Condensed Matter Physics -I

Programme: M. Sc. **Year:** 1st **Semester:** 2nd

Course: Core course **Credits: 4** **Hours (LTP): 40+12+0**

Course overview:

Condensed matter physics is a branch of physics that deals with the physical properties of a large number of interacting particles. Such systems are omnipresent in our daily life. Examples include metallic utensils, semiconductors chip, LED screens and many more. Their studies are important for both scientific developments and for further progress of our daily life.

This course is designed for the first year M Sc. students to give an overview of introductory descriptions of condensed matter systems. Focus will be on giving exposer of various physical properties of different materials, their theoretical understanding and possible applications.

Prerequisites:

Basic Mathematical Physics and Thermodynamics.

Course Outcomes:

On completion of this course, the students will have the ability to:
CO1 : Understand symmetry based classification of condensed matter systems.
CO2 : Understand the basics of crystallography and the relation between crystal symmetry and macroscopic physical properties.
CO3 : Understand the phenomena of diffraction of waves by crystals.
CO4: Understand various kind of crystal bindings.
CO5 : Understand the basics of lattice dynamics and its consequences on various physical properties.
CO6: Understand various metallic behavior based on free electron model.
CO7: Understand the basics of semiconductors.

Following topics will be covered in this course:

Topics	**Lecture Hours**
UNIT – I Classification of condensed matter systems: Crystalline and Noncrystalline materials, Nanophase solids, Liquids, Liquid crystals and Glasses (symmetry based description).	**1**

UNIT – II Crystal symmetry and macroscopic physical properties: Bravais lattices, Primitive vectors, conventional unit cell, Wigner-Seitz cell, Symmetry operations; crystal systems, point groups, space groups and typical crystal structures. Their relation with various physical properties like pyroelectricity, ferroelectricity, determination of elastic constants.	**7**
UNIT – III Diffraction of waves by crystals: X-rays, neutrons and electrons scattering, Reciprocal Lattice, Bragg's law and Lau's interpretation, Atomic and geometric structure factor, Explanation of experimental methods on the basis of Ewald construction, Principles of diffraction techniques, the concept of Brillouin zones.	**6**
UNIT – IV Crystal binding: Concept of bonding, understanding of interaction potential energy, Ionic crystals – covalent and metallic binding. Van der Waals binding - rare gas crystals and binding energies.	**4**
UNIT-V Lattice dynamics: Classical Theory of lattice vibration under harmonic approximation, Monoatomic and Diatomic lattices. Born-von Karman method. Phonon frequencies and density of states. Dispersion curves, inelastic neutron scattering., Lattice specific heat. Thermal expansion. Thermal conductivity. Normal and Umklapp processes.	**8**
UNIT-VI Free electron theory of metals: Nearly free electron approximation, Bloch functions, Formation of energy bands, Gaps at Brillouin zone boundaries. Electron states and classification into insulators, conductors and semimetals. Effective mass and concept of holes. Fermi surface. Cyclotron resonance. thermal and electrical transport properties, Electronic specific heat, Hall effect.	**10**
UNIT-VII Semiconductors: Carrier statistics in intrinsic and extrinsic semiconductors. Electrical conduction in semiconductors.	**4**

Text Books

1. Charles Kittel, *Introduction to Solid State Physics*, Wiley, 5th Edition (1976).
2. N.W. Ashcroft and N.D. Mermin, *Solid State Physics*, Saunders College Publishing (1976).
3. M. Ali. Omar, *Elementary Solid State Physics*, Pearson (2009).

Reference Books

1. Manijeh Razeghi, *Fundamentals of Solid State Engineering*, 3rd Edition, Springer (2009)

2. A.J. Dekker, *Solid State Physics*, Prentice Hall, (1957).
3. J.S. Blakemore, *Solid State Physics*, 2nd Edition, Cambridge University Press. (1974).
4. Harald Ebach and Hans Luth, *Solid-State Physics*, Springer International Student Edition, Narosa Pub. House, (1991).
5. Steven H. Simon, *The Oxford Solid State Basics*, Oxford(2013).
6. John Singleton, *Band Theory and Electronic Properties of Solid*, The Oxford Master Series in Physics(2001).

7. Martin T. Dove, *Structure and Dynamics, An Atomic View of Materials*, Oxford Master Series in Physics(2001).