B.Sc. Part I

Paper-1 Mechanics and Special Relativity Theory

1.Mechanics:

Background of Vector Calculus, Concept of gradient, divergence and curl of line, surface and volume integral.

Frame of Reference, Galilean transformation, Galilean invariance, Inertial and Non-inertial frames, Pseudo forces, Rotating reference frame, Centrifugal force, Coriolis Force. Inertial and Gravitational mass, Principle of Equivalence.

System of particles, Centre of Mass, Linear momentum, Centre of mass frame, Rotational motion in two and three dimensions, Angular momentum, Moment of inertia tensor, Central forces, Conservative forces, Potential energy, Gravitational potential and field due to a uniform spherical shell and solid sphere, Conservation Laws.

2. Motion Under a Central Force:

Two-particle central force problem reduced mass, lab and Center of mass co-ordinate systems, Motion in an inverse square field, Kepler's laws.

3. Mechanics of Non-rigid Bodies:

Strain and stress in an isotropic homogeneous medium, Elastic moduli and relations between them, Torsion of cylinders, Bending of beams, Internal energy of a strained body.

4. Fluid Mechanics:

Ideal fluids, Equation of continuity, Streamline flow, Rotational and irrotational flows, Euler's equation of motion, Bernoulli's Theorem, Viscous fluids, Poiseuille's equation, Viscosity by rotating cylinder method.

5. Special Theory of Relativity:

Inference of Michelson-Morley Experiments. Postulates of special relativity, Lorentz transformations, Length contraction, Time dilation, Simultaneity in relativity theory, Addition of velocities, Relativistic dynamics, Variation of mass with velocity, mass-energy relation. Relativistic Doppler shift Aberration.

Paper-II Thermal Physics

1. Thermodynamics :

Thermodynamic systems, Macroscopic and Microscopic Variables, Thermodynamical Equilibrium, Thermodynamical state, Zeroth law of thermodynamics and concept of Temperature.

Heat and Work and their path-dependence, Thermal processes, First law of thermodynamics and internal energy, Joule's law, Applications of first law.

Carnot cycle, Carnot Engine and Refrigerator, Reversible and irreversible processes, Carnot's Theorem. Thermodynamical scale of temperature, Clausius-Clapeyron's equation, Specific heat of saturated vapour, Clausius theorem, Clausius inequality, Entropy, Calculation of entropy in various processes, Entropy and unavailable energy, Physical significance of entropy, Second Law of thermodynamics.

Conditions for natural changes, Thermodynamic potentials and Maxwell's equation, Applications of Maxwell's equations, Joule-Thomson effect, Inversion Temperature.

Change of phase, First and second order phase transitions, and Ehrenfest's equations.

2. Kinetic Theory of Gases :

Maxwell-Boltzmann Law of distribution of molecular velocities, Evaluation of r.m.s. Velocity and average and most probable speeds, Mean free path, Transport phenomenon.

3. Conduction of Heat :

Fourier equation for one-dimensional flow of heat and its steady-state solution, Periodic flow of heat (only sinusoidal heat current).

4. Radiation :

Radiation as electromagnetic waves, Emissive and Absorptive powers, Radiation in a hollow enclosure, Black-body radiation, Kirchoff's Law, Intensity and energy density, Pressure and energy density, Stefan-Boltzmann law, Solar constant and temperature of sun, Temperature of Non-black bodies, Distribution of energy in the spectrum of black body radiation, Adiabatic expansion of black-body radiation, Wein's distribution law, Wein's displacement law, Wein's formula, Rayleigh-Jean's law, Planck's law.

Paper-III Electrical Circuit and Basic Semiconductor Electronics:

1. Electrical Circuits :

Circuit parameters, R, L, and C, Kirchoff's Law for a loop and junction, Solutions by determinant and matrix method: application to T, π and bridge circuits, Norton and Thevenin's Theorem, Maximum power transfer Theorem.

Difference between steady state and transient, Growth and decay of current in an inductive circuit, Charging and discharging of a capacitor through a resistor and through inductor and resistor in series. Ballistic Galvanometer, Cs and Qs, Measurement of capacity and of high resistance by leakage method.

AC analysis (Vector treatment only): Complex impedance and phasor notations, Impedance and Admittance operators, vector diagram for voltage and current in LR, CR and LCR in series and parallel, Power consumed in the circuit, Series and parallel resonance, Q of a coil, Transformer – its equivalent circuit.

AC Bridges: Balance and sensitivity conditions for AC bridge, Measurement of L by Maxwell's bridge, Measurement of C by Schering's bridge.

2. Basic Semi-conductor Electronics :

Conduction in Solids: conductor, insulator and semi-conductor, insulator and semi-conductor, Electrons and holes as charge carriers, Intrinsic and extrinsic semi-conductors, Conductivity and mobility, Conduction by diffusion and drift.

P.N. Junction: Built-in-voltage and charge depletion region, Statement of diode equation and diode characteristics, Forward and reverse resistance, Zener diode: its characteristics. Filtering by RC and LC circuit. Regulation: voltage regulation using Zener diode.

BJT: NPN and PNP transistor action, characteristics in CB and CE configurations. Hybrid, alpha and beta parameters, their inter-relationships. Load line, Small signal hybrid equivalent circuit, CE amplifier, Middle frequency response, Practical amplifier circuit, Principles of feedback Barkhausen criteria for sustained oscillations. Qualitative discussion of collector tuned oscillator, Circuits of Hartley and Colpitts oscillator.

Modulation: Need for modulation, three types of modulation. Frequency spectrum and power in a.m. wave, A typical a.m. circuit. Linear diode detector.

C.R.O.: working of cathode ray tube, block diagram of CRO, typical applications of CRO.

B.Sc. Part II Syllabus

Paper-I Optics

Cardinal Points of coaxial optical systems. Simple problems on combination of thin lenses, Eyepieces, Aplantic points.

Nature of light, Elementary ideas of electromagnetic wave and photon theories of light. Complex representation of waves and its application (to be used in the theory of various phenomenona).

Conditions for observing interference, Degree of coherence and visibility of fringes, Production of interference fringes and determination of wavelength, Michelson interferometer and its uses, Colour of thin films, Newton's Rings. Theory of Multiple Reflections, FP Etalon.

Temporal and Spatial Coherence. Michelson Stellar interferometer. Stimulated emission, Basic ideas about laser emission, Ruby and He-Ne lasers as examples.

Fresnel's theory of diffraction, Half-period elements. Diffraction from circular obstacle and aperture (Elementary theory), Zone Plate, Cornu's Spiral, Fresnel diffraction by straight edge and single slit.

Fraunhofer's diffraction by single slit and double slit. Theory of plane grating, Width of principal maxima. Rayleigh's criterion of resolution, Resolving power of prism, grating and FP etalon. Limit of resolution for telescope. Concave grating (elementary theory), and its mountings.

Unpolarised, polarised and partially polarised lights. Polarisation by reflection, Double refraction by uni-axial crystals, Polaroids, Huygen's theory of double refraction. Half and quarter waveplates. Production of elliptically polarised light.

Babinet compensator, Analysis of elliptically polarised light by using a Nicol and a quarter wave plate, and by using Babinet compensator. Optical activity. Fresnel's theory of optical rotation, Specific rotation, Biquartz and Laurent's half-shade polarimeters.

Paper II Oscillation, Waves and Electromagnetism

1. **Oscillations:**
   Simple Harmonic Motion, Damped Motion, Steady Forced Oscillations. Resonance. Fourier Series Decomposition. Simple cases of square, Saw-tooth and Rectified Sinusoidal Waves.
2. **One-dimensional Wave-motion in Non-dispersive Media:**
   Wave Equation, Progressive Wave solution, Particle Velocity and Wave Velocity. Equations for Wave in fluids and on Strings. Specific Acoustic Impedance of fluids and Characteristic Impedance of strings. Energy density. Intensity of Energy Transfer. Reflection and transmission of plane Waves at a discontinuity, Standing Wave Solutions. Modes of Natural Oscillations. Energy Considerations.
3. **Ultrasonics:**
   Generation and detection. Measurement of velocity in Liquids, Applications.
4. **Electrostatics in Free Space:**
   Coulomb Law, Electric Field. Simple cases of charge distributions. Gauss Flux Law (Integral and Differential forms). Electric Dipole in Electrostatic Field. Irrotational Nature of Electrostatic Potential. Simple Cases of Charge Distributions.
5. **Electrostatics in Dielectrics :**
   Polarization. Polarization Charges. Field D. Gauss Flux Law (Integral and Differential forms) and simple Applications.Energy of Charge Distribution. Energy as an integral over the Field. Simple Problems (Parallel Plate Condenser, Uniformly charged spherical surface and volume.
6. **Electric Current:**

Current Density Vector. Equation of Continuity, Ohm and Joule's Laws (Integral and differential forms).

7. Magnetostatics:

Ampere's Law, Biot Savart's Law, Law of Force in Magnetic Field on Currents and charged particles. Magnetic Field due to a straight infinite wire. Magnetic Field due to circular loop and solenoid at axial points. Vector potential and its Evaluation for Uniform Magnetic Field and for Straight Infinite Wire. Divergence and Curl of B. Distant Field due to a Loop of Current. Magnetic Moment. Magnetic Materials and Magnetization. Magnetization Current Field H, Curl of H and Calculation of H.

8. Time Varying Fields:

Displacement Current, Curl H. Faraday's Law (Integral and Differential forms). Self and Mutual Inductances. Energy of Coupled Circuits and current distribution. $M \leq \sqrt{L1L2}$ Energy as an Integral over the Magnetic Field. Energy of Solenoid.

9. Electromagnetic Waves in Free-Space:

Maxwell Equations, Plane polarized Plane Wave solution. Characteristics of these Electromagnetic waves.

Paper III Atomic and Nuclear Physics

1. **Atomic Physics:**

   Bohr-Sommerfield Model (Historical developments), Bohr model and the spectra of hydrogenic atoms, Critical resonance and the Ionisation potentials. Frank-Hertz experiment. Characteristic and continuous X-rays, Moseley's law, Bragg's law.

   Space Quantization, Vector atom model and Quantum Numbers, Magnetic moment of the electrons and magneton, Larmor Precession, Electron Spin, Stern-Gerlach experiment, Qualitative concept of various quantum number of an electron, Pauli's exclusion principle and electronic configuration of atoms.

2. **Magnetic Properties of Materials :**

   Diamagnetism, Larmor's theory and diamagnetic susceptibility. Paramagnetism, Langevin's theory and Curie-Weiss Law, Qualitative discussion of Ferromagnetism and antiferromagnetism.

3. **Quantum Concepts:**

   Particle nature of radiation, Photoelectric effect and Compton effect. Wave nature of particles.

   De-Broglie Waves, Davisson-Germer experiment, Wave Packets, Phase velocity and group velocity, Heisenberg's Uncertainty Principle and applications, One dimensional Schrodinger's Wave Equation and concept of probabilities, amplitude, application to one-dimensional potential step and barrier, Quantum Mechanical Tunneling.

4. **Nuclear Physics:**

   Natural radioactivity, Laws of radioactive disintegration, radioactive series, Detection of radiation, GM Counter and Bubble Chamber, Scintillation Counter.

   Kinematics of nuclear reactions, artificial nuclear transmutation, discovery of neutron, radioactive tracers, transuranic elements.

   Cyclotron

   Constitution of nucleus, Binding energy, liquid drop model and the semiempirical mass formula, Elementary theory of α-decay, β-decay and discovery of neutrino Magic numbers and the shell model, exchange forces in nuclei and Yukawa theory (qualitative), Fission and fusion, Nuclear reactors (qualitative), Thermonuclear energy.

   Classification of Elementary Particles, Leptons, mesons and bayrons and their quantum numbers, Conservation Laws.

B.Sc. Part III Syllabus

Paper – I QUANTUM MECHANICS

Need of Quantum Mechanics, Schrodinger Equation and interpretation of wave function.

Observables and Operators, Hermitian operator, Parity operator, Commutation relations, Eigen values and eigen functions, orthonormality and completeness, Dirac Delta function.

Measurement in Quantum Mechanics, Non-Commutability, uncertainty, Expectation values, Ehrenfest's Theorem.

Separation of variables in Time-Dependent Schrodinger Equation. Density of states, One-dimensional Potential Barrier problems. Tunneling through square well potential.

One – dimensional Harmonic Oscillator, Hermite Polynomials, Zero-point energy, Correspondence with Classical theory.

Angular Momentum, Commutation Relations. Eigen Values and Eigen functions of $\hat{L}^2$, $\hat{L}_Z$ and ladder ($\hat{L}_+$, $\hat{L}_-$) operators.

Spherically symmetric potentials, Complete solution of the Hydrogen – Atom Problem, Hydrogen Spectrum.

Elementary concept of spin, Pauli Matrices and spin wave functions. Total angular momentum.

Time-independent, non-degenerate, first – order Perturbation Theory, Spin – Orbit coupling. Ground and excited states of Helium atom and exchange degeneracy.

Qualitative and Elementary Idea about Lamb Shift.

Identical Particles, Symmetric and Antisymmetric wave functions, Pauli's Exclusion Principle.

Paper – II STATISTICAL MECHANICS AND SOLID STATE PHYSICS

Statistical Mechanics:

Elementary concepts of Lagrangian and Hamiltonian, Hamilton equations of Motion, Microscopic and Macroscopic systems, Phase space representation, Division of phase space into cells, Liouville theorem and its consequences, Statistical ensembles, Equilibrium and fluctuations, Distribution probability, Equilibrium between two macroscopic systems in thermal diffusive and mechanical contacts, Postulates of quantum statistical mechanics, Entropy and probability, Entropy of a perfect gas using the concept of micro canonical ensemble, Gibbs Paradox, Partition functions, Thermodynamical functions, Calculations of entropy of perfect monoatomic gas using canonical and grand canonical ensemble. Principle of Equipartition of the energy, Maxwell's velocity distribution, Distribution function for two types of quantum statistics (Bose–Einstein and Fermi-Dirac): Simple applications (Black – body radiations, and Electronic specific heat).

Solid State Physics:

Crystalline amorphous and glassy state of solids, Lattices translation vector, Crystal lattices, Primitive lattice cell, Miller indices, interplaner spacing, Bravais lattices, Crystal structures of s. c., b. c. c., f. c. c., diamond and h. c. p.

Reciprocal Lattice: s. c., b. c. c., and f. c. c. lattices, Brillouin Diffraction conditions in reciprocal lattice, Bragg's law.

Interatomic forces and classification of solids: Inert gas solids, Vander Waals-London interaction, Repulsive interaction and equilibrium lattice constant, Compressibility and Bulk modulus, Lattice energy of ionic crystals. Madelung constant, Cohesive energy, Generalised Hooke's law, Elastic constants of cubic crystals, Vibrations of monoatomic linear chain, Dispersion relation, Density of modes, Group velocity, Vibrational spectrum of lattice with two atoms per primitive cell, acoustic and optical modes. Lattice specific heat, Einstein and Debye models.

Free electron theory: Free electron gas in one dimension: Energy levels and density of states, Fermi Energy, Electrical conductivity,Hall effect.

Band theory of solids: Energy Bands; Kronig – Penny model in one dimension, Energy gap, Number of state in a branch, Distinction between metal, semi-conductor and insulator. Intrinsic semi-conductors, Variation of Fermi level with temperature, Effective mass.

Paper – III BASIC DIGITAL ELECTRONICS AND PHOTONIC DEVICES

Review of characteristics of a semi-conductor diode: cut-in voltage, explanation of storage and transition capacitances.

BJ transistor as a switch, Analytic expression using Ebers-Moll model, saturation properties for normal, inverse and emitter follower mode and their comparisons. Switching speed of a diode, storage and transition time, switching speed of a BJT**.** Metal-semi-conductor junction, Schottky diode and transistor.

Field effect transistor, principle of operation, a practical FET structure, MOSFET, enhancement and depletion modes, their representations. The MOS switch.

Logic Circuits: AND, OR, NOR, NOT, NAND and Ex-OR operations, Truth tables, their representations, Venn diagrams.

Binary notation, Boolean algebra, Karnaugh mapping. The Resistance-transistor logic, RTL nor gates, pull-up resistors, fanout, I/O characteristics, noise margin, rise time, RTL Ex.- OR gate.

The diode-transistor gate, fan out, I/O characteristics. The transistor-transistor logic, comparison between TTL and DTL. The active pull-up, I/O characteristics.

Combinational logic circuits: Half-adder, full adder, parallel and series addition. Half and full subtractor. BCD adder.

Integrated circuits: Various techniques of fabrication, LSI and MSI, metal semi-conductor contact.

Photonic devices: Photoelectric effect in semi-conductors, photoresistors and photoconductors, visible light emitting diodes and displays, Photodiode, phototransistor, p-n junction solar cell and its characteristics.

Paper – IV ELECTROMAGNETIC THEORY, LASER, HOLOGRAPHY AND OPTICAL INSTRUMENTS

Electromagnetic Theory: Electrostatic potential due to a charge distribution, Multipoles and their interaction with electrostatic field, Solution of Laplace Equation by separation of variables in Cartesian Spherical and Polar Coordinates.

Poynting's Theorem, Conservation of energy and momentum for a system of charged particles and electromagnetic fields, Maxwell's stress tensor.

Plane wave solution of Maxwell's equations in source-free space and simple dielectrics.

Polarisation of electromagnetic waves. Plane wave propagation in metal and plasma.

Elementary theory of dispersion.

Boundary condition at a discontinuity, Fresnel's formula.Total internal reflection, Metallic reflection, and skin depth.

Laser: Stimulated and spontaneous emission. Einstein's coefficients, relative contribution of stimulated and spontaneous emissions, population inversion, Laser emission, characteristic of Laser light (including temporal), Amplification in an inverted medium, threshold condition for lasing.

Holography : Basic principles of Holography, Recording and Viewing of a hologram. Thick Hologram, Multiplex hologram, White light reflection holograms.

Optical Instruments: Introduction of multiple beam interferometry, Fabry-perot interferometer and etalon (resolving power and determination of wavelengths), Resolving power of Lumer Gehreck plate, Grating and prism spectrograph for visible, IR and UV regions.