Condensed Matter Physics-II

Programme: M. Sc. **Year:** 2nd **Semester:** 3rd
Course: Core course **Credits:** 4 **Hours (LTP):** 40+12+0

Course Context and 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 final year M Sc. Students and is a continuation of previously taught course Condensed Matter Physics - I.

Prerequisites: Condensed Matter – I and Statistical Mechanics-I

Course Outcomes:

On completion of this course, the students will have the ability to:
CO1 : Understand theoretical descriptions of various optical properties of solids.
CO2 : Understand dielectric properties of materials.
CO3 : Understand the fundamentals of magnetic behavior of various materials.
CO4: Understand various kind of defects present in the solids and their consequences.
CO5 : Understand the basics of superconductors.

Course Topics

Topics	**Lecture Hours**
UNIT – I Optical properties of solids: General view of optical properties of solids, definition of absorption, transmission reflection coefficient. Classical theory of optical properties of solids, Quantum theory; Band to band absorption, Luminescence, excitons, polarons.	**8**
UNIT – II Dielectric properties of insulators: Introduction to dielectric materials, Internal electric field in a dielectric. Clausius-Mossotti and Lorentz-Lorenz equations. Electronic, ionic and orientational polarization, static dielectric constant of gasses and solids - Dielectric dispersion and loss, relaxation time, Debye equations, Cole-Cole distributions, Ferroelectrics: types and models of ferroelectric transition.	**8**
UNIT – III Magnetic properties of solids: Diamagnetic susceptibility. Classical and Quantum theory of paramagnetism, Pauli paramagnrtism. Transition metal ions and rare earth ions in solids. Crystal field effect and	**8**

orbital quenching. Ferromagnetic and anti-ferromagnetic ordering. Curie-Weiss theory, Heisenberg exchange interaction , Curie and Neel temperatures. Domain walls.	
UNIT – IV Defects in a crystal: Classification of defects**,** Point defects, vacancies, concept of statistical vacancies, Frenkel and Schottky defects. Colour centres, Formation enthalpies. Diffusion in solids , Fick's 1^{st} and 2^{nd} law of diffusion to understand doping of atoms in a solid solution. Extended defects: dislocations, models of screw and edge dislocations. Burgers vector.	**7**
UNIT-V Superconductivity: experimental and theoretical aspects, new materials and models. [Phenomenological description of superconductivity – occurrence of superconductivity, destruction of superconductivity by magnetic field, Meissner effect; Type-I and Type-II superconductors; superconductivity from thermodynamics perspective; heat capacity, entropy and isotope effect; outline of Landau theory, outlines of BCS theory, Flux quantization; a.c. and d.c. Josephson effect; high TC superconductors (information only).	**9**

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. Mark Fox, Optical Properties of Solids, 2^{nd} Edition, (Oxford Master Series in Physics).
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).