DEPARTMENT OF PHYSICS

Syllabus

Specialization: Nuclear Physics, Condensed Matter Physics And Astrophysics

I. Classical Mechanics

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions- scattering in laboratory and Centre of mass frames. Rigid body dynamics-non-inertial frames and pseudo forces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Periodic motion.

II. ElectromagneticTheory

Electrostatics:Gauss'slawanditsapplications,LaplaceandPoissonequations. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell'sequations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials. Electromagnetic waves in free space. Dielectrics and conductors.

III. Quantum Mechanics

Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigen value problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Wave-function incoordinate and momentum representations. Heisenberg uncertainty principle. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment.

IV. Thermodynamic and Statistical Physics

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibria. Phase space, micro-and macro-states. Micro-canonical, canonical and grand-canonical ensembles. Classical and quantum statistics. Blackbody radiation and Planck's distribution law. First- and second-order phase transitions. Diamagnetism, paramagnetism, and ferromagnetism. Bose-Einstein condensation.

V. Atomic & Molecular Physics

Quantum states of an electron in an atom. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclearmagneticresonance.Lasers:spontaneousandstimulatedemission,EinsteinA&Bcoefficients.Opticalpumping,population inversion,rate equation. Modes of resonators and coherence length.

VI. Nuclear and Particle Physics

General properties of nuclei: Constituents of the nucleus, nuclear charge, mass and binding energy, nuclear radius, spin, parity and statistics, Coulomb energy of mirror nuclei, nuclear size from electron scattering experiments, magnetic dipole moment and electric quadrupole moment. Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Elementary ideas of alpha, beta and gamma decays and their selection rules, Liquid drop model semi-empirical mass formula, Nuclear shell model, Fission and Fusion. Nuclear reaction kinematics, Q-value equation, threshold energy and cross-section of nuclear reactions. Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.).

VII. Condensed Matter Physics

Fundamental types of lattices-two and three-dimensional lattice types, Reciprocal lattice, Bragg's Law, X-ray diffraction by crystals, Drude model of electrical and thermal conductivity. Hall effect, magnetoresistance and thermoelectric power. Magnetic properties of solids: Ferromagnetism, Paramagnetism, Diamagnetism, Ferrimagnetism and Anti-ferromagnetism. Electron motion in a periodic potential, Band theory of solids; metals, semiconductors and insulators; conductivity, mobility and effective mass: dielectric properties of solid; dielectric function, polarizability, Superconductivity: Type-I and Type II superconductors, Josephson junctions, Meissner effect, London equation, BCS Theory, flux quantization.

VIII. Astrophysics

The Sun, The Physical Processes in the solar system, The Terrestrial and the Giant Planets, Formation of Planetary Systems. The brightness of the stars, Color-magnitude diagrams (The HR diagrams), The luminosities of the stars, Angular radii of stars, Effective temperatures of stars, Masses and radii of stars: Binary stars, Search for Extrasolar Planets.

Spectral classification, Understanding stellar spectra, Population II stars, Stellar rotation, Stellar magnetic fields, Stars with peculiar spectra, Pulsating stars, Explosive stars, Interstellar absorption. The shape and size of our Galaxy, Interstellar extinction and reddening, Galactic coordinates, Galactic rotation, Stellar population, Inter Stellar Medium, The galactic magnetic field and cosmic rays. Expansion of the Universe, Gamma ray bursts.