Semester:V

Course Name: Condensed Matter Physics

Credits: 4 (Theory: 03, Lab: 01) Course Code - PHY050204

Total Lectures: **45 (Theory) (Total Marks 100: Internal-25+External-75)**

Course objectives:

- To provide the elementary idea about crystal structure, bonding and lattice dynamics in solids.
- To make the students understand the concepts of transport properties, dielectric properties, ferroelectric properties and magnetic properties in solids.
- To familiarise the students with nanomaterials, thin film, soft matter and superconductivity.

Course Outcome: *On successful completion of the course students will be able to acquire the basic knowledge of crystal structure, bonding in solids and elementary idea lattice dynamics of materials, dielectric, ferroelectric and magnetic properties of solids, the physics of electrons in solids, basic idea about nanomaterials, thin film and soft matter and understand the basic concept in superconductivity.*

Unit I: Crystal Structure and Bonding in solids (Lectures 09)

Amorphous, crystalline and polycrystalline materials, lattice translation vectors, unit cell, types of crystal lattice, Bravais Lattice, Miller Indices, inter planer spacing.

Ionic, covalent, metallic, van-der-waal and hydrogen bondings, cohesive energy of ionic crystal, Madelung constant.

Unit II: Elementary Lattice Dynamics (Lectures: 04)

Basic idea of lattice vibration and phonon. Dulong and Petit’s Law. Einstein and Debye theories of specific heat of solids, T^3 law.

Unit III: Dielectric and Ferroelectric Properties of Materials (Lectures 10)

Polarization. local electric field at an Atom, depolarization field, electric susceptibility, polarizability. Clausius Mosotti equation, classical theory of electric polarizability, normal and anomalous dispersion, Cauchy and Sellmeir relations, Langevin-Debye equation.

Piezoelectric effect, pyroelectric effect, ferroelectric effect, electrostrictive effect, Curie-Weiss Law.

Unit IV: Transport properties of materials (Lectures 09)

Free electron theory of metals, electrical and thermal conductivity of metals, Wiedemann-Franz law, drawback of classical theory and modification with quantum theory, preliminary idea of band theory, band gap, conductor, semiconductor (*p* and *n* type) and insulator, conductivity of semiconductor, mobility, measurement of conductivity (2-

probe & 4-probe resistivity measurement method), Hall Effect (Qualitative idea).

Unit V: Nanophysics and soft matter (Lectures 03)

Basic idea about nanomaterials, thin film physics and soft matter.

Unit VI: Magnetic Properties of Matter (Lectures 07)

Dia, para, ferri, ferro and anti ferromagnetic materials, classical Langevin Theory of dia and paramagnetism, Curie’s law, Weiss’ theory of ferromagnetic domains, discussion of B − H Curve, hysteresis and energy Loss.

Unit VII: Superconductivity (Lectures 03)

Basic idea of superconductivity, critical temperature, critical magnetic field, Meissner effect. Type I and type II Super- conductors, isotope effect.

Lab:

A minimum of four experiments to be done.

1. Indexing of powder X-Ray diffraction data of cubic crystalline materials and determination of lattice parameters including inter planner spacing (XRD data needs to arrange by the department).
2. Measurement of susceptibility of a paramagnetic solution (Quinck's Tube Method).
3. To measure the magnetic susceptibility of solids.
4. To determine the Coupling Coefficient of a piezoelectric crystal.
5. To measure the Dielectric Constant of a dielectric materials with frequency.
6. To study the *P-E* Hysteresis loop of a Ferroelectric Crystal.
7. To draw the B − H curve of Fe using Solenoid & determine energy loss from Hysteresis.
8. To measure the variation of resistivity of a semiconductor with temperature by four-probe method and to determine its band gap.
9. To determine the Hall coefficient of a semiconductor sample.

Suggested Books

1. *Introduction to Solid State Physics*, C Kittel
2. *Lattice Dynamics*, A K Ghatak and L S Kothari
3. *Solid State Physics*, A J Dekker.
4. *Introductory Solid State Physics*, H P Myers.
5. *Solid State Physics*, N W Ashcroft and N D Mermin
6. *Magnetism in solids*, D H Martin
7. *Physics of Magnetism*, S Chikazumi.
8. *Solid State Physics, S O Pillai*
9. *Introduction to Nanotechnology*, C. P. Poole, J. F. J. Owens