SOLID STATE PHYSICS

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Department of Physics
IISER Bhopal

TYPE OF COURSE : New | Core | UG/PG
COURSE DURATION : 8 Weeks (23-Aug' 21 - 15-Oct' 21)
EXAM DATE : 23 Oct 2021

INTENDED AUDIENCE : BSc third year, MSc first year

PREREQUISITES : One should have some idea of quantum mechanics, statistical mechanics, vector algebra & calculus, and simple geometry.

COURSE OUTLINE :

This course is designed to introduce the structure, electronic, and other fundamental properties of solids to the students. It is supposed to be the fundamental course on solid state physics, covering in details the representation of crystal structure, symmetries in solid, x-ray diffraction, bonding, transport properties, electronic structure, vibration of the lattice, outline of magnetism, and superconductivity. We will carefully develop the concepts in logical steps and solve problems, resulting in a concrete understanding of the topics. While a course covering these topics is mandatory in almost every university around the world for the Physics students, Chemistry and Electrical Engineering students interested in research of condensed matter physics may benefit from the course.

ABOUT INSTRUCTOR :
Dr. Nirmal Ganguli finished his masters and PhD from IIT Bombay, carrying out a significant part of the research work at IACS, Kolkata. He moved to University of Twente, the Netherlands in 2011 and subsequently to Max Planck Institute for Solid State Research, Germany in 2015 for postdoctoral research.

COURSE PLAN :

Week-1: Structure of solids, Symmetry, Bravais lattices, Unit cell, Miller indices, Simple crystal structure, Reciprocal lattice, Laue equations and Bragg's law, Brillouin Zones, Diffraction of x-rays, Atomic scattering and structure factors.

Week-2: Bonding in solids, van der Waals and Repulsive interactions, Lennard Jones potential, Cohesive energy and compressibility, Ionic crystals, Madelung constant, Covalent crystals, Metals, atomic and ionic radii.

Week-3: The Drude theory of metals: DC electrical conductivity of a metal; Hall effect and magnetoresistance; AC electrical conductivity of a metal and propagation of electromagnetic radiation in a metal; Thermal conductivity of a metal, The Sommerfeld theory of metals: Density of states; Fermi-Dirac distribution; Specific heat, thermal, and electrical conductivity of degenerate electron gases.

Week-4: Free electron theory, Kronig-Penney Model, Crystal lattices: Periodic potential, Band theory, Tight binding, Classification of metals, insulators and semiconductors, Symmetry of energy bands, Density of state, Fermi surface.

Week-5: Vibrations of one dimensional monoatomic and diatomic chain, Normal modes and Phonons, Phonon spectrum, Long wavelength acoustic phonons and elastic constants, specific heat capacity, Density of states, thermal expansion and conductivity, Phonons: Vibrational Properties, normal modes, acoustic and optical phonons.

Week-6: Dia-, Para-, and Ferromagnetism, origin of magnetism, Langevin's theory of paramagnetism, Weiss Molecular theory

Week-7: Superconductivity: Phenomenological description, BCS theory, thermodynamics, London equation, type-I and type-II superconductors, flux quantization, electron tunneling, Josephson effect.