

GENERIC ELECTIVE (GE – 5): SOLID STATE PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
SOLID STATE PHYSICS GE – 5	4	3	1	0	Passed 12 th Class	NIL

LEARNING OBJECTIVES

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. It also communicates the importance of solid state physics in modern society. Emphasis should be given on the applications and uses of solids.

LEARNING OUTCOMES

On successful completion of the module students should be able to,

- Elucidate the concept of lattice, basis and symmetry in crystals. Learn to appreciate structure and symmetry of solids.
- Understand the elementary lattice dynamics and its influence on the properties of materials.
- Describe the main features of the physics of electrons in solids: origin of energy bands.
- Introduction to dia-, para-, ferri and ferro-magnetic properties of solids and their applications.
- Introduction to dielectric properties exhibited by solids and the concept of polarizability.
- Introduction to superconductivity.

SYLLABUS OF GE - 5

THEORY COMPONENT

UNIT – I

(21 Hours)

Review of Atomic Structure and bonding in solids: Classification of matter as solid, liquid and gas: salient features and properties, Qualitative discussion on Rutherford Model and Bohr model of atom, qualitative idea about discrete energy levels, wave-mechanical concept of the atom, forces between atoms, Ionic bonding, covalent bonding, metallic bonding, Hydrogen bonding and Van der Waals bonding, Properties of solids exhibiting different bonding.

Crystal structure: Periodicity in crystals: lattice points and space lattice, translational, rotational and reflection symmetry elements, lattice with a basis and crystal structure, unit cells and lattice parameters, Bravais lattices (in 2D and 3D) and crystal systems SC, BCC and FCC lattices, conventional and primitive unit cell, Wigner Seitz unit cell, amorphous and crystalline materials. Planes, Miller Indices, directions, density of atoms in different planes, inter-planar spacing, concept of Reciprocal Lattice, Brillouin zones (2 D lattice)

Atomic Packing and Imperfections in crystals: Packing of spheres in 2D and 3D, hexagonal close packing, packing fraction of SC, FCC, and BCC. Point defects and line defects and their consequences on the crystal properties

X-rays: Their generation and properties, Bragg's law and Laue Condition, single crystal method and powder diffraction method, simple problems related to X-Ray diffraction in SC, BCC, FCC

UNIT – II (4 Hours)

Elementary Lattice Dynamics: Lattice vibrations and phonons: linear monoatomic and diatomic chains, acoustic and optical phonons, qualitative description of the phonon spectrum in solids.

UNIT – III (10 Hours)

Electrical properties of metals: Free electron theory of metals (Drude model), its success and drawbacks, concept of relaxation time, collision time and mean free path, electrical conductivity, mobility and Ohm's law, thermal conductivity of metals, Wiedemann-Franz-Lorentz law.

Band Theory: The Kronig-Penney model (Qualitative idea), Band Gap, direct and indirect bandgap, concept of effective mass, Hall Effect (Metal and Semiconductor).

Optical properties of solids: (Qualitative) Absorption process, transmission and reflectance in solids. Discussion on photoconductivity, photoluminescence.

UNIT – IV (3 Hours)

Magnetic Properties of solids: Dia-, Para-, Ferri- and Ferro- magnetic Materials, definition in terms of susceptibility. Weiss's Theory of Ferromagnetism and Ferromagnetic Domains (qualitative treatment only), B-H curve, soft and hard material and their applications (discussion only) as cores in generators, transformers and electromagnets, energy loss in Hysteresis curve.

UNIT – V (4 Hours)

Dielectric Properties of solids: Dipole moment, polarization, local electric field in solids. Depolarization field, electric susceptibility, various sources of polarizability, piezo-, pyro- and ferroelectric materials and their applications (discussion only) as transducers, pickups, sensors, actuators, delay lines.

UNIT – VI (3 Hours)

Superconductivity: (Qualitative treatment only) Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, applications of superconductors. Discussion on applications in MRI, particle collider, power transmission, magnetic levitation etc.

References:

Essential Readings:

- 1) Solid State Physics, M. A. Wahab, 3rd Edition, Narosa Publications, 2015
- 2) Solid State Physics, S. O. Pillai, New Age International Publishers
- 3) Introduction to Solid State Physics, Charles Kittel, 8th Edition, Wiley India Pvt. Ltd, 2004
- 4) Elements of Solid State Physics, J. P. Srivastava, 2nd Edition, Prentice-Hall of India, 2006
- 5) Solid State Physics, A. J. Dekker, Macmillan Education, 2008

Additional Readings:

- 1) Introduction to Solids, Leonid V. Azaroff, Tata Mc-Graw Hill, 2004
- 2) Solid State Physics, N. W. Ashcroft and N. D. Mermin, Cengage Learning, 1976
- 3) Elementary Solid State Physics, M. Ali Omar, Pearson, 2006
- 4) Solid State Physics, Rita John, McGraw Hill, 2014
- 5) Superconductivity: A Very short Introduction – Stephen J Blundell – Audiobook
- 6) Crystallography applied to solid state physics, A. R. Verma and O. N. Srivastava, New Age International Publishers, 2005