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UNIVERSITY OF DELHI

SCHEME OF EXAMINATION
AND
COURSES OF READING
FOR
B.Sc. (Honours)
in
PHYSICS EXAMINATION

Part I	Examination	2001
Part II	Examination	2002
Part III	Examination	2003

Syllabus applicable for students seeking admission to the B.Sc. (Hons.) in Physics Course in the Academic Year 2000 - 2001

Price Rs. 15.00

THE COURSES OF STUDY FOR
B.Sc (HONS.) PHYSICS
EFFECTIVE FROM THE SESSION 2000 - 2001

The integrated B.Sc. (H) Physics programme will be of three years duration. The theory and practical examinations will be held at the end of each year in April/May. There will be six theory papers and two practical laboratory courses each year. In addition, there will be a qualifying English paper in the first year. The final division/rank of a student will be determined by taking into consideration the marks in both the theory and the laboratory papers in all the three years. The marks in qualifying English will not be taken towards determining the division/rank of the student.

Two-thirds of all theory papers (12) and laboratory papers (4) are from the main discipline, viz. physics, and one-third of theory papers (6) and laboratory papers (2) are from other disciplines; there is one paper of qualifying English.

The courses of study and examination scheme for B.Sc. (H) Physics shall be as follows.

Paper No.	Title	Duration (Hours)	Maximum Marks
First Year (Part I)			
I	Mathematical Physics I	3	50
II	Mechanics	3	50
III	Electricitty & Magnetism	3	50
IV	Mathematics I	3	50
V	Chemistry	3	50
VI	Linear & Digital Integrated Circuits & Instruments	3	50
VII	Physics Lab. I	5	75
VIII	Chemistry Lab.	6	75

Q1	English (qualifying)*	3	100
		Total Marks	450
Second Year (Part II)			
IX	Mathematical Physics II	3	50
X	Thermal Physics	3	50
XI	Vibrations & Wave Optics	3	50
XII	Quantum Mechanis and Nuclear Physics	3	50
XIII	Mathematics II	3	50
XIV	Computer Fundamentals and Programming	3	50
XV	Physics Lab. II	5	75
XVI	Digital, Microprocessor & Computer Lab.	5	75
		Total Marks	450
Third Year (Part III)			
XVII	Mathematical Physics III	3	50
XVIII	Electromagnetic Theory	3	50
XIX	Statistical Physics	3	50
XX	Physics of Materials	3	50
XXI	Electronic Devices : Physics and Applications	3	50
XXII	Any one of the following	3	50
	(i) Modern Chemistry	3	50
	(ii) Biophysics	3	50
	(iii) Economics	3	50
XXIII & XXIV	Physics Lab. III & IV (Including Project)	5 + 5	150
		Total Marks	450
Grand Total of I, II and III year marks			1350

* Marks obtained in the qualifying paper shall not be counted for determining the aggregate score or division/rank of the student.

Optiion to Students

A studen has the optiori to offer any one of the papers listed under paper no. XXII. No paper shall be offered unless the numbers of students opting for that particular paper equals or exceeds five. Every college shall offer Modern Chemistry and one more option out of Biophysics and Economics.

Remarks on Examinations

1. The examination of each paper in theory and laboratory will be held at the end of the academic year.
2. Students in each theory paper will be required to answer five questions out of which one question will be compulsory with different parts covering the entire course and disigned to test application and understanding. There will be some internal choice in compulsory and other questions. The other questions will be distributed over the entire syllabus. In those papers where the syllabus is divided into 4 units, one question must be attempted from each units.
3. In each laboratory paper the students will be required to do one experiment at the time of examination and appear in a written test. Different experiments can be merged or some parts of long experiments deleted to make the experiments roughly of the same difficulty level at the time of examination.
4. In first and second year laboratory papers VII, VIII, XV and XVI, students will be required to do at least ten experiments out of the suggested list distributed over different units.
   Third year laboratory papers XXIII and XXIV will run together. The students will be required to perform sixteen experiments (eight in each paper distributed over different units) along with a compulsory project.

5. There will be a written test (objective/short answer) based on laboratory experiments and general experimental techniques. This test will be simultaneously held in all colleges separately for I, II and III years before the commencement of the practical examinations on a day to be notified.

   The question paper will be set by a board of examiners appointed by the committee of courses, which will set four to six papers that may be randomly sent to the various colleges.

   The answer books will be separately evaluated in each college by the group of examiners appointed to conduct the practical examination in that college.

   Students who fail to appear in the written test will not be given any chance to reappear.

6. The distribution of marks in laboratory papers VII, VIII, XV and XVI will be as follows :

Written test (45 minutes duration)	15
Internal assessment including laboratory report	20
Experiment and viva (35 + 5)	40
Total (each paper)	75

The distribution of marks in third year laboratory papers XXIII and XXIV (taken together) will be as follows :

Written test (one hour duration)	20
Internal assessment including laboratory report	30
Experiment and viva (30 + 5) (Paper XXIII)	35
Experiment and viva (30 + 5) (Paper XXIV)	35
Project including 10 marks for viva	30
Total marks	150

For the detailed course of qualifying English, please see the syllabus for 'BA (Pass), B.Com (Pass) and subsidiary/qualifying English.'

Promotion Scheme and Final Result

The present scheme of promotion and facility for repetition of theory papers will continue in regard to two papers which can be carried to the next higher class. The final division will be determined at the end of Third year taking into consideration all theory and laboratory papers in three years except qualifying English.

Schedule of Teaching

(a) Theory : Three periods for each theory course per week.

(b) Practicals : Three periods twice a week for each laboratory course.

(c) Qualifying English : Two periods per week only in the first year.

Detailed Courses of Study for B.Sc. (Hons.) Physics

The following is the detailed syllabus for each course in first, second and third year of the B.Sc. (H) Physics programme.

B.Sc. (H) Part I (First Year)

Paper I : Mathematical Physics I

Unit I Vector Algebra and Analysis

Review of vector algebra – addition, subtraction and product of two vectors. Polar and axial vectors and their examples from physics. Triple and quadruple product (without geometrical applications).

Scalar and vector fields, differentiation of a vector w.r.t. a scalar. Unit tangent vector and unit normal vector (without Frenet – Serret formulae).

Directional derivatives, gradient, divergence, curl and Laplacian operations and their meaning. Idea of line, surface and volume integrals. Gauss, Stokes and Green's theorems.

Unit II Orthogonal Curvilinear Coordinates and Multiple Integrals

Orthogonal curvilinear coordinates. Derivation of gradient, divergence, curl and Laplacian in cartesian, spherical and cylindrical coordinate systems. Change of variables and Jacobian. Evaluation of line, surface and volume integrals.

Calculus of Variations

Constrained maxima and minima. Method of Legrange undetermined multipliers and its application to simple problems in physics.

Variational principle. Euler-Lagrange equation and its application to simple problems.

Unit III Differential Equations

Classification of differential equations : linear and nonlinear, homogeneous and non-homogenous equations.

Linear ordinary Differential Equations

First order: Separable and exact equations. Intergrating factor.

Second Order: Homogeneous equations with constant coefficients. Wronskian and general solution. Statement of Existence and Uniqueness theorem for initial value problems. Solution of non-homogeneous equations by operator (D) method. Particular integral. Method of undetermined coefficients and variation of parameters Equations reducible t0 those with constant coefficient. Bernoulli and Euler equations.

Unit IV Fourier Series

Fourier series, Dirichlet conditions (statement only). Orthogonality of sine and cosine functions. Sine and cosine series. Distinctive features of Fourier expansions. Half-range expansions.

Applications : Square wave, triangular wave, output of full wave rectifier and other simple functions. Summing of infinite series.

Theory of Errors

Systematic and random errors. Propagation of errors. Normal law of

errors, standard and probable error. Least square fitting of data (linear case).

Paper II : Mechanics

Unit I : Fundamentals of Dynamics

Motion of charged particle in electric and magnetic fields.

Dynamics of a system of particles. Centre of mass. Conservation of momentum. Idea of conservation of momentum from Newton's third law. Impulse. Momentum of variable mass system ; motion of rocket, Work-energy theorem. Potential energ. Energy diagram. Stable and unstable equilibrium. Conservative and non-conservative forces. Force as gradient of potential energy. Particle collisions. Centre of mass frame and laboratory frame.

Unit II Rotational Dynamics

Angular momentum of a particle and system of particles. Torque. Conservation of angular momentum. Rotation about a fixed axis. Moment of inertia ; its calculation for rectangular and cylindrical bodies; idea of calculation for spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Oscillatory Motion

Motion of simple and compound pendulum. Loaded spring, Energy considerations. Time average of energy. Damped harmonic oscillator. Resonance in a lightly damped system.

Unit III : Gravitation and Central Force Motion

Law of gravitation. Inertial and gravitational mass. Potential energy and field due to spherical shell and solid sphere.

Self energy. Motion of a particle under central force field. Angular momentum conservation, one body problem, two body problem and its reduction to one body problem and its solution. The energy equation and energy diagram. Kepler's laws. Satellites.

Unit IV Non-Inertial Systems

Inertial frames and Galilean transformations. Non-inertial frames and fictitious forces. Uniformly accelerating system. Physics in rotating coordinate systems. Centrifugal and Coriolis forces.

Special theory of Relativity

Michelson-Morley experiment and its outcome. Postulates of special theory of relativity. Lorentz transformations. Simultaneity and order of events. Lorentz contraction and time dilation. Relativistic transformation of velocity, frequency and wavenumber. Velocity dependence of mass and equivalence of mass and energy. Relativistic Doppler effect. Relativistic kinematics. Transformation of energy and momentum.

Paper III : Electicity and Magnetism

Unit I Electric Circuits

Kirchhoff's laws for A.C. circuits. Series and parallel resonant circuits, A.C. bridges. Thevenin's theorem and Norton's theorem and their applications to D.C. circuits.

Electric Field

Electric charge ; conservation and quantisation. Coulomb's law and superposition principle. Electric field and electric lines. Gauss's Law. Field of spherical, linear and plane charge distributions. Line integral of electric field. Electric potential. Potential and electric field of a dipole, a charged wire and a charged disc. Multipole expansion of potential due to arbitrary charge distribution. Force and torque on a dipole. Laplace's equation : uniqueness theorem. Conductors in an electrostatic field. Description of a system of charged conductors. An isolated conductor and capacitance. Method of images and its application to simple electrostatic problems : plane infinite sheet and sphere.

Unit II Electrostatic Energy

System of point charges, a uniform sphere, a condenser, an ionic crystal, nuclear electric field, point charge.

Dielectric Properties of Matter

Dielectric polarisation and polarisation charges. Gauss's law in dielectrics. Field vectors **D** and **E** and their boundary conditions. Capacitors filled with dielectrics.

Unit III Magnetic Field

Magnetic force between current elements and definition of **B**. Properties of **B** Ampere's Circuital Law, Curl and divergence of **B**, Vector potential. Magnetic flux. Calculation of B for circular and solenoidal currents. Torque on a current loop in a uniform magnetic field. Magnetic dipole. Forces on an isolated moving charge.

Magnetic Properties of Matter :

B, **H** and their relation. Magnetic susceptibility. Stored magnetic energy in matter. Magnetic circuit. **B-H** curve and energy loss in hysteresis.

Unit IV : Electromagnetic Induction :

A conducting rod moving through a uniform magnetic field. A loop through non-uniform magnetic field. A stationary loop with field source moving. Faraday's law of induction. Curl E-D B/dt. Mutual induction-- reciprocity theorem ($M_{12} = M_{21}$). Self-induction, energy stored in magnetic field.

Paper IV : Mathematics I

Sequences of real numbers. Convergent, Cauchy, monotonic and bounded sequences. Subsequences. Limit superior and limit inferior of a sequence. Infinite series and their convergence. Comparison test, Cauchy's root test, d' Alembert's ratio test, Raabe's test, Cauchy's integral test. Alternating series and Leibnit test. Absolute and conditional convergence.

Functions of a real variable. Limits, continuity and differentiability of functions. Uniform continuity. Continuity on (a,b) implying uniform continuity and boundedness. Intermediate value theorems and Taylor's theorem for analytic functions. Taylor's and Maclaurin's series of elementary analytic functions.

Functions of two and three real variables, their continuity and differentiability. Schwarz and Young's theorem, implicit function theorem, Taylor's theorem. Maxima and minima.

Definition and examples of Riemann integral of a bounded function. Riemann integrability of continuous and monotonic functions. Riemann integral as the limit of a sum. The fundamental theorem of integral calculus. Mean-value theorems.

Integration of rational and irrational functions. Integration by partilal functions. Properties of definite integrals. Reduction formulae.

Paper V : Chemistry

Section A

Bonding : Qualitative approach to valence bond theory and its limitations. Hybridisation, equivalent and non-equivalent hybrid orbitals, Bent's rule and applications.

Molecular orbital theory, symmetry and overlap. Molecular orbital diagrams of diatomic and simple polyatomic systems (O_2, C_2, B_3, CO, NO and their ions; HCl, BeF_2, CH_4, BCl_3) (Idea of Sp^3 mixing and orbital interaction to be given.

Organisation of soilds

(i) Packing of ions in cyrstals, close packed structures. Spinel, ilmenite and perovskite structures of mixed metal oxides. Size effects, radius ratio rules and their limitations. Lattice energy - Born equation (calculations of energy in ion pa. and ion pairs square formation), Madelung constant. Kapustinskii, equation and its applications. Born-Haber cycle and its applications.

(ii) Solvation energy. Packing of atoms in metals, qualitative idea of valence bond and band theories. Semiconductors and insulators. Defects in solids. Conductance in ionic solids. Introduction to superconductors.

(iii) Weak chemical forces : van der Waals forces, hydrogen bonding. Effects of chemical forces on m.p., b.p. and solubility. Energetics of dissolution process.

Coordination Compounds and Inorganic Reaction Mechanisms

Crystal field theory – measurement of 10 Dq CFSE in weak and strong fields. Pairing energies, factors affecting the magnitude of 10 Dq. Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral symmetry. The Jahn-Teller theorem, square-planar coordination. Ligand field and molecular orbital theories.

The trans effect, mechanism of the trans effect, kinetics of square planar substitution reactions. Thermodynamic and kinetic stability. Labile and inert complexes.

Kinetics of octahedral substitution reaction. Mechanism of substitution in octahedral complexes. Mechanism of electron transfer reactions (inner and outer sphere mechanism).

Section B

General Organic Chemistry

Bonding in organic molecules and its effects on shape, chirality and RS nomenclature as applied to chiral centres. Treatment of chirality upto three chiral centres. Conformation of acyclic and cyclic systems, conformational analysis of disubstituted cyclohexanes. Geometrical isomerism and E-Z nomenclature.

Electronic displacements in organic molecules. Aromaticity. Reactivity of organic molecules. Heterolytic and homolytic fission. Nucleophiles, electrophiles, acids and bases and their relative strengths (including carbon acids). Addition, elimination and substitution reactions (including electrophilic, nucleophilic and aromatic types).

Arynes and carbenes as reaction intermediates.

Functional Group Chemistry

Rationalisation of functional group reactivity on mechanistic basis of the following groups : hydroxyl, carbonyl, carboxyl and its derivatives such as ester and amide, cyano, nitro and amino. Orientation effect in aromatic substitution, polymerisation and overview of polymers. Organic reactions as synthetic tools: Claisen, Cannizzaro, Grignard, Michael, Mannich, Darzen, aldol, Diekmann, Perkin etc.

Paper VI

Linear and Digital Integrated Circuits and Instruments

Unit I Basic Concepts of Integrated Circuits

Active and passive components, discrete component circuits, wafer, chip, advantages of integrated circuits, MSI, LSI and VLSI (basic idea and definitioins only).

Operational Amplifiers (Op-Amp)

Basic characteristics without detailed internal circuit of IC : Requirement of ideal voltage amplifier, characteristics of ideal operational amplifier, feedback in amplifier (black box approach), open loop and close loop gain, inverting and non-inverting amplifier, zero crossing detector.

Application of op-amps : Mathematical operations addition, multipicatijon, integration and differentiation. Electronic circuits - oscillator (Wien's bridge), rectangular and triangulâr wave generators (all circuit analysis based on Kirchhoff's laws).

Unit II Digital Circuits

Difference between analog and digital circuits, binary numbers, binary to decimal conversion, AND, OR and NOT gates (realisation using diodes and transistor), Boolean algebra, Boolean equations of logic circuits, de Morgan theorem, NOR and NAND gates.

Combinational logic : Boolean laws and theorems, sum of proudcts method of realising a circuit for a given truth table, truth table to Karnaugh map and simplification (elementary idea).

Data processing circuits : Multiplexers, demultiplexers, decoders, encoders, exclusive OR gate, parity checker, read-only memories (ROM), PROM, EPROM.

Arithmetic circuits : Binary addition and subtraction (only 2's complement method), half adders and full adders and subtractors (only upto eight bits).

Unit III

Sequential circuits : Flip-flops - RS, JK, D, clocked, preset and clear operation, race-around conditions in JK Flip-flop, master slave JK flip-flop as building block of sequential circuits.

Shift registers : Serial-in-serial-out, serial-in-parallel-out, parallel-in-parallel-out, parallel-in-parallelled-out (only upto 4 bits).

Counters : Asynchronous counters, synchronous counter, decade counter.

D/A and A/D conversion : D/A converter—resistive network, accuracy and resolution. A/D converter (only counter method)—accuracy and resolution.

Unit IV Electronic Instruments

Timer : Simple applications of 555 timer circuits.

Power supply : Requirement of ideal voltage and current source, voltage source, half-wave and full-wave rectifier, bridge rectifier, L and C filters, some idea of ripple.

Oscilloscope : Input attenuators, DC, AC and ground, horizontal and vertical deflecting system, time base generation and synchronization ; measurement of positive, positive-negative wave shape, rise time and fall time; frequency, amplitude and phase of sinusoidal waves.

Paper VII : Physics Laboratory I

Unit I : Methodology and Familiarisation

1. Measurement of length using
   (i) crude estimation, ungraduated and graduated scales.
   (ii) triangulation method.
   (iii) vernier callipers, screw gauge, travelling microscope.
   (iv) indirect methods, e.g. for estimation of atomic size.
2. Familiarisation with basic electronic components.
3. Familiarisation with operation of basic measuring and test equipment (power supplies, analog and digital multimeters, function generator and CRO).
4. To test a diode and transistor using multimeter and CRO.

Unit II

1. To study the random error in observations.
2. Experiments for generation of data in linear and non-linear regions for the following systems :
   (i) flow of liquid through capillary tube
   (ii) diode characteristics (I-V).
   (iii) pendulum with large amplitude
3. Frequency and phase measurements using CRO.
4. Spring constant and mass from vertical oscillations of a spring and determination of modulus of rigidity.

Unit III : Electronics and Instrumentation

1. To design an amplifier of given gain using op-amp 741 in inverting and non-inverting configurations and to study its frequency response.

2. To design a precision differential amplifier of given I/O specification using 741.
3. To design an astable oscillator of given specifications using 555.
4. To design a monostable oscillator of given specifications using 555.

Unit IV : Measurement of Resistance and Voltage

1. Precise measurement of a low resistance using Carey Foster's bridge/potentiometer.
2. To calibrate a Resistance Temperature Device (RTD) to measure temperature in a specified range using null method/off-balance bridge with galvanometer based measurement.
3. To calibrate a thermocouple to measure temperature in a specified range using null method/direct measurment using an op-amp difference amplifier and to determine neutral temperature.

Unit V : Mechanics

1. To determine the acceleration due to gravity using compound pendulum.
2. To determine the acceleration due to gravity using Kater's pendulum.
3. To determine the acceleration due to gravity and velocity for a freely falling body, using digital timing techniques.

Unit VI : Oscillators

1. To investigate the motion of a simple or physical pendulum with
   (i) variation of moment of inertia and
   (ii) viscous, frictional and electro-magnetic damping (e.g. motion of coil of a B.G.).
2. To investigate the motion of coupled oscillators.

3. To investigate the forced oscillations of an LCR circuit in series and parallel configurations and calculate quality factor Q.

Paper VIII : Chemistry Laboratory

1. Separation of cations and anions by paper chromatography.
2. Preparation of
   (i) Manganese (III) phosphate. Estimation of Mn content in the above complex colorimetrically (periodate oxidation). Estimation of oxidising equivalents in the above complex titrimetrically (titration of liberated iodine).
   (ii) Tetrammine copper (II) sulfate and estimation of copper as CuCNS gravimetrically in the above complex.
3. Preparation of
   (i) Aspirin (ii) Hippuric acid (benzoylglycine) (iii) Methyl orange or phenolphthalein. Characterisation by mp, mmp, and TLC.
4. Two-step preparations
   (i) Nitrobenzene from benzene, purification of nitrobenzene and characterisation by refractive index, further nitration.
   (ii) *p*-bromoacetanilide from aniline.
5. Preparation of lactose and casein from milk or isolation of caffeine from tea leaves (mp, colour test).
6. Estimation of glucose, saponification value or iodine value of a fat or oil.
7. Potentiometric titration of Mohr's salt with $K_2Cr_2O_7$ or $KMnO_4$ using digital multimeter or low cost potentiometer.
8. Conductometric titration of a solution of HCl or CH_3 COOH with NaOH by a direct reading conductometer.
9. Determination of molecular mass of a poymer by measurement of viscosity.

10. The effect of detergent on the surface tension of water. (Variation of surface tension with concentration to be studied.)
11. Determination of the rate law for one of the following reactions. All solutions needed to be provided.
    (i) Persulphate-iodide reaction.
    (ii) Iodination of acetone.
12. To study the kinetics of inversion of cane sugar (polarimetrically).

Paper Q 1 : Qualifying English

For the detailed course of qualifying English, please see the syllabus for 'B.A. (Pass), B.Com. (Pass) and subsidiary qualifying English.'

B.Sc. (H) Part II (Second Year)

Paper IX : Mathematical Physics II

Unit I Complex Variables

Importance of complex numbers and their graphical representation. De Moivre's theorem. Roots of complex numbers. Euler's formula. Functions of complex variables. Examples. Cauchy-Riemann conditions. Analytic functions. Singularities. Differentiation and integration of a function of a complex variable. Cauchy's theorem. Cauchy's integral formula. Morera's theorem, Cauchy's inequality. Liouville's theorem. Fundamental theorem of algebra.

Multiple valued functions. Simple ideas of branch points and Riemann surfaces. Power series of a complex variable. Taylor and Laurent series. Residue and residue theorem.

Unit II

Contour integration and its application to evaluation of integrals.

Series Solution of Linear Second Order Ordinary Differential Equations :

Singular points of second order differential equations and their importance. Series methods (Frobenius). Legendre, Bessel, Hermite and Laguerre differential equations.

Unit III : Special Functions

Gamma and Beta functions.

Legendre, Hermite and Laguerre Polynomials : Rodrigues' formulae, generating functions, recurrence relations, orthogonality.

Series expansion of a function in terms of a complete set of Legendre functions.

Bessel functions : first and second kind, generating function, recurrence formulas, zeros of Bessel functions and othogonality. Fraunhofer diffraction integral for circular aperture.

Unit IV : Partial Differential Equations

General solution of wave equation in 1 dimension. Transverse vibration of stretched string. Oscillation of hanging chain. Wave equation in 2 and 3 dimensions. Vibrations of rectangular and circular membrane.

Derivation of the equation of heat conduction. Heat flow in one– two– and three–dimensional rectangular systems of finite boundaries. Temperature inside circular plate.

Laplace equation in Cartesian, cylindrical and spherical coordinate systems. Problems of steady flow of heat in rectangular and circular plate. Gravitational potential of a ring.

Paper X : Thermal Physics

Unit I : Kinetic Theory of Gases

Derivation of Maxwell's law of distribution of velocities and its experimental verification. Mean free path. Transport phenomena, viscosity, conduction and diffusion. Brownian motion. The theories of Langevin and Einstein and experimental determination of Avogadro's number. Examples of Brownian motion in physics (galvanometer mirror, sedimentation, Johnson's noise).

Unit II

Ideal gases : Equation of state, internal energy, specific heats, entropy. Isothermal and adiabatic processes. Compressibility and expansion coefficient. Adiabatic lapse rate.

Real gases : Deviations from the ideal gas equation. The virial equation. Andrew's experiments on CO_2 gas, continuity of liquid and gaseous state. Van der Wal's equation. Critical constants and law of corresponding states. Free expansion. Joule–Thomson effect.

Unit III Thermodynamics

Zeroth and first law of thermodynamics. Reversible and irreversible processes. Conversion of heat into work, Carnot theorem. Second law of thermodynamics. Thermodynamic temperature. Clausius inequality. Entropy. Entropy changes in reversible and irreversible processes. Temperature-entropy diagrams. The principle of increase of entropy : applications.

Unit IV

Thermodynamic potentials : Enthalpy, Gibbs and Helmholtz functions. Maxwell relations and their applications. Magnetic work. Magnetic cooling by adiabatic demagnetization, approach to absolute zero. Change of phase, equilibrium between a liquid and its vapour. Clausius-Clapeyron equation. The triple point with examples from physics. Second order phase transitions.

Paper XI : Vibrations and Wave Optics

Unit I : Vibrations

Free oscillations of system with one degree of freedom. Linearity and superposition principle. Superposition of (i) two and (ii) N collinear harmonic oscillations; beats. System with two degrees of freedom (coupled oscillators). Normal coordinates and normal modes. Energy relation and energy transfer. Normal modes of N coupled oscillators. Normal modes of stretched string. Energy of vibrating string. Plucked and struck strings.

Waves

Wave equation. Travelling waves. Plane and spherical waves. Superposition of two harmonic waves. Standing waves on a string. Superposition of N harmonic waves. Pulses and wave packets.

Unit II : Wave Optics

Introduction to different models, light waves, electromagnetic nature of light waves.

Coherence and Interference

Interaction of independent light sources. Classification in terms of division of amplitude and division of wavefront. Young's double slit experiment, Lloyd's mirror and Fresnel's biprism. Interference in thin films : parallel and wedge-shaped films. Fringes of equal inclination (Haidinger fringes) and fringes of equal thickness (Fizeau fringes).

Michelson's interferometer : Theory, form of fringes (mention only), applications, visibility of fringes.

Theory of partial coherence. Coherence time and coherence length, i.e. temporal and spatial coherence.

Fabry-Perot interferometer : Theory, Airy's formula, sharpness of fringes, finesse, visibility of fringes.

Unit III Diffraction

Kirchhoff's integral theorem. Fresnel-Kirchhoff integral formula and its application to diffraction problems.

Fraunhofer diffraction : Single slit, rectangular and circular aperture. Multiple slit. Plane diffraction grating. Resolving power and dispersive power of a plane diffraction grating.

Unit IV

Fresnel diffraction : Fresnel's integrals, Cornu's spiral, Fresnel diffraction pattern at a straight edge, a slit and a wire (qualitatively using Cornu's spiral).

Holography : Principle of holography, recording and reconstruction method and its theory as interference between two plane waves.

Paper XII : Quantum Mechanics and Nuclear Physics

Unit I Particles and Waves

Photoelectric effect. Compton effect. Reduced mass correction. De Broglie hypothesis. Wave particle duality. Davisson-Germer experiment. Wave packets. Two Slit experiment with electrons. Probability. Wave amplitude and wave functions. Uncertainty principle.

Quantum Mechanics

Basic postulates and formalism : Schrodinger equation, wave function, eigenvalues, probabilstic interpretation, conditions for physical acceptability of wave functions. Free particle. Time independent Schrodinger equation, stationary states. Particle in one dimensional box, quantization of energy. Tanck-Hertz experiment.

Unit II

Scattering problem in one dimension : Rèflection and transmission by a finit potential step. Stationary solutions, Attractive and repulsive potential barriers.Gamow theory of alpha decay. Quantum phenomenon of tunnelling. tunonel diode-qualitative discription. Spectrum for a square well. (Mention upper bound-no calculation).

Bound state problems : General features of a bound particle system . One dimensional simple harmonic oscillator. Particle in a spherically symmetric potential rigid rotator. Orbital angular momentum and azimuthal quantum numbers and space quantization. Physical significance. Radial solutions and principal quantum number. Hycrogen atom.

Unit III

Atoms in electric and magnetic fields : Electron spin. Stern-Gerlach experiment. Orbital angular momentum, magnetic dipole moment and energy in magnetic field from classical viewpoint. Zeeman effect. Spin-orbit coupling. Fine structure. Total angular momentum.

Many-electron atoms : Pauli exclusion principle. Many particles in one dimensional box. Symmetric and anti-symmetric wave functions. Atomic shell model and periodic table. Spectral notations for atomic states. Vector model. LS and JJ coupling. Doublet structure of alkali spectra. Empirical evidence of multiplets. Selection rules.

Unit IV : Nucleus

Properties : Mass, size, angular momentum, constituents, binding energy, stability.

Models : Liquid drop model. Mass formula. Shell model. Nuclear forces.

Radioactivity : Law of radioactive decay. Theory of successive radioactive transformations. Radioactive series (mention the series-diagram not needed)

Paper XIII : Mathematics II

Analysis

Sequences and series of functions of real variable. Pointwise and uniform convergence. Weierstrass M-test. Uniform convergence and continuity. Uniform convergence and differentiation. Uniform convergence and integration. Weierstrass approximation theorem. Power series and their convergence and uniform convergence. Definition of exponential, logarithmic and trigonometric functions by means of power series.

Improper integrals and their convergence. Comparison, Abel's and Dirichlet's tests. Beta and Gamma functions and their properties. Differentiation under the sign of integration.

Statistics

Probability : Classical, relative frequency and axiomatic approaches to probability. Theorems of total and compound probability. Conditional probability. Independent events. Bayes theorem. Random variables. Discrete and continuous random variables. Distribution function. Expectation of a random variable. Moments, moment generating function and probability generating function.

Discrete and continuous distribution : Binomial, Poisson, geometric, normal and exponential distributions, bivariate distribution, conditional distribution and marginal distribution. Correlation and regression for two variables only. Weak law of large numbers. Central limit theorem for independent and identically distributed random variables.

Statistical inference : definitions of random sample, parameter and statistic. Concept of sampling distribution and standard error. Sampling distribution of mean variance of random sample from a normal population. Tests of significance based on t, F and chi-square distributions.

Paper XIV : Computer Fundamentals and Programming

Unit I

Basic components of computer system, their function and inter-relation, types of computer systems.

Brief idea of data storage and input/output devices. Hexadecimal number system and arithmetic.

Microprocessor architecture and operations (Intel 8085/8086)

Basic concepts, pin-out, functional block diagram, memory, memory organization and addressing, memory interfacing, memory map, ALU, registers, bus, timing and control circuitry, interrupts, input/output, instruction cycle (timing diagram). Microprocessor programming : algorithm and flowcharts, assembly language, 8085 instruction set and format; data transfer, arithmetic, logical and control operations, RIM and SIM. Addressing modes (register, immediate, direct and indirect). Simple programming exercises (addition and multiplication, both 8 and 16 bit etc.)

Unit II : Problem solving using Pascal

Algorithms and flowcharts, structured programming. Fundamentals of Pascal : data types, constants and variables, expressions and statements, I/O commands, control statements, unconditional/conditional

looping, arrays (vectors and matrices), sub-programs (functions and procedures). Programming exercises based on the above—roots of a quadratic equation, least square fitting of data, sorting of numbers, prime numbers, sum and average, largest of n numbers, sorting a list in ascending/descending order, manipulations of tables (sum, product, inverse of matrices), generation of random numbers, factorials etc. Basic idea of records, files, sets and pointers.

Unit III : Errors and Iterative Methods

Truncation and round-off errors, floating point computation, overflow and underflow, single and double precision arithmetic. Iterative process, solution of non-linear equations : bisection, secant and Newton-Raphson methods. Comparison and error estimation. Program for finding zeros of a given function.

Solution of simultaneous linear equations : Gauss elimination and iterative (Gauss-Seidel) method. Computation of eigenvalues and eigenvectors of matrices using iterative process. Program for finding solution of a given system of three coupled linear equations.

Unit IV : Numerical Differential and Integral Calculus

Interpolation (Newton forward and backward formulas). Program for (a) interpolating data points and (b) first and second derivative of a given function/data.

Integration : General quadrature formula, trapezoidal and Simpson's rule. Gauss quadrature formulas : Gauss-Hermite, Gauss-Legendre. Program for integrating a given function using Simpson and Gauss-Legendre methods.

Solution of ordinary differential equations : Euler method and Runge-Kutta method of second order with error estimation. Idea of predictor-corrector method. Program for solving initial value problem for a first order differential equation using Runge-Kutta method.

Paper XV : Physics Laboratory II

Unit I : Familiarisation with Devices

1. Measurement of focal length of a lens; combination of lenses. Familiarisation with eye-pieces.
2. Familiarisation with spectrometer : Schuster's focussing; determination of angle of prism.
3. Familiarisation with ballistic galvanometer : determination of charge sensitivity, current sensitivity, time period, logarithmic decrement and critical damping resistance.
4. Investigation of factors which affect induced voltages in a coil using a CRO.
5. Investigation of factors which determine secondary emf and current in coupled coils.

Unit II : Optics

1. Experiments on prism – Resolving power/Dispersive power/ Determination of wavelength/Cauchy's constants.
2. Experiments on grating – Resolving power/Dispersive power/ Determination of wavelength.
3. Determination of wavelength using Fresnel's biprism.
4. Determination of wavelength using Newton's rings.
5. Determination of wavelength using Michelson's interferometer.
6. Measurement of small thickness using interference or diffraction.
7. Measurement of refractive index of transparent and opaque liquids using total internal reflection.
8. Measurement of intensity using photosensor and laser in diffraction patterns of single and double slits.

Unit III : Measurement of High Resistance and Charge

1. Determination of dielectric constant of a dielectric placed inside

a parallel plate capacitor using a B.G.

2. Measurement of charge by determination of time of impact.
3. Measurement of high resistance by method of leakage.

Unit IV : Measurement of Self Inductance and Mutual Inductance

1. Using absolute method.
2. Using A.C. bridge.

Unit V : Measurement of Temperature

1. Determination of heat conductivity of a good conductor by Angstrom method/Searle's method.
2. Determination of heat conductivity of a bad conductor by Lee's method. (Use of heating elements in preference to steam recommended.)

Paper XVI : Digital Electronics, Microprocessor and Computer Laboratory

Unit I : Combinational logic

1. Verification and design of AND, OR, NOT and XOR gates using NAND gates.
2. To design a combinational logic system for a specified truth table.
3. To convert a boolean expression into a logic gate circuit and assemble it using logic gate ICs.
4. To minimise a given logic circuit.
5. To study TTL ICs (binary decoder, 7-segment decoder, Schmitt trigger).
6. To design a seven-segment display driver.

Unit II : Arithmetic and Logic Units (ALU)
(Building of basic ingredients of ALU)

1. Half adder, full adder and 4-bit binary adder.

2. Half subtractor, full subtractor, adder-subtractor using full adder I.C.

Unit III : Flip-Flops, Counters and Shift Registers

1. To build flip-flop circuits using elementary gates (RS, clocked RS, D-type, JK flip-flop).
2. To build a 4-bit counter using D-type/JK flip-flop.
3. To make a shift register from D-type flip-flop.
4. Serial and parallel shifting of data.

Unit IV : Analog/Digital Conversion

1. To design an analog to digital converter of given specifications.
2. To design a digital to analog converter of given specifications.

Unit V : Use of Microprocessor Kit and Elements of assembly language

1. Use of hardware.
2. Addition and subtraction of numbers using direct and indirect addressing modes.
3. Multiplication by repeated addition.
4. Division by repeated subtraction.
5. Handling of 16-bit numbers.
6. Use of CALL and RETURN instruction.
7. Block data handling.
8. Other exercises (e.g. parity check etc.)

Unit VI : Elements of Pascal Programming

1 To evaluate a polynomial (e.g. converting Fahrenheit to Celsius, area of a circle, volume of sphere etc.)

2. To find roots of a quadratic equation (real and distinct, real and repeated and imaginary)

3. To find sum and average of a list of numbers, both with and without the use of arrays.
4. To calculate powers of a number
5. (i) To locate a number in a given list (linear search)
   (ii) To check whether a given name is in a list
6. (i) To find the largest of three numbers
   (ii) To find the largest number in a given list of numbers
7. (i) To check whether a given number is a prime number
   (ii) To calculate the first 100 prime numbers
8. To rearrange a list of numbers in ascending and descending order
9. (i) To calculate factorial of a number
   (ii) To calculate the first factorials.
10. Manipulation of matrices
    (i) Addition, subtraction and multiplication
    (ii) Trace of a matrix
    (iii) Sum of elements of a row and a column
11. Solution of simultaneous equations.
12. Programming exercises based on numerical methods.

B.Sc. (H) Part III (Third Year)

Paper XVII : Mathematical Physics III

Unit I (A) : Linear Vector Spaces and Matrices

Introduction to groups, rings and fields.

Vector spaces and subspaces. Linear independence – basis and dimensions. Linear transformations. Algebra of linear transformations. Non-singular transformations. Isomorphism. Representation of linear transformations by matrices.

Unit II

Matrix algebra: Addition and multiplication. Null and unit matrices. Singular and non-singular matrices. Inverse of a matrix. Eigenvalues and eigenvectors. Diagonalisation. Solution of coupled linear ordinary differential equations.

Unit I (B)

Special matrices: Hermitian and skew-Hermitian, symmetric and antisymmetric, orthogonal and unitary matrices. Similarity transformations and bilinear and quadratic forms. Trace of a matrix. Cayley-Hamilton theorem. Function of a matrix.

Metric spaces. Inner product and metric concept.

Unit III : Cartesian Tensors

Transformation of co-ordinates. Tensorial character of physical quantities. Symmetric and antisymmetric tensors. Contraction and differentiation. Pseudotensors. Kronecker and alternating tensors. Higher order alternating tensors using determinants. Stress and strain tensor. Elasticity tensor. Moment of inertia tensor.

Unit IV : Integral Transforms

Step function and Diract delta function.

Fourier transform: Fourier integral theorem. Sine and cosine transforms. Convolution theorem. Solution of one-dimensional diffusion and wave equations. Heat flow in an infinite and semi-infinite rod.

Laplace transform: Transform of elementary functions, derivatives and integrals. Unit step function. Periodic functions. Translation, substitution and convolution theorem. Inverse transform (Bromwich integral). Solution of first and second order ordinary differential equations with constant coefficients and simultaneous first order ordinary differential equations. Solution of partial differential equations.

Evaluation of integrals using transforms.

Paper XVIII : Electromagnetic Theory

Unit I

Maxwell equations. Displacement current. Vector and scalar potentials. Gauge transformations : Lorentz and Coulomb gauge. Boundary conditions at interface between different media. Wave equations. Plane waves in dielectric media.

Poynting theorem and Poynting vector. Energy density. Physical concept of electromagnetic (e.m.) field momentum density and e.m. field angular momentum density.

Unit II

Reflection and refraction of a plane wave at a plane interface between dielectrics. Fresnel formulae. Total internal reflection. Brewster's angle. Waves in conducting media. Metallic reflection (normal incidence). Skin depth.

Maxwell's equations in microscopic media (plasma). Characteristic plasma frequency. Refractive index. Conductivity of an ionized gas. Propagation of e.m. waves in ionosphere.

Unit III

Polarization of e.m. waves. Description of linear, circular and elliptical polarization.

Propagation of e.m. waves in anisotropic media. Symmetric nature of dielectric tensor. Fresnel's formula. Light propagation in uniaxial crystal. Double refraction. Nicol prism. Production of circularly and elliptically polarized light. Babinet compensator. Analysis of polarized light.

Unit IV

Wave guides. Coaxial transmission line. Modes in rectangular wave guide. Energy flow and attenuation in wave guides. Rectangular resonant cavities.

Planar optical wave guides. Planar dielectric wave guide, condition of continuity at interface, phase shift on total reflection, eigenvalue equations, phase and group velocity of the guided waves, field energy and power transmission. Optical fibre—numerical aperture, step index and graded index (definitions only). Single mode and multiple mode fibres (concept and definition only).

Paper XIX : Statistical Physics

Unit I : Classical Statistics

Entropy and thermodynamic probability. Maxwell-Boltzmann distribution law. Partition function. Thermodynamic functions of finite number of energy levels. Negative temperature. Thermodynamic functions of an ideal gas. Classical entropy expression, Gibbs paradox. Law of equipartition of energy—applications to specific heat and its limitations.

Unit II : Classical Theory of Radiation

Properties of thermal radiation, Kirchhoff's law, Stefan-Boltzmann law and Wien's displacement law. Saha's ionization formula.

Quantum Theory of Radiation

Planck's law of black-body radiation. Deduction of Wien's radiation formula, Rayleigh-Jeans law, Stefan-Boltzmann law and Wien's displacement law from Planck's law.

Laser : working principle, thermal equilibrium of radiation, principle of detailed balance, Einstein's A and B coefficients, population inversion. Two-level and three-level systems.

Unit III : Bose-Einstein Statistics

B-E distribution law. Thermodynamic functions of an ideal weakly degenerate gas. Strongly degenerate Bose gas, Bose-Einstein condensation, properties of liquid He (qualitative description). Radiation as photon gas, Bose's derivation of Planck's law, thermodynamic functions of photon gas.

Specific heat of hydrogen : quantization of rotational and vibrational motion, ortho - and para-hydrogen.

Unit IV : Fermi-Diract Statistics

Fermi-Dirac distribution law, Fermi energy. Thermodynamic functions of an ideal weakly degenerate Fermi gas. Strongly degenerate Fermi gas. Electron gas in a metal, specific heat of metals, Richardson's equation of thermionic emission. Relatives fermi gas. White dwarf stars. Chandrasekhar mass limit.

Third law of thermodynamics. Absolute definition of entropy. Consequences of third law, unattainability of absolute zero.

Paper XX : Physics of Materials

Unit I : Crystal Structure

Amorphous and crystalline materials.

Lattice translation vectors. Lattice with a basis – central and non-central elements. Unit cell, reciprocal lattice. Types of lattices. Crystal diffraction : Bragg's law, diffraction of X-rays, atoms and geometrical structure factor.

X-ray diffraction methods – measurement of lattice parameter for cubic lattices.

Unit II : Elementary Lattice Dynamics

Lattice vibrations. Linear monoatomic and diatomic chains. Acoustical and optical phonons. Qualitative description of the phonon spectrum in solid. Brillouin zones. Einstein and Debye theories of specific heat of solids. T^3 law.

Magnetic Properties of Matter

Response of substances of magnetic field. Dia-, para- and ferri- and ferromagnetic materials. Classical Langevin theory of dia – and paramagnetic domains. Quantum mechanical treatment of paramagnetism. Curie's law, Weiss's theory of ferromagnetism and

ferromagnetic domains and discussion of B-H hysteresis. Qualitative discussion of ferrimagnets and ferrites

Unit III : Dielectric Properties of Materials

Polarization. Local electric field at an atom. Depolarization field. Lorentz fields of dipoles inside a cavity.

Dielectric constant and polarizability : Electric susceptibility, polarizability, Clausius-Mosotti equation. Classical theory of electronic polarizability. Normal and anomalous dispersion. Cauchy and Sellmeier relations. Orientational polarizability and Langevin-Debye equation. Complex dielectric constant, dielectric constant and loss. Qualitative discussion of ferroelectric properties of materials and P-E hysteresis loop.

Unit IV : Electrical Properties of Materials

Qualitative description of free electron theory and its inadequacies with reference to Hall effect and specific heat of electrons in a metal.

Elementary band theory—Bloch theorem, Kronig-Penney model, effective mass of electron, concept of hole. Band gaps, difference between conductors, semiconductors and insulators, intrinsic and extrinsic semiconductors, p- and n-type semiconductors, law of mass action, conductivity in semiconductors, mobility of carriers (lattice & impurity scattering—qualitative discussion only), Hall effect in semiconductors (qualitative).

Superconductivity :

Experimental properties, Meissner effect. Type I and type II superconductors, London's equation and penetration depth.

Paper XXI : Electronics Devices : Physics and Applications

Unit I

Mesh analysis for d.c. and a.c. circuits : Nodal analysis, duality in networks, T Equivalent of a four terminal network. Thevenin and Norton

theorems. Maximum power transfer, superposition and reciprocity theorems. Z, Y, H parameters.

Basic semiconductor physics – p and n type semiconductors, energy level diagram, conductivity and mobility, pn junction fabrication (simple idea). Barrier formation in pn junction diode, current flow mechanism in forward and reverse biased diode (recombination, drift and saturation of drift velocity). Derivation of mathematical equations for barrier potential, barrier width and current for step junction.

Unit IIA

Single pn junction devices (physical explanation, current voltage characteristics and one or two applications). Two-terminal devices – rectifier diode, Zener diode, photo diode, LED, solar cell and varactor diode. Three-terminal devices – junction field effect transistor (FET), unijunction transistor (UJT) and their equivalent circuits.

Two-junction devices – p-n-p and n-p-n transistors, physical mechanism of current flow, active, cutoff and saturation regions. Transistor in active region and equivalent circuit.

Unit III

Amplifiers – Only bipolar junction transistor, CB, CE and CC configurations. Single stage CE amplifier (biasing and stabilization circuits, Q-point, equivalent circuit, input impedance, output impedance, voltage and current gain). Class A, B, C amplifiers (definitions). RC coupled amplifiers (frequency response, Bode plot, amplitude and phase). Class B push-pull amplifier.

Feedback in amplifiers – Voltage feedback and current feedback. Effect of negative voltage series feedback on input impedance, output impedance and gain, stability, distortion and noise.

Unit IV

Oscillators – Barkhausen criterion. Colpitts, phase shift and crystal oscillators.

Multivibrators and sweep circuits – Basic circuits of astable, bistable and monostable multivibrators. Details of astable multivibrators (derivation of time period). Sweep circuit using transistor as a switch and UJT (derivation of time period).

Unit IIB

Modulation and detection – Basic concepts of amplitude, frequency and phase modulations and demodulation. Detailed circuit of CE amplitude modulator and diode detector.

Paper XXII (Option 1) : Modern Chemistry

Quantum Chemistry

A review of Schrodinger equation, quantum mechanical operators (e.g. Hamiltonian operator). Solution of Schrodinger equation for single particle system. Electron spin. Pauli exclusion principle.

Quantum mechanics of polyelectronic systems (atoms and molecules). The helium atom. Self-consistent field method (qualitative account). The variation theorem – its statement and use. Chemical bonding. Valence Bond and Molecular Orbital approaches. The LCAO treatment of H_2^+ and H_2 molecules. Valence bond treatment of H_2.

Bonding in heteroatomic diatomic molecules (e.g. HF), triatomic molecules (BeH_2, H_2O), polyatomics (e.g. NH_3), pi-electron theory (Huckel theory) for conjugated systems (e.g. butadiene).

Molecular Spectra

Electromagnetic radiation, quantisation of different forms of energies in molecules (translational, rotational, vibrational and electronic). Interaction of electromagnetic radiation with molecules; various types of spectra, Born-Oppenheimer approximation.

Rotational Spectra

Rigid rotator model, rotational spectra, intensity of spectral lines and determination of bond distance of diatomic molecules. Isotopic substitution.

Vibrational Spectra

Vibrational energies of diatomic molecules, zero-point energy. Evaluation of force constant and stiffness of the bond. Amplitude of diatomic molecular vibrations, anharmonicity, Morse potential. Dissociation energies. Concept of group frequencies.

Raman Spectra (Qualitative treatment)

Raman effect, rotational Raman spectra. Vibrational Raman spectra, Stokes and anti-Stokes lines and their intensity difference. Rule of mutual exclusion.

Electronic Spectra

Frank-Condon principle, electronic transitions. Singlet and triplet states. Fluorescence and phosphorescence. Dissociation and predissocation. Calculation of electronic transitions of polyenes using free electron model (particle in a box).

NMR: Principle, Larmor precession. Chemical shift and low resolution spectra and scales. Spin-spin coupling and high resolution spectra (interpretation of PMR spectra of A-X type organic molecules).

ESR: Principles, hyperfine structure, ESR of simple radicals (methyl radical, vanadyl ion).

Paper XXII (Option 2) : Biophysics

Intra–and intermolecular interactions: Forces responsible for molecular conformation, e.g. hydrogen bonds. Ionic interaction, van der Waals interaction, hydrophobic interaction, interaction between structural units.

Protein structure : Amino acids, peptide bond, primary, secondary, tertiary, quaternary structure of proteins. Principles of protein folding. Enzymes.

Nucleic acid structure : Purine and pyrimidine bases, sugar, nucleosides and nucleaotides. RNA structure. DNA–the genetic material. DNA structure and conformation, polymorphism, supercoiling of DNA,

linking, twisting and writhing (brief ideas). The phenomenon of cooperativity, helix-coil transitions in nucleic acids and proteins.

Biological membranes : Basic components of membrane structure, lipids, micelles and reverse micelles. Bilayers, liposomes, structural determinants of bilayer formation. Phase transitions in bio-membranes. Techniques to detect phase transitions, e.g. scanning calorimetry etc.

Elements of non-equilibrium thermodynamics, membrane transport, active and passive transport, coupling of transport processes, membrane potential. Basic ideas of cybernetics.

Other biological polymers -: Polysaccharides, associations formed among different macromolecular types, protein-lipid interaction, nucleoproteins.

Nonlinear dynamical processes : Nonlinear systems, critical points, stability, limit cycles, bifurcation theory, autocatalytic systems, Lotka-Volterra equation and its application in ecosystem analysis, oscillatory reactions in bioiogy.

Prebiotic evolution : Theories and models, Eigen's hypercycle. Kimura's ideas, nonlinearity and biological evolution.

Biological spectroscopy : Quantum physics of chemical bonding. Molecular orbitals. Absorption spectroscopy, infrared and Raman spectroscopy, fluorescence spectroscopy. Light scattering in biology, X-ray crystallography in biomolecular structure determination. NMR, ESR, CD-ORD.

Neurobiophysics : Biophysics of perception : Brain structure and function, neurones; excitation and transmission of impulse, information processing in brain. Fundamentals of sensory transduction systems in cells, mechanoreception, chemoreception, photoreception, electroreception. Geobiophysics.

Applications and current trends in biophysics : e.g. biomechanics, medical biophysics, various kinds of instrumentation. Biosensors, drug delivery, use of isotopes.

Paper XXII (Option 3) : Economics

I. Microeconomics

1. The theory of consumer behaviour :

   Utility function and demand function, substitution and income effects. The Slutsky equation, the theory of revealed preference, consumer surplus. The expenditure and the indirect utility functions.

2. The theory of the firm :

   The production function, constrained output maximisation and cost minimisation. Cost function. The short run and the long run.

3. Market structures :

   Perfect competition. Monopoly, monopolistic competition. Duopoly and oligopoly.

4. General equilibrium theory : The existence of equilibrium stability and uniqueness of the equilibrium.

5. Welfare economics :

   Pareto optimality and the efficiency of perfect competition, social welfare functions, utilitarianism and equity.

II. Macroeconomics

1. National income accounting :

   The concepts of Gross National Product. Net National Product and other macro aggregates. Real and nominal GNP.

2. The simple Keynesian model :

   Equilibrium level of income and output. The consumption function, saving and investment, the multiplier.

3. Money, interest and income :
   The product market and the money market equilibrium. The role of monetary and fiscal policy in macroeconomic management.

5. Macroeconomics in an open economy :

Trade and capital flows under fixed and flexible exchange rates. The monetary approach to the balance of payments. Devaluation.

III. Econometrics

1. Problems of estimation and inference in the two-variable linear regression model.
2. Multiple regression – estimation and interpretation tests and tests of the general linear hypothesis.
3. Violations of the classical assumptions : multicollinearity, serial correlation and heteroscedasticity.

Paper XXIII : Physics Laboratory III

Unit I : Measurement of Magnetic Field and Related Parameters

1. Measurement of field strength B and its variation in a solenoid (determination or dB/dx).
2. Determination of B-H curve using ballistic galvanometer.
3. Determination of magnetic susceptibility for liquids and solids.

Unit II : Polarisation

1. Polarisation of light by simple reflection (determination of variation of percentage reflection and degree of polarisation with angle of incidence).
2. Determination of specific rotation for cane sugar solution.
3. Study of elliptically polarised light.

Unit III : Determination of Fundamental Constants

1. Determination of Boltzmann constant by studying forward characteristics of a diode.
2. Determination of e/m by method of magnetic focussing or bar magnet.

3. Determination of Stefan's constant.

Unit IV : Measurements in Solid State Physics

1. Measurement of resistivity as a function of temperature for a Ge crystal using four probe method (from room temperature to 200 C) and determination of energy gap.
2. Determination of Hall coefficient of a given sample.
3. Determination of PE hysteresis of a ferroelectric crystal.
4. Measurement of magnetic susceptibility.

Unit V : Miscellaneous

1. Ultrasonic grating.
2. Determination of wavelength of H-alpha emission line of hydrogen atom.
3. Determination of absorption lines in the rotational spectrum of iodine vapour.

Paper XXIV : Physics Laboratory IV

Unit I : Power supply

1. To design a semiconductor power supply of given rating using half wave a full wave or bridge rectifier and investigate the effect of C-filter.
2. To investigate simple regulation and stabilization circuits using zener diodes and voltage regulator ICs.

Unit II : Transistor Applications

1. To study the various transistor biasing configurations.
2. To design of CE amplifier of a given gain (midgain) using voltage divider bias.
3. To design an oscillator of given specifications.
4. To study the characteristics of a FET and design a common source amplifier.