PHYSICS-2014
(Syllabus for M.Sc. Entrance Examination)

Unit 1

Motion of a point particle: The position vector $\vec{r}$ (t) of a moving point particle and its Cartesian components. Velocity and acceleration as the vector derivatives, derivative of a planar vector of constant magnitude, radial and transverse component of velocity and acceleration for arbitrary planar motion, deduction of results for uniform circular motion – centripetal force.

Frames of reference: Inertial reference frames with examples, uniform rectilinear motion in an inertial frame- Galilean transformation equation. The Galilean principle of relativity. Motion in a non-inertial reference frame- uniformly accelerated rectilinear motion concept of fictitious force- illustration -plumb line accelerometer and freely falling lift. Qualitative discussion of centrifugal force, Coriolis force and earth as non –inertial frame.

Special theory of Relativity: The Michelson-Morley experiment. Basic postulates of theory of relativity. Lorentz transformation. The Lorentz-Fitzgerald contraction. Time dilation, velocity addition theorem, the relativity of simultaneity. Einstein's mass variation formula and the energy equation $E= mc^2$. The energy-momentum relation. The principle of equivalence.

Statistical ideas in physics: The Maxwell-Boltzmann. Bose-Einstein and Fermi-Dirac energy distribution formulae. A qualitative comparison of the three distribution formulae.

Unit 2

Conservation laws : Basic symmetries of nature, conservation of linear momentum for a system of two particles, rocket motion in a uniform gravitational field (single stage rocket equation -- with and without gravity), multi stage rockets, elastic and inelastic collisions, elastic head on collision, elastic oblique collision in lab frame, reduced mass.

Conservation of energy: Conservative and non-conservative forces with examples, conservation of energy in a conservative force field. Applications –1.Vertical oscillations of loaded light spiral spring and 2. Calculation of escape velocity in the gravitational field of the earth. Conditions for a geo-stationary satellite. Space programs in India.

Conservation of angular momentum : Relation between torque and angular momentum, areal velocity –derivation $\frac{dA}{dt} = \frac{1}{2} r^2 \dot{\theta}\ \hat{n}$, Central forces- physical insight into the nature of central forces, two body central force problem- Kepler's laws of planetary motion –derivation using Newton's law of gravitation.

Elementary particles: Particles and anti-particles. Classification of particles. Mention of the basic interactions in nature and conservation laws.

Unit 3

Rigid body dynamics : Moment of inertia and radius of gyration, kinetic energy of a rigid body, the angular momentum, Statement of the theorems of parallel and perpendicular axes, Calculation of the moment of inertia of rectangular and circular lamina. The theory of the compound pendulum.

Elasticity: Hooke's law. Moduli of elasticity. Relation between elastic constants. Poisson's ratio-limiting values, elastic potential energy, bending moment. Theory of the light cantilever. I-section girders. Torsion-calculation of couple per unit twist. The torsional pendulum. Static torsion, Searle's double bar experiment.

Surface Tension: Surface energy and definition of surface tension. Pressure inside curved liquid surface, examples. The drop-weight method, angle of contact and Quincke's method – theory.

Unit 4

Mean free path: Probability of a molecule having mean free path. Real gases, Andrews's isothermals, Van der Waals equations-expression for critical constants, calculation of mean velocity, most probable velocity and RMS velocity.

Equation of flow of heat through a solid bar. Determination of the thermal conductivity of bad conductor by Lee and Charlton method.

Planck's quantum theory of radiation, induced and spontaneous emission of radiation. Rayleigh-Jeans' law. Stefan's law and Wien's displacement law.

Thermodynamic coordinates, concept of heat, work and internal energy, the zeroth law of thermodynamics, indicator and phase diagrams, isothermals and adiabatic changes. First law of thermodynamics, second law of thermodynamics. The Carnot engine. Reversible and irreversible process. Refrigerators-principle of working and coefficient of performance. Thermodynamic scale of temperature and its identity with perfect gas scale, Clausius-Clapeyron first latent heat equation.

The concept of entropy, change of entropy in reversible and irreversible cycles. Entropy and non-available energy. Principle of increase of entropy. Entropy of ideal gas, T-S diagram, probability and entropy -Boltzmann relation, Concept of absolute zero and the third law of thermodynamics.

Unit 5

Waves in one dimension. Differential equation of wave motion. Relation between amplitude and intensity. Expression for velocity of progressive waves in a medium. Newton's formula, Laplace's correction. Longitudinal vibrations in a rod. Expression for frequency of vibration of a stretched string-harmonics. Kundt's tube experiment.

Theory of interference. Coherent sources. Fresnel's biprism. Lloyd's mirror. Thin films of uniform thickness. Newton's rings. Interference at a wedge. Michelson's interferometer.

Fresnel and Fraunhofer diffraction. Zone plate; Comparison with a convex lens. Fresnel diffraction at a straight edge. Fraunhofer diffraction at a single slit. Transmission grating-theory for the case of normal incidence.

Double refraction in uniaxial crystals; positive and negative crystals. Principal refractive indices. Huygen's constructions of O and E wave fronts in a uniaxial crystal. Retarding plates. Production and analysis of linearly, circularly and elliptically polarized lights. Optical activity, Fresnel's theory, rotatory polarization.

Unit 6

Mechanical force and electric pressure on a charged surface. The path traced by a charged particle in electric field. The attracted disc electrometer-construction, theory and applications.

Alternating current: R.M.S. values. Response of LR, CR and LCR circuits to sinusoidal voltages. Series and parallel resonance-half-power frequency, band-width and Q-factor. Power in electrical circuits-power factor. The maximum power transfer theorem.

High-pass and low-pass filters with LR and CR combinations. Expression for cut-off frequency. Band pass filters.

Self-inductance and mutual inductance; Calculation of the self-inductance of a solenoid. Anderson's bridge. Mutual inductance. Calculation of the mutual inductance of a pair of coils.

The thermocouple. Seebeck, Peltier and Thomson effects. The law of intermediate metals and the law of intermediate temperatures.

Electromagnetism: Scalar and vector fields. The physical significance of gradient, the divergence and curl. Statement of theorems of Gauss and Stokes. Concept of dipole. Ampere's circuital law. Current loop as a dipole. The torque on a dipole. Maxwell's field equations. Plane electromagnetic waves–Helmholtz equation, Transverse nature, intrinsic impedance, and wave equation for dielectric.

UNIT 7

Atomic spectra: Sommerfeld relativistic atomic model. Excitation and ionization potentials-Frank-Hertz experiment. Magnetic moment of an electron due to its orbital motion. Stern-Gerlach experiment. Quantum numbers and selection rules. Pauli's exclusion principle, Electronic configuration of atoms. Valence electron. Explanation of the normal Zeeman effect on the basis of the vector model of the atom. Expression for the Zeeman shift and experimental details.

Raman effect: Quantum theory; intensity and polarization of Raman lines. Applications.

Lasers: General principles. Three level laser, The He-Ne laser.

Wave mechanics: The concept of matter waves. The Davisson and Germer experiment. Heisenberg's uncertainty principle-the gamma ray microscope. Setting up the time-independent and time dependent Schrödinger equations. Born's interpretation of the wave function. Solution of the time-dependent Schrödinger equation for particle in one-dimensional box and its eigenvalues. Energy eigenvalues for the one-dimensional simple harmonic oscillator and the zero-point energy.

UNIT 8

The nucleus: The proton-neutron hypothesis. Nuclear forces and their characteristics.

Radioactive decay: Successive disintegration, Radioactive equilibrium radioactive series, range and energy of alpha-particle and their measurement. Theory of alpha-decay. Geiger-Nuttal law. Beta Decay - Pauli's neutrino hypothesis, K-electron capture, Internal conversion, Nuclear isomerism.

Nuclear detectors: G.M. counter, Bubble chamber. Principle of semiconductor detector.

Nuclear models: Liquid-drop model. Semi-empirical mass formula. Shell model and magic numbers.

Nuclear fission and fusion: Estimation of the fission energy on the basis of the liquid-drop model. The four-factor formula. Thermonuclear reactions-sources of stellar energy. The C-N cycle.

Compton effect- expression for Compton shift.

UNIT 9

Free electron theory of metals: Classical theory. Expression for electrical conductivity-Ohm's law. Weidman –Franz law, Statement of number of the available energy states between E and E+dE. Expression for the Fermi-energy. Hall effect and magneto resistance. Expression for Hall coefficient.

Band theory of solids: Concept of bands in solids, intrinsic and extrinsic semi-conductor. Expression for carrier concentration and electrical conductivity of intrinsic semiconductors. Expression for the energy-gap.

Dielectric materials and its properties, Methods of determining dielectric constant for solids and liquids.

Specific heat of solids: Dulong and Petit's law and its limitations. Einstein's theory of specific heat. Debye's theory of specific heat.

Superconductivity: Elementary ideas and experimental facts. Meissner effect. Critical magnetic field.

UNIT 10

Semiconductor Devices: P-N Junction diode. Bridge rectifier. Expression for ripple factor and efficiency. Zener diode and its use as a voltage regulator, LED-characteristics, Photo diode.

Transistors: Type and configuration: Transistor action and& characteristics for the CE configuration. DC and AC current gain. Operating point. DC load line and self-biasing (potential divider type) in transistors.

Amplifiers: Single stage CE amplifier. Expressions for voltage gain. Current gain, power gain. Input resistance and output resistance (No derivation), mention of CB and CC amplifiers and their special properties in comparison with the CE amplifier.

Oscillators: The feedback concept-positive and negative feedback. Mention of the Barkhausen criteria. Types of oscillator - Hartley oscillator.

Logic circuits: Construction of AND, OR gates using diodes and NOT logic gates using transistor. Symbols and truth table for NOR, NAND and XOR logic gates.