Physics Syllabus for PhD Admission test (Fall 2024)

Classical and Quantum Mechanics: Newton's laws; two body collisions - scattering in laboratory and center of mass frames; central force motion; special theory of relativity - Lorentz transformations, relativistic kinematics and mass–energy equivalence; Generalized coordinates, Lagrangian and Hamiltonian formulations, equations of motions and applications to simple problems. Postulates of quantum mechanics; uncertainty principle; Schrodinger equation; one-, two- and three-dimensional potential problems; particle in a box, transmission through one-dimensional potential barrier, harmonic oscillator, hydrogen atom.

Electromagnetism: Coulomb's law, Gauss's law, Multipole expansion, Electric fields in matter, Poisson's and Laplace's equation, Induced dipoles, Polarization, Electric displacement, Linear Dielectrics. The Lorentz force law, The Biot-Savart law, The divergence and curl of B, Magnetic vector potential, Magnetization, linear and nonlinear media. Time varying fields, Maxwell's equations and Conservation Laws; Faraday's law of induction, Energy in Magnetic field, Maxwell's Displacement current, Wave equations, continuity equations, Poynting's theorem, Electromagnetic Waves, The Wave Equation, EM Waves in Vacuum and matter, absorption and dispersion.

Mathematical Physics: Fourier series and Fourier transforms, their properties & applications. Definition and properties of Dirac delta function. The method of separation of variables for partial differential equation. Linear ordinary differential equations with constant coefficients and the Euler equation. The Frobenius method of series solution. Geometrical representation of complex numbers. Functions of complex variables. Properties of elementary trigonometric and hyperbolic functions of a complex variable. Vector spaces, Linear dependence. Basis subspace, Dimension, Linear functions, Linear operators, Inverse and rank of an operator. Eigenvalues and Eigenvectors. Matrix representation, Change of basis.

Solid State Physics: Crystal lattice – Primitive and Unit cells – Bravais lattices: Two Dimensional and Three Dimensional Bravais lattices – Miller Indices – different Structure of Crystals. X ray diffraction and reciprocal space lattice. Drude-Lorentz and Sommerfield Theory of Electrical Conductivity, and Widemann-Franz's Law, Hall Effect. Formation of bands, Periodic Potential of a solid, Wave function in a Periodic Lattice and Bloch Theorem, and Kronig Penny model. Different types of magnetic materials. Superconductivity - General properties.

Nuclear and Particle Physics: Nuclear Structure & Properties: Rutherford scattering. Nuclear mass, charge, size, shape, binding energy, spin and electric/magnetic moments; Unstable Nuclei: α, β & γ – decay. Geiger-Nuttal law. Elementary particles: Four basic interactions in nature and their relative strengths; Quantum Numbers: Mass, charge, spin, Isotopic spin, strangeness, hypercharge, Conservation laws. Classification of elementary particles: Hadrons and leptons, Baryons and mesons. Particle accelerators: Cyclotron, basic theory, Synchrotron, linear accelerator, Hadron colliders.

Photonics: Geometrical optics; interference, diffraction and polarization of light; lasers and amplifiers – stimulated emission and absorption, spontaneous emission, laser rate equations for two-, three-, and four-level systems, threshold gain, cavity design; semiconductor photonic devices – lasers, LEDs, photodetectors, solar cells.