# Paper-III: 3230
## SOLID STATE, NUCLEAR AND PARTICLE PHYSICS
### UNIT – I

Crystal geometry: crystal lattice, crystal planes and Miller indices, unit cells. Typical crystal structures, coordination number, packing fraction, symmetry elements, rotation, inversion and reflection, point groups and crystal classes, space groups.

Crystallography: Bloch functions, Bloch's theorem, diffraction of X-rays by a crystal lattice. Laue's formulation of X-ray diffraction, reciprocal lattice, Brillouin zones, Laue spots, rotating crystal and Debye-Scherrer methods

Introduction to nano particles, Definition, length scales, Importance of nanoscale and Technology.

### UNIT – II

Types of binding in solids: covalent binding and its origin, ionic binding, energy of binding, transition between covalent and ionic binding, metallic binding, Van der Waal's binding, hydrogen bond.

Conduction in metals : Drude's theory, DC conductivity, AC conductivity, plasma frequency, thermal conductivity of metals, Fermi-Dirac distribution, thermal properties of free-electron gas, Sommerfeld's theory of conduction in metals.

### UNIT – III

Conduction in semiconductor: Bands in solids, metals, insulators and semiconductors. Motion of free electrons on a chain of atoms, effective mass, electrons and holes, donor and acceptor impurities, donor impurity levels. Thermal excitation of carriers, electrical conductivity. Elementary ideas of Hall effect in metals and semiconductors and magnetoresistance.

Charge transport in semi-conductors: Ionization energy of impurity atoms, carrier concentration in doped semiconductors at high and low temperatures, control of conductivity of semiconductors by impurities and current flow in semi-conductors.

### UNIT – IV

Structure of nucleus: discovery of the nucleus, composition. Basic properties: charge, mass, size, spin, magnetic moment, electric quadrupole moment, binding energy, binding energy per nucleon and its observed variation with mass number of the nucleus. Coulomb energy, volume energy, surface energy, other corrections, explanation of the binding energy curve. Liquid drop model of the nucleus.

Nuclear forces: two-nucleon system, deuteron problem, binding energy, nuclear potential well, results of p-p and n-p scattering experiments, meson theory of nuclear forces e.g. Bartlett, Heisenberg, Majorana forces and potentials (No derivations)

Radioactivity: decay constant and half-life, spectra of emitters, Geiger-Nuttal law, Gamow's explanation. Beta decay: elementary Fermi's theory (No derivations). Antineutrino. Nuclear radiation, energy levels.

## UNIT – V

Detectors for charged particles: Ion chamber, Geiger counter, resolving time, cloud chamber.

Accelerators: Need for accelerators; cyclic accelerators, cyclotron, betatron, synchrocyclotron, variable energy cyclotron, phase stability. Brief introduction to Accelerator facilities in India.

Rutherford scattering formula, different types of nuclear reactions.

Artificial radioactivity: Nuclear fission, neutron reactions, Fermi and transuranic elements, chain reaction, criticality, moderators. Brief discussion of Reactor facilities in India

Discovery of cosmic rays: hard and soft components, discovery of muon, pion, heavy mesons and hyperons, mass and life time determination for muon and pion. Primary cosmic rays: Extensive air showers, solar modulation of primary cosmic rays, effect of earth's magnetic field on the cosmic ray trajectories.

Elementary particles: Discovery and important properties, Standard Model Strangeness, conservation of strangeness in particle interactions, quark hypothesis, high energy electron scattering from protons, basic interactions of quarks and leptons, interrelation between particle physics and cosmology. Big Bang theory (Brief study. No derivations) Brief introduction to Larger Hadron Collider "Big Bang" experiments at CERN

Recent developments in Physics including discussion of Nobel prizes in Physics (no questions to be set in the theory examination).

### Text Book

1. Nuclear Physics, Brijlal & Subramannian
2. Solid State Physics, Charles Kittel
3. Solid State Physics, Nuclear Physics and Particle Physics (In Hindi)
Kalra,Kakani and Mandot

### Reference books:

1  D.J. Griffiths: Introduction to Electrodynamics, Prentice Hall of India, 1989.
2  Reitz and Milford: Introduction to Electrodynamics, Addison-Wesley.
3  A.M. Portis: Electromagnetic Fields
4  J.B. Marion: Classical Electromagnetic radiation (Academic Press)

5   R.P. Feynmann, R.B. Leighton and M. Sands: The Feynmann lectures in physics, Vol. II (B.I. Publications).

6   B. Saraf et al. : Physics through experiments Vol. I – EMF, constant and varying, Vikas Publishing House.

7   D.R. Corson and P. Lorrain: Introduction to Electromagnetic fields and waves, Freeman-Taraporevala, Bombay, 1970.

8   E.C. Jordan and K.G. Balmain: Electromagnetic waves and radiating systems, 2nd Ed., Prentice Hall of India, New Delhi, 1971.