PHYSICS

Unit 1 : Mathematical Methods

Vector fields: Orthogonal curvilinear co-ordinate systems – Expressions for gradient, divergence, curl and Laplacian- Linear vector spaces: Linear independence, basis, dimension, inner product – Schwartz inequality – Orthonormal basis –Gram – Schmidt orthogonalization process –Linear operators – Representation of vectors and operators in a basis – Matrix theory- Cayley-Hamilton theorem – Inverse of a matrix – Diagonalisation of matrices – Operational methods: Laplace transforms – Solution of linear differential equations with constant coefficients – Fourier integral –Fourier transforms- Convolution theorems – Applications – Complex variables: Analytic function – Cauchy-Riemann conditions –Singular points- Multivalued function and branch points – Cauchy's integral theorem and formula – Taylor's and Laurentz's expansions - Residue theorem and its applications.

Unit 2 : Classical Mechanics and Relativity

Lagrangian and Hamiltonian formulations – Newton's equations and conservation laws for a system of particles – D'Alembert's principle and Lagrange's equations of motion – Hamiltonian and Hamilton's equation of motion – Application: Two-body central force problem – Scattering by central potential, two particle scattering – Cross section in Lab system-Small oscillations- Transformation to normal coordinates and frequencies of normal modes- Mechanics of rigid bodies: Angular momentum and kinetic energy – Moment of inertia tensor – Euler angels – Euler's equation of motion – Torque free motion – Symmetric top – Wave motion – Phase velocity- Group velocity –Dispersion – Relativity: Special theory of relativity – Lorentz transformation – Addition of velocities – Mass- energy equivalence.

Unit 3: Quantum Theory and its Applications

Basic principles: Wave – particle duality –Heisenberg's uncertainty principle – Postulates of quantum mechanics- Interpretation of wave function – Schordinger's wave equation and its application to particle in a box- Harmonic oscillator- tunneling through a barrier – Motion in central field potential: Hydrogen atom –angular momentum and spherical harmonics – Addition of two angular momenta – Approximate methods: Time independent perturbation theory for non-degenerate case – application to anharmonic oscillator – time dependent perturbation theory – Fermi's golden rule- Scattering theory: Scattering amplitude – cross section – Born approximation – Partial wave analysis – Identical particles and spin – Symmetric and antisymmetric wave functions – Representation theory – Coordinate and momentum representations.

Unit 4: Electromagnetic Theory

Electrostatics – Laplace and Poisson equations – Boundary value problems –Magnetostatics – Ampere's theorem-Biot- Savart law – Electromagnetic induction – Maxwell's equations in free space and in linear isotropic media – Boundary conditions on the fields at interfaces- Scalar and vector potentials – Gauge invariance –Electromagnetic waves- Reflection, refraction, dispersion, interference, diffraction and polarization- Electrodynamics of a charged particle in electric and magnetic fields – Radiation from moving charges and from a dipole - Retarded potential.

Unit 5 : Thermodynamics and Statistical Mechanics

Laws of thermodynamics and their consequences – Thermodynamic potentials and Maxwell's relations – Chemical potential and phase equilibria – Phase space, microstates and macrostates- Partition function – Free energy and its connection with thermodynamic quantities – Classical and quantum statistics- Degenerate electron gas- Black body radiation and Planck's distribution law – Bose – Einstein condensation – Einstein and Debye models for lattice specific heat.

Unit 6 : Atomic and Molecular Physics

Quantum states of an electron in an atom – Hydrogen atom spectrum – Electron spin – Stern-Gerlach experiment – Spin - orbit coupling – Fine structure – Relativistic correction – Spectroscopic terms and selection rules- Hyperfine structure- Exchange symmetry of wave functions –Pauli's exclusion principle - Periodic table – Alkali-type spectra LS and JJ coupling – Zeeman, Paschen –Back and Stark effects – X-rays and Auger transitions- Compton effect – Principles of ESR, NMR - Molecular Physics: Covalent, ionic and Vander Waal's interactions – Rotation/vibration spectra – Raman spectra – Selection rules- Nuclear spin and intensity alternation – Isotopic effects – Electronic states of diatomic molecules – Frank –Condon principle – Lasers: Spontaneous and stimulated emission – Optical pumping – Population inversion- Coherence (temporal and spatial) – Simple description of ammonia maser – co_2 and He-Ne lasers.

Unit 7 : Condensed Matter Physics

Crystal classes and systems – 2d and 3d lattices – Bonding in common crystal structures – Reciprocal lattice – Diffraction and structure factor - Elementary ideas about point defects and dislocations – Lattice vibrations – Phonons – Specific heat of solids – Free electron theory – Fermi statistics – Heat capacity – Electron motion in periodic potential – Energy bands in metals, insulators and semiconductors – Tight binding approximation – Impurity level in doped semiconductors – Electronic transport from classical kinetic theory – Electrical and thermal conductivities – Hall effect and thermoelectric power – transport in semiconductors – Dielectrics – Polarization mechanism – Clausius- Mossotti equation – Piezo, pyro and ferroelectricity – Dia and paramagnetism – Exchange interactions –

Magnetic ordering : ferro, antiferro and ferrimagnetism – Superconductivity: Basic phenomenology – Meissner effect – Type 1 and Type 2 superconductors – BCS pairing mechanism.

Unit 8 : Nuclear and Particle Physics

Basic nuclear properties – Size, shape, charge distribution, spin and parity – binding energy – empirical mass formula- liquid drop model – Nuclear forces- Elements of two – body problem – Charge independence and charge symmetry of nuclear forces- Evidence of nuclear shell structure – Single particle shell model – Its validity and limitations – Collective model – Interactions of charged particles and e.m.rays with matter – Basic principles of particle detectors – Ionization chamber – Proportional counter – GM counter – Scintillation and semiconductor detectors – Radioactive decays: Basic theoretical understanding – Nuclear reactions – Elementary ideas of reaction mechanism – Compound nucleus and direct reactions – Elementary ideas of fission and fusion – Particle Physics: Symmetries and Conservation laws –Classification of fundamental forces and elementary particles – Iso-spin – Strangeness- Gell-Mann Nishijima formula – Quark model – C.P.T.invariance in different interactions – Parity nonconservation in weak interaction.

Unit 9: Electronics

Physics of p-n junction – Diode as a circuit element – Clipping – Clamping – Rectification – Zener regulated power supply – Transistor as a circuit element - CC,CB and CE configuration – Transistor as a switch, OR, AND, NOT gates – Feedback amplifiers – Operational amplifiers and its applications – Inverting, non-inverting amplifier – Adder – Subtractor – Integrator – Differentiator – Waveform generator – Comparator – Schmidt trigger – Digital integrated circuits – NAND and NOR gates as building blocks – X- OR gate – Simple combinational circuits – Half and full adder – Flip-flop – Shift register – Counters – Basic principles of A/D and D/A converters- Simple applications of A/D and D/A converters – Microprocessor 8085: Architecture – Addressing modes – Instruction sets – Simple programming.

Unit 10 : Experimental Physics

Measurement of fundamental constants: e, h, c – Measurement of high and low resistances, L and C – Detection of X-rays, gamma rays, charged, particles, neutrons etc – Iionization chamber – proportional counter – GM counter – Scintillation detectors – Solid state detectors – Emission and absorption spectroscopy – Measurement of magnetic field. Hall effect – Magnetoresistance – X-ray and neutron diffraction – Vacuum techniques – Basic idea of conductance – Pumping speed etc - Pumps: Mechanical pump – Diffusion pump – Gauges: Thermocouple – Penning – Pirani – Hot cathode – Low temperature: cooling a sample over a range upto 4 K and measurement of temperature – Error analysis and hypothesis testing – Propagation of errors – Plotting of graph - Distributions – Least squares fitting - Criteria for goodness of fits – Chi square test.