

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 6: 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 PHYSICS DSC – 6	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Understanding of basic concepts of Physics

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.

LEARNING OUTCOMES

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

- Elucidate the concept of lattice, crystals and its planes
- Understand the elementary lattice dynamics and its influence on the properties of materials
- Understanding about origin of energy bands, and their influence on electronic behaviour
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

SYLLABUS OF PHYSICS DSC – 6

THEORY COMPONENT

Unit – I - Crystal Structure

(10 Hours)

Solids: amorphous and crystalline materials, lattice translation vectors, lattice with a basis, unit cell, types of lattices, Miller indices, reciprocal lattice, Ewald's construction (geometrical approach), Brillouin zones, diffraction of X-rays by crystals. Bragg's law

Unit – II - Elementary Lattice Dynamics

(6 Hours)

Lattice vibrations and phonons: linear monoatomic and diatomic chains, acoustical and optical phonons, Dulong and Petit's law, qualitative discussion of Einstein and Debye theories, T^3 law.

Unit – III - Elementary Band Theory**(5 Hours)**

Qualitative understanding of Kronig and Penny model (without derivation) and formation of bands in solids, concept of effective mass, Hall effect in semiconductor, Hall coefficient, application of Hall Effect, basic introduction to superconductivity

Unit – IV - Magnetic Properties of Matter**(6 Hours)**

dia-, para-, and ferro- magnetic materials, classical Langevin theory of dia- and para-magnetism (no quantum mechanical treatment), qualitative discussion about Weiss's theory of ferromagnetism and formation of ferromagnetic domains, B-H curve hysteresis and energy loss

Unit – V - Dielectric Properties of Materials**(3 Hours)**

Polarization, local electric field in solids, electric susceptibility, polarizability, Clausius Mosotti equation, qualitative discussion about ferroelectricity and PE hysteresis loop

References:**Essential Readings:**

- 1) Introduction to Solid State Physics, C. Kittel, 8th edition, 2004, Wiley India Pvt. Ltd.
- 2) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
- 3) Introduction to Solids, L. V. Azaroff, 2004, Tata Mc-Graw Hill
- 4) Solid State Physics, N. W. Ashcroft and N. D. Mermin, 1976, Cengage Learning
- 5) Solid State Physics, M. A. Wahab, 2011, Narosa Publications

Additional Readings:

- 1) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
- 2) Solid State Physics, R. John, 2014, McGraw Hill
- 3) Superconductivity: A very short introduction, S. J. Blundell, Audiobook

PRACTICAL COMPONENT**(15 Weeks with 4 hours of laboratory session per week)**

At least six experiments to be performed from the following list

- 1) Measurement of susceptibility of paramagnetic solution (Quinck's tube method)
- 2) To measure the magnetic susceptibility of solids
- 3) To determine the coupling coefficient of a piezoelectric crystal
- 4) To study the dielectric response of materials with frequency
- 5) To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique
- 6) To determine the refractive index of a dielectric layer using SPR technique
- 7) To study the PE Hysteresis loop of a ferroelectric crystal
- 8) To draw the BH curve of iron (Fe) using a Solenoid and determine the energy loss from hysteresis loop
- 9) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150° C) by four-probe method and determine its band gap
- 10) To determine the Hall coefficient of a semiconductor sample
- 11) Analysis of X-ray diffraction data in terms of unit cell parameters and estimation of particle size
- 12) Measurement of change in resistance of a semiconductor with magnetic field.

References for laboratory work:

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
- 2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
- 3) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
- 4) An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 2013, New Book Agency (P) Ltd.
- 5) Practical Physics, G. L. Squires, 4th edition, 2015
- 6) Practical Physics, C. L. Arora, 19th edition, 2015, S. Chand