance of plasma for various application

Production of plasma in the laboratory: physics of glow discharge, electron emission, ionization, breakdown of gases, paschen's laws and different regimes of E/p in a discharge, Townsend discharge and the evolution of a discharge

Plasma discharge probes, energy analyzers, magnetic probes and optical diagnostics, preliminary concepts.

Single particle orbit theory: Drifts of charged particles under the effects of different combinations of electric and magnetic fields. Crossed electric and magnetic fields, homogeneous electric and magnetic fields, spatially varying electric and magnetic fields, time varying electric and magnetic fields, particle motion in large amplitude waves.

Fluid description of plasma: distribution functions and Liouville's equation, macroscopic parameters of plasma,

two and one fluid equations for plasma, MHD approximations commonly used in one fluid equations and simplified one fluid and MHD equations

Waves in fluid plasmas: dielectric constant of field free plasma, plasma oscillation, space charge waves of warm plasma dielectric constant of a cold magnetized plasma, ion - acoustic waves, Alfven waves, Magnetosonic waves.

Stability of fluid plasma: The equilibrium of plasma, plasma instabilities, stability analysis, two stream instability, instability of alfven waves, plasma supported against gravity by magnetic field, energy principle.

Kinetic description of plasma: microscopic equations for many body systems, statistical equations for a many body systems, Vlasov equation and its properties, drift kinetic equation and its properties.

Waves in Vlasov plasma: Vlasov equation and its Linearization, solutions of linearised Vlasov equation, theories of langumuir waves, Landau damping, Ion Acoustic waves, Drift waves in magnetized plasma.

Non - linear plasma theories: Non linear electrostatic waves, solutions, shocks, non linear Landau Damping.

Thermonuclear fusion: Status, problems and technological requirements.

Application of cold low pressure and thermal plasma.

Text and Reference Books

1. Introduction of plasma physics, FF Chen
2. Principles of plasma physics, Krall and Trivelpiece
3. introduction to Plasma Theory, DR Nicholson
4. The Plasma state, JL Shohet
5. Introduction to Plasma physics, M Uman
6. Principles of Plasma Diagnostic, IH Hutchinson
7. Plasma Diagnostic Techniques, RH Huddlestone and SL Leonard

The problem given in the text and reference books will from tutorial course.

M.Sc. Physics (Final Year)

Elective paper (Vth, I)

QUANTUM MANY BODY PHYSICS

Formation of second quantization

Wavefunctions for identical particles, Symmetrized bases for Fermions and Bosons, one particle & two - particle operators and their matrix elements in symmetrized basis. Number space representation of the basis, creation and annihilation operators, commutation relations, Representation of operators in terms of creation and annihilation operators. Equation of motion for operators in number space.

Simple Application

Electron gas: Hartree Fock approximation, ground state energy and single particle energy in Paramagnetic and Ferromagnetic states. Role of exchange term, Ground State of interacting Bosons, Bose - Einstein Condensate, Spectrum of elementary excitations, Superfluidity.

Green's Functions and Linear Response Theory

One particle and two particle green's function, Ground State energy and linear response in terms of Green's functions, Analytic properties of Green's function. Equation of Motion for Green's function.

Perturbation Theory

Interaction representation, Gell - Mann - Low theorem for Ground State Energy, Perturbation Expansion for Green's

functions, Wick's Theorem, diagrammatic representation, Dyson's equation, self energy, Polarization.

Application to Interacting Fermi Gas

Dilute Fermi gas, Landau's Theory, Screening of Coulomb interaction, random Phase approximation for electron gas.

M.Sc. Physics (Final Year)

Elective paper (Vth, M)

NONLINEAR DYNAMICS

Introduction to Dynamical Systems

Physics of nonlinear systems, dynamical equation and constants of motion, phase space, fixed points, stability analysis, bifurcation and their classification, Poincare section and interative maps.

Dissipative Systems: One - dimensional noninvertible maps, simple and strange attractors, interative maps, period doubling and universality, intermittency, invariant measure, Lyapunov exponents, higher - dimensional systems, Henon map, Lorenz equation. Fractal geometry, generalized dimensions, examples of fractals.

Hamiltonian Systems

Integrability, Liouville's theorem, action - angle variables, introduction to perturbation techniques, KAM theorem, area preserving maps, concepts of chaos and stochasticity.

Advanced Topics

One selection from quantum chaos, cellular automata and coupled map lattices, solutions and completely integrable systems, turbulence.

Text and Reference books

1. Percival and D. Richards: Introduction to dynamics
2. E.A. Jackson: Nonlinear Dynamics I & II
3. R.L. Devaney: Introduction to dynamical systems
4. Hao Bai -lin: Chaos
5. A.J. Lichtenberg and M.A. Lieberman: Regular and Stochastic Motion
6. M.C. Gutzwiller: Chaos in Classical and Quantum mechanics
7. E. Ott
8. M. Tabar

The problems given in the and Reference Books will form tutorial course.

M.Sc. Physics (Final Yr.)

Elective paper (Vth, N)

ENVIRONMENTAL PHYSICS

1. **Essential of Environmental Physics**

Structure and thermodynamics of the atmosphere. Composition of air. Greenhouse effect. Transport of matter, Energy and momentum in nature. Stratification and stability of atmosphere. Laws of motion. Hydrostatic equilibrium. General circulation of the tropics. Elements of weather and climate of India.

2. **Solar and Terrestrial Radiation**

Physics of radiation. Introduction of light with matter. Raylegh and Mie scattering. law of radiation (Kirchoff's law, Planck's law, Beer's law, Wien's displacement law, etc). Solar and terrestrial spectra. UV radiation. Ozone

depletion problem. IR absorption energy balance of the earth atmosphere system.

3. Environmental Pollution and Degradation

Elementry fluid dynamics. Diffusion. Turbulence and turbulent diffusion. Factors governing air, water and noise pollution. Air and water quality standards. Waste disposal. Heat island effect. Land and sea breeze. Puffs and plumes. Gaseous and particular matters. Wet and dry deposition.

4. Envoirmental Changes and Remote Sensing

Energy sources and combustion process. Renewable sources of energy. Solar energy, wind energy, bioenergy, hydropower, fuel cells, nuclear energy. Forestry and bioenergy.

5. Global and Regional Climate

Elements and weather 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. Energy balance- a Zero-dimensional Greenhouse model. Global climate models.

Text and Reference Books

1. Egbert Boeker & Rienk Van Grondelle, Environmental Physics (John Wiley)
2. J.T.Houghton: The Physics of Atmosphere (Cambridge University Press, 1997)
3. J.Twidell and J.weir: Renewable Energy Resources (Ellis, 1998)
4. Sol Wieder: An Introduction to Solar Energy for Scientist and Engineers (John Wiley, 1982)
5. R.N Keshvamurthy and M.Shanker Rao: The Physics of Monsoons (Allied Publishers,1992)

6. G.J.Haltiner and R.T.Williams: Numerical Weather Prediction (John Wiley, 1980)

The problems given in the Text and Reference books will form tutorial course.

M.Sc. Physics (Final Yr.)

Elective paper (Vth. O)

PHYSICS OF NANOMATERIALS

Free electron theory (qualitative ideal and its features, Idea of band structure, Metals, insulators and semiconductors, Density of state in bands. Variation of density of states with energy, Variation of density of state and band gap with size of crystal.

Quantum Size Effect.

Electron confinement in infimitely deep square well, confinement in two and one dimensional well. Idea of quantum well structure, Quantum dots, Quantum wires.

Determination of particle size, Increase in width of XRD peaks of nanoparticles, Shift in photoluminescence peaks, Variations in Raman spectra of nanomaterials.

Different methods of preparation of nanomaterials. Bottom up : Cluster beam evaporation, Ion beam deposition, Chemical path deposition with capping techniques and Top down : Ball Milling.

Text and Reference Books

1. Nanotechnology Molecularly designed materials by Gan-Moog Chow, Kenneth E. Gonsalves, American Chemical Society.
2. Quantum dot heterostructures by D. Bimerg, M. Grundmann and N. N. Ledentsov, John Wiley & Sons, 1998.

3. **Nono technology :** Molecular speculations on global abundance by B.C Crandall, MIT Press 1958.

4. Physics of low dimensional semiconductors by John H Davies, Cambridge Univ. Press 1997.

5. Physics of semiconductor nano structures by K.P Jain, Narosa 1997.

6. Nano fabrication and bio system : Integrating materials science engineering science and biology by Harvey C. Hoch, Harold G. Craighead and Lynn Jelinski, Cambridge Univ. Press 1996.

7. Nano particles and nano structured films; Preparation characterization and applications Ed. J. H. Fendler, John Wiley & Sons 1998.

Tutorial :-

1. Find surface to volume ratio for a spherical object as a function of radius.

2. A piece is cubic in shape with atoms distant 0.4nm along the three directions parallel to the edges. Find the ratio of number of atoms on the surface to the number of atoms in the cube for the cases when the edge lengths are 1.2nm, 1.6nm, 2.0nm, and 2.4nm.

3. What is melting point ? Does it have any meaning for an atom? Explain. Comment on the melting point (quasi melting) of nanoparticles.

4. What is quantum confinement ?

5. Discuss the case of 2 - dimensional electron gas (i.e. an electron being confined in a plane) and extend the discussion to quantum wire and quantum dot.

6. Discuss the determination of particle size by various methods (X-ray diffraction, transmission electron microscopy, scanning electron microscopy, scanning tunneling electron microscopy and atomic force microscopy). Which one would be the most suitable?

7. Discuss (or comment) the possibility of enhanced photoemission efficiency in nanoparticles and wavelength dependence of the emitted radiation on size of nanoparticles.

8. Nanoparticles can give rise to new structural variants. Explain by taking examples of flornenes and tubules of carbon. Comment on the diffraction effects from beamless tubular arrangement of atoms accomplished by folding atomic planes.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. (Physics) (final Year)

Max. Marks - 100

PROJECTS

This course will be based on preliminary research oriented topics both in theory and experiment. The teachers who will act as supervisors for the projects will float projects and any one of them will be allocated to the student. At the completion of the project by the semester end, the student will submit Project Report in the form of Dissertation which will be examined by the examiners. The examination shall consist of (a) Presentation and (b) Comprehensive viva - voce.

M.Sc. Physics (Final Year)

Laboratory/Practical Course

Max. Marks 100

The students are required to select practicals of their respective special papers.

A :- CONDENSED MATTER PHYSICS

1. Measurement of lattice parameters and indexing of powder photographs.
2. Interpretation of transmission Laue photographs.
3. Determination of orientation of a crystal by back reflection Laue method.
4. Rotation/Oscillation photographs and their interpretation.
5. To study the modulus of rigidity and external friction in metals as a function of temperature.
6. To measure the cleavage step height of a crystal by Multiple Fizeaue fringes.
7. To obtain Multiple beam Fringes of Equal Chromatic Order. To determine crystal step height and study birefringence.
8. To determine magnetoresistance of a Bismuth crystal as a function of magnetic field.
9. To study hysteresis in the electrical polarization of a TGS crystal and measure the Curie temperature.
10. To measure the dislocation density of a crystal by etching.

Tutorial:

1. Study of X-ray diffraction from liquid, amorphous materials.
2. Determination of dislocation density by Reflection X-ray topography.
3. To take Buerger Precession photograph of a crystal and index the reflections.

4. To measure the superconductivity transition temperature and transition width of high - temperature superconductors.
5. To determine the optical constants of a metal by reflection of light.
6. Model evaluation of dispersion curves of one - Dimensional lattice.

M.Sc Physics (Final Year)

Laboratory/Practical Course

Max. Marks - 100

B :- ELECTRONICS

1. Pulse Amplitude Modulation/Demodulation
2. Pulse position/Pulse width Modulation
3. FSK Modulation Demodulation using Timer/PLL
4. Microwave characterization and Measurement
5. PLL circuits and applications
6. Fibre Optics communication
7. Design of Active filters
8. BCD to Seven segment display
9. A/D and D/A conversion
10. Experiments using various types of memory elements
11. Addition, substraction, multiplication & division using 8085/8086
12. Wave form generation and storage oscilloscope
13. Frequency, Voltage, Temperature measurements
14. Motor Speed control, Temperature control using 8086.
15. Trouble shooting using signature analyzer.
16. Assembler language programming on PC.

17. Experiments based on Computer Aided Design

Setting up of new experiments will form tutorial for this laboratory course.

M.Sc. Physics (Final Year)

Laboratory/Practical Course

Max. Mark - 100

C :- ATOMIC AND MOLECULAR PHYSICS

1. Study of line spectra on photographed plates/films and calculation of plate factor
2. Verification of Hartmann's dispersion formula
3. Study of sharp and diffuse series of Potassium atom and calculation of spin orbit interaction constant
4. Determination of metallic element in a given inorganic salt.
5. To record the spectrum of CN violet bands and to perform vibrational analysis
6. To record the visible bands of AlO and to perform vibrational analysis.
7. To photograph and analyse the reddish glow discharge in air under moderate pressure.
8. To photograph and analyse the whitish glow discharge in air under reduced pressure.
9. To perform vibrational analysis of a band system of N_2.
10. To perform vibrational analysis of a band system of C_2.
11. To photograph and analyse the line spectrum of Calcium atom
12. To record/analyse the Raman spectrum of a sample.
13. To record/analyse the fluorescence spectrum of a sample.

14. Study of Hyperfine structure of the green line of mercury.
15. To photograph the (0,0) band of CuH and to perform rotational analysis

Setting up of new experiments will form tutorial for this laboratory course.

M.Sc. Physics (Final Year)

Laboratory/Practical Course

Max. Marks - 100

D :- NEUCLEAR AND PARTICLE PHYSICS

1. To determine the operating voltage, slope of the plateau and dead time of a G. M. counter.
2. Feathers' analysis using G. M. Counter.
3. To determine the operating voltage of a - photomultiplier tube and to find the photopeak efficiency of a NaI (Tl) crystal of given dimensions for gamma rays of different energies
4. To determine the energy resolution of a NaI (Tl) detector and to show that it is independent of the gain of the amplifier
5. To calibrate a gamma ray spectrometer and to determine the energy of a given gamma ray source.
6. To determine the mass attenuation coefficient of gamma rays in a given medium.
7. To study the Compton scattering using gamma rays of suitable energy.
8. To study the various modes in a multichannel analyzer and to calculate the energy resolution, energy of gamma ray

9. To determine the beta ray spectrum of Cs - 137 source and to calculate the binding energy of K - shell electron of Cs - 137.
10. To study the Rutherford scattering using aluminiun as scatterer and Al - 241 as a source..
11. To measure the efficiency and energy resolution of a HPGe detector.
12. Alpha spectroscopy with surface barrier detector - Energy analysis of an unknown gamma source.
13. Determination of the range and energy of alpha particles using spark counter.
14. The proportional counter and low energy X-ray measurements.
15. X-ray fluorescence with a proportional counter.
16. Neutron activation analysis.
17. Gamma - gamma coincidence studies.
18. Identification of particles by visual range in nuclear emulsion.
19. Construction and testing of single channel analyzer circuit.
20. Decoding and display of the outputs from the IC -7490.

Text and Reference Books

1. S.S.Kapoor and V.S.Ramamurthy, Nuclear Radiation Detectors, Wiley Eastern Ltd, New Delhi, 1986.
2. R.M.Singru, Introduction to Experimental Nuclear Physics, John Wiley & Sons, 1974.
3. Alpha, Beta and Gamma Ray Specroscopy, K. Siegbahn, North - Holland, Amsterdam, 1965.
4. W.H.Tait, Radiation Detection, Butterworths, London, 1980.
5. K.Sriram and Y. R. Waghmare, Introduction to Nuclear Science and Technology, A. M. Wheeler, 1991.

6. Nicholson, Nuclear Instrumentation.

Tutorial:-

1. Mounting a Scintillation Crystal to a Photomultiplier Tube.
2. Pulse Cable Making
3. Pulse Shaping With an RC Circuit and to Display With an Oscilloscope.
4. Training in the Usage of Oscilloscope and Electronic Meters - Sensitivity and Resolution Study.
5. Usage of Radiation Monitors.
6. Setting up the Gamma Ray Spectrometer.
7. Photoelectric Effect, Compton Effect, Pair Production and Back Scattering
8. Discriminators
9. Pulse Height as a Function of Applied Voltage for Gas Counters
10. Proportional Counter Characteristics
11. Scintillation Process in Intrinsic and Extrinsic Inorganic Crystals and Organic Crystals.
12. Signal Formation in Solid State Devices
13. Neutron Activation Analysis

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

M.Sc. Physics (Final Year)

Laboratory/Practical Course

Max. Marks - 100

E :- INFORMATICS

List of Experiments for Informatics

1. To study PCM - TDM
2. To study TDM -PAM
3. To study sampling and reconstruction (TDM - PAM)
4. To study Frequency Modulation
5. To study delta modulation, adaptive delta modulation, sigma delta modulation and demodulation techniques.
6. To study PSK, QPSK modulation techniques.
7. To generate PAM, wave form
8. Optical Communication (Optical Fibre Based Experiments)

Tutorial :-

1. Configuration of a network operating system (Windows NT, Windows 2000 server, Linux, Unix, Solaris).
2. Design a network of 10 nodes under Windows NT system with TCP/EP networking at 100 mbps speed using intelligent hubs.
3. Design a mail client.
4. Configuration of a Web (HTTP) server.
5. Configuration of US.
6. Configuration of a mail server.

C.S.J.M. UNIVERSITY, KANPUR

COURSE STRUCTURE FOR STATISTICS

M.Sc. / M.A. (Prev.) 2004 and onwards

		Max. Marks
PAPER I	Measure Theory, Probability and Distribution.	100
PAPER II	Real Analysis and Stochastic Processes	100
PAPER III	Linear Methods and Design of Experiments.	100
PAPER IV	Econometrics	100
PAPER V	Practical - Based on Paper I, Paper II & Paper III (matrices).	100
PAPER VI	Practical - Based on Paper III (Design of Exp.) & Paper IV.	100

M.Sc./M.A. (Final) - To be included during April 2003

DETAILED SYLLABUS

STATISTICS

M.Sc. / M.A. (Prev.) Statistics Exam. 2004 & onwards

PAPER I MEASURE THEORY, PROBABILITY AND DISTRIBUTIONS.

Unit I Sets, sequence of sets and their limits, Fields and sigma fields, Minimal sigma field, Monotone classes of sets, Borel sigma field. Set function, Continuity of set function, Measure function, properties of measure function, Probability measure, Caratheodory Extension Theorem of

measure (Statement only). Lebesgue Measure and Lebesgue - Stieltjes measure.

Unit 2 Measurable function - its descriptive definition and properties, simple and elementary functions, construction of measurable functions. Random variable, sequences of measurable functions and random variables.

Convergence of measurable function and Random variables - almost everywhere convergence, almost sure convergence, convergence in distribution (law). Helly - Bray Theorem (without proof).

Unit 3 Borel - Cantelli lemma, Borel 0-1 law, weak & strong law of large numbers for independent random variables, Kolmogorov's inequality and theorem, Levy's inequality and Chebyshev's inequality.

Unit 4 Central Limit Theorems : Lindberg-Levy Theorem, Laplace - Liapounoff Theorem, Lindberg - Feller Theorem (without proof) Characteristic functions, inversion theorem. Continuity Theorem and its application.

Unit 5 Sampling Distribution of

(i) Mean and Variance, Non - Central Chi-square, t and F and their properties.

(ii) Order statistics and sample range.

(iii) Sample correlation Coefficient.

References

Halms, P.R. (1964) Measure Theory, (Affiliated East - West Press Pvt. Ltd.)

Bhat, B.R. (1985) Modern Prob. Theory, (Wiley - Eastern Limited)

Ash, R. (1972) Real Analysis & Probability; (Academic Press)

Berberian S.K. (1965) Measure and Integration; (Collier - Macmillan Ltd.; London)

Loeve, M. (1988) Probability Theory; (Affiliated East - West Press Pvt.Ltd.)

Chow Y.S. & Teicher H (1979) Probability Theory; (Narosa Publishing House)

Fisz, M Probability Theory & Mathematical Statistics, II Ed.; (John Wiley).

Goon, Gupta & Das Gupta An out line of statistical Theory Vol. 1; (World Press, Kolkata).

Arnold, B.C. Balkrishnan, N. and Nagaraja, H.N. (1992) A first Course in Order Statistics (John Wiley).

PAPER-II REAL ANALYSIS AND STOCHASTIC PROCESS.

Unit 1 Real valued functions, continuity of functions of one variable, uniform continuity. Differentiability, Mean value Theorem, Taylor's theorem with statements of various remainder terms.

Maxima - Minima of functions of many variables (Method of undetermined multipliers only).

Unit 2 Fundamental theorem and Mean value theorem of integral calculus, Test of convergence of infinite integrals, uniform convergence of improper integrals, differentiations under the sign of integral.

Unit 3 Multiple integrals and their evaluation by repeated integration, change of variables in multiple integration, Drichlet's multiple integral.

Stochastic Processes : Its introductionm (Definition & Examples) and classification into

discrete/continuous time, discrete/continuous state spaces, types of stochastic processes with elementary problems.

Unit 4 Markov Chains : Definition & examples of Markov chain Chapmann - Kolmogrove equations, Calculation of n-step transition probability matrix and its limit. Stationary distribution classification of states, transient Markov chain.

Unit 5 Random walk and Gambler's ruin problem. Idea's of Branching process, Poisson Process, Pure Birth Process, Pure Death Process, Birth & Death Process. Applications from social physical & Biological sciences.

References

Apostal T.M. (1985) Mathmatical Analysis, (Narosa Pub. House (Indian Ed.))

Smith Concepts of Real Analysis.

Rudin, Walter (1976) Principals of Mathematical Analysis.

Shanti Narain Mathematical Analysis.

Parzen E (1962) Stochastic Processes (Holden - day)

Feller, W. (1968) Introduction to probability and its application Vol. 1 (Wiley Eastern)

Hoel. P.G.; Port S.C. and Stone C.F. (1972) Introduction to stochastic processes (Houghton Miffin & Co.)

Karlin & Taylor H.M. (1975) A first course in stochastic processes, Vol.1 (Academic Press).

Cinlar E (1975) Introduction to stochastic processes, (Prentice Hall).

Adke S.R. & Manjunath SM (1984) An introduction to finite Markev processes (Willey Eastern)

Bhat BR (2000) Stochastic Models : Analysis & Application (New Age International, India).

PAPER - III LINEAR METHODS & DESIGN OF EXPERIMENTS.

Unit 1 Finite dimensional vector spaces, existence of basis, Orthogonal matrices, Gram - Schmidt orthogonalisation method. Algebra of Matrices, rank and inverse of a matrix, solution of Linear equations. Generalised inverse of a matrix and its elementary properties.

Characteristic roots & vectors of a matrix, Caley-Hamilton Theorem. Idempotent matrices.Real quadratic forms, rank & index, congruence of symmetric matrix, reduction of quadratic forms.

Unit 2 **Linear estimations :** Linear models with assumptions on error components, estimable function, estimation & error spaces, Best Linear Unbiased Estimate (BLUE) for Linear functions of parameters, unified theory of BLUE and least square estimate.

Unit 3 Testing of general liner hypothesis under normality of errors. Analysis of variance in general two-way classification. Missing plot techniques.

Unit 4 General Block Design and its information matrix. Criteria of connectedness and orthonormality.

Balanced and partially balanced design. Analysis of block designs. Extension to row-column designs.

BIBD, recovery of inter & intra block informations in BIBD. Lattice Design, split plot design.

Unit 5 General factorial experiments, factorial effects, best estimates and testing of the significance of factorial effects, study of 2 & 3 factor experiments in randomised blocks. Complete & partial confounding. Fractional replication for symmetric factorials.

Reference

Rao, C.R. (1973)	Linear Statistical inference & its applications (2nd Ed.) (John Wiley)
Biswas, S. (1984)	Topics in Algebra of Matrix, (Academic Publication).
Hadley, G.(1987)	Linear Algebra, (Narosa Publicity House)
Graybill, F.A. (1983)	Matrics with applications in statistics (2nd Ed.) (Wards worth)

Searle S.R.Linear Models (Wiley)

Searle S.R. (1982)	Matrix Algebra useful for statistics (Wiley)
Chakrabarti M.C.	Mathematics of Designs & Analysis of Experiments (Asia Publishing House)
Joshi, D.D.	Linear Estimation and Design of Experiments (Wiley Eastern)
Das M.N. & Giri N. (1979)	Design and Analysis of Experiments (Wiley Eastern)
Montgomery C.D. (1976)	Design & Analysis of Experiments (Wiley)
Kempthorn, O.	Design & Analysis of Experiments.
Scheffe	Analysis of Variance (Wiley).
Giri N.	Analysis of Variance.

PAPER - IV ECONOMETRICS

Unit 1 Nature of Econometrics, The General Linear Model ordinary least squares estimation and prediction. Use of dummy variables. Least squares estimates with restriction on parameters. Pure and mixed methods of estimation. Generalized least squares and prediction.Test of significance and confidence intervals, use of orthogonal polynomials.

Unit 2 Heteroscedastic disturbances and its solutions. Autocorrelation, its consequences. Durbin-Watson test. Multicollinearity problem, its implication and tools for handling the problem. Ridge Regression.

Unit 3 Residuals and their plots as a test for departure from assumptions such as fitness of model, normality, homogenity of variances, detection of outliers and remedies. Selection of explanatory variables - use of R^2, S^2 Mallows C_p statistics and stepwise regression.

Unit 4 Linear regression with stochastic regressores. Error in variable model and instrumental variable estimation. Autoregressive linear regression. Distributed lag model.

Introduction to Non-linear models. Intrinsically non linear models. Linearization (Taylor's series) method of estimation of structural parameters.

UNIT 5 Simultaneous linear equation model. Examples. Identification problems - restriction on structural parameters, Rank and order conditions. Estimation in simultaneous equation model. Indirect least squares, 2SLS estimators. General out line of LIML, K-class estimators, 3SLS and FIML estimators.

References

Kontsoyiannis, A. (1979)	Theory of Econometrics, (Macmillan Press).
Johnston, J.	Econometric methods III Ed.
Theil, H.	Introduction to theory and practice of Econometrics.
Draper N.R. and Smith, H.	Applied Regression Analysis, II Ed.
Wetherill, G.B. (1986).	Regression analysis with applications (Chapmann Hall).
APK, P.G. (1990)	Text Book of Econometrics, (Tata McGraw Hill).