PHY-413 Solid State Physics I

Credit Hours: 3-0

Pre-requisite: None

Course Objectives: It is an undergraduate core course, which aims to introduce condensed matter and solid-state physics to students.

Core Contents: Crystal Structure, reciprocal lattice and wave diffraction, phonons, thermal properties of materials, free electron fermi gas, energy bands, semiconductor crystals.

Detailed Course Contents: Crystal structure, periodic arrays of atoms, two and three dimensional monoatomic lattices, Index system for crystal planes, simple crystal structures, Lattices with bases and their classification by symmetries, direct imaging of atomic structures, non-ideal crystal structures, Diffraction of waves by crystals, scattered wave amplitude, Brillouin zones, Fourier analysis of the basis, crystal vibrations, vibrations of crystals with monoatomic basis, Two atoms per primitive basis, quantization of elastic waves, phonon momentum, inelastic scattering by phonons, Phonon heat capacity, Planck distribution, normal modes enumeration, density of states in one dimension, density of states in three dimensions, Debye model for density of states, Debye T3 law, Einstein model of the density of states, anharmonic crystal interactions, thermal conductivity, Free electrons fermi gas, energy levels in one dimension, effect of temperature on the Fermi-Dirac distribution, free electron gas in three dimensions, heat capacity of the electron gas, Electrical conductivity and Ohm’s law, motion in magnetic fields, thermal conductivity of metals, Energy bands, nearly free electron models, Bloch functions, Kronig-Penny model, Wave equation of electrons in a periodic potential, number of orbitals in a band, Semiconductor crystals, band gap, equation of motion, effective mass, physical interpretation of effective mass, effective masses in semiconductors, Intrinsic carrier concentration, impurity conductivity, thermoelectric effects, Fermi surfaces and metals, reduced zone scheme, periodic zone scheme, tight binding method for energy band calculation.

Course Outcomes: Student should be able to understand:

- the concept of periodicity of direct and reciprocal lattice.
- electronic structure of metal, semiconductor and insulators.

- band calculation methods.
- crystal vibrations.

Textbook: Charles Kettel, Introduction to Solid State Physics, 8th edition, John Wiley & Sons Inc., 1997.

Reference Book: Steven H. Simon, The Oxford Solid State Physics Basics, 1st edition, Oxford University press, 2013

Weekly Breakdown		
Week	Section	Topics
1	Kittel: pp. 1-9	Crystal structure, periodic arrays of atoms, two- and three-dimensional monoatomic lattices, Index system for crystal planes, simple crystal structures,
2	Kittel: pp. 11-19 and handouts	Lattices with bases and their classification by symmetries, direct imaging of atomic structures, non-ideal crystal structures
3	Kittel: pp. 23-32	Diffraction of waves by crystals, scattered wave amplitude
4	Kittel: pp. 33-43,	Brillouin zones, Fourier analysis of the basis
5	Kittel: pp. 89-94	Crystal vibrations, vibrations of crystals with monoatomic
6	Kittel: pp. 95-100	Two atoms per primitive basis, quantization of elastic waves, phonon momentum, inelastic scattering by phonons
7	Kittel: pp. 105-113	Phonon heat capacity, Planck distribution, normal modes enumeration, density of states in one dimension, density of states in three dimensions, Debye model for density of states
8	Kittel: pp. 114-126	Debye T3 law, Einstein model of the density of states, anharmonic crystal interactions, thermal conductivity
9	Kittel: pp. 131-140	Free electrons fermi gas, energy levels in one dimension, effect of temperature on the Fermi-Dirac distribution, free electron gas in three dimensions, heat capacity of the electron gas
10	Kittel: pp. 141-156	Electrical conductivity and Ohm's law, motion in magnetic fields, thermal conductivity of metals
11	Kittel: pp.	Energy bands, nearly free electron models, Bloch functions, Kronig-

	161-168	Penny model
12	Kittel: pp. 169-181	Wave equation of electrons in a periodic potential, number of orbitals in a band
13	Kittel: pp. 185-200	Semiconductor crystals, band gap, equation of motion, effective mass, physical interpretation of effective mass, effective masses in semiconductors
14	Kittel: pp. 201-214	Intrinsic carrier concentration, impurity conductivity, thermoelectric effects
15	Kittel: pp. 221-225, 232-235	Fermi surfaces and metals, reduced zone scheme, periodic zone scheme, tight binding method for energy band calculation