DISCIPLINE SPECIFIC CORE COURSE – DSC - 11: 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 DSC – 11	**4**	**3**	**0**	**1**	Class XII Pass with PCM	Studied 'Thermal Physics, Electricity & Magnetism' and Mathematical Physics-I,II & III

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 the arrangement of its atomic and molecular constituents. The gained knowledge helps to solve problems in solid state physics using relevant mathematical tools. 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 symmetry operations
- Understand elementary lattice dynamics and its influence on the properties of materials
- Describe the 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
- Understand the basics of superconductivity
- 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 DSC - 11

THEORY COMPONENT

Unit – I - Crystal Structure **(10 Hours)**

Classification of solids as amorphous and crystalline materials, basic understanding of bonding in crystals, closed packed structure and packing fractions, lattice translation vectors, lattice with a basis, types of lattices, unit cell, symmetry elements, crystal planes and Miller indices, reciprocal lattice and Ewald's construction (geometrical), Brillouin Zones, Diffraction of X-rays: single crystal and powder method. Bragg's Law

Unit – II - Elementary band theory **(6 Hours)**

Brief discussion on free electron model, success and failure of free electron model, Kronig-Penney model, band gap, direct and indirect band gap, effective mass, concept of mobility, Hall effect (Semiconductor).

Unit – III - Elementary Lattice Dynamics (10 Hours)
Lattice Vibrations and Phonons: Linear monoatomic and diatomic chains, acoustic and optical phonons, Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law

Unit – IV - Magnetic Properties of Matter (9 Hours)
Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin Theory of dia– and para-magnetism, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains, Curie's law, B-H Curve, hysteresis and energy loss, soft and hard material

Unit – V - Dielectric Properties of Materials (7 Hours)
Polarization, local electric field in solids, depolarization field, electric susceptibility, polarizability, Clausius Mossotti equation, classical theory of electronic polarizability, AC electronic polarizability, normal and anomalous dispersion, complex dielectric constant, basic idea of ferroelectricity and PE Hysteresis loop.

Unit – VI – Superconductivity (3 Hours)
Experimental results, critical temperature, critical magnetic field, Meissner effect, Type I and type II superconductors

References:
Essential Readings:

1) Introduction to Solid State Physics, Charles 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, Leonid 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, H. Ibach and H. Luth, 2009, Springer

Additional Readings:

1) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
2) Solid State Physics, R. John, 2014, McGraw Hill
3) Solid State Physics, M. A. Wahab, 2011, Narosa Publications

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

- Sessions on the construction and use of specific measurement instruments and experimental apparatus used in the solid state physics laboratory, including necessary precautions.
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the laboratory.

At least four 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 study the dielectric constant of a material/s (solid/liquid) as a function of temperature and frequency.
4) To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique.
5) To determine the refractive index of a dielectric material using SPR technique.
6) To study the PE Hysteresis loop of a ferroelectric crystal.
7) To draw the BH curve of iron (Fe) using solenoid and determine the energy loss from hysteresis loop.
8) To measure the resistivity of a semiconductor (Ge) with temperature (up to 150^{o}C) by four-probe method and determine its band gap.
9) To determine the Hall coefficient of a semiconductor sample.
10) Analysis of X-ray diffraction data in terms of unit cell parameters and estimation of particle size.
11) To study magnetoresistance in 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) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal
3) Elements of Solid State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
4) Practical Physics, G. L. Squires, 4th edition, 2015, Cambridge University Press.
5) Practical Physics, C. L. Arora, 19th edition, 2015, S. Chand