PHY-438 Condensed Matter Physics

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, 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, Superconductivity, occurrence of superconductivity, destruction of superconductivity of magnetic fields, Meissner effect, heat capacity, energy gap, microwave and infrared properties, isotope effect, thermodynamics of the superconducting transition, London equation, coherence length, BCS theory of superconductivity, BCS ground state, flux quantization in a superconducting ring, duration of persistent currents, Type II superconductors, vortex state, estimation of Hc1 and Hc2, single particle tunnelling, Josephson superconductor tunnelling, Dc and Ac Josephson effect, macroscopic quantum interference, high temperature superconductors, Langevin diamagnetism equation, quantum theory of diamagnetism of mononuclear systems, paramagnetism, quantum theory of paramagnetism, paramagnetic susceptibility of conduction electrons, ferromagnetic order, magnons, ferrimagnetic order, Antiferromagnetic order, ferromagnetic domains, single domain particles.

Course Outcomes: Student should be able to understand:

- the concept of periodicity of direct and reciprocal lattice.
- electronic band structure of materials using nearly free electron model.
- Semiconductors and their properties.
- Superconductors
- Magnetism and its types

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. 161-168	Energy bands, nearly free electron models, Bloch functions, Kronig-Penny model
6	Kittel: pp. 169-181	Wave equation of electrons in a periodic potential, number of orbitals in a band
7	Kittel: pp. 185-200	Semiconductor crystals, band gap, equation of motion, effective mass, physical interpretation of effective mass,

		effective masses in semiconductors
8	Kittel: pp. 201-214	Intrinsic carrier concentration, impurity conductivity, thermoelectric effects
	Midterm	
9	Kittel: pp. 257-269	Superconductivity, occurrence of superconductivity, destruction of superconductivity of magnetic fields, Meissner effect, heat capacity, energy gap, microwave and infrared properties, isotope effect
10	Kittel: pp. 269-282	Thermodynamics of the superconducting transition, London equation, coherence length, BCS theory of superconductivity, BCS ground state, flux quantization in a superconducting ring, duration of persistent currents
11	Kittel: pp. 283-293	Type II superconductors, vortex state, estimation of Hc1 and Hc2, single particle tunneling, Josephson superconductor tunneling, Dc and Ac Josephson effect, macroscopic quantum interference, high temperature superconductors
12	Kittel: pp. 297-311, 315-316	Langevin diamagnetism equation, quantum theory of diamagnetism of mononuclear systems, paramagnetism, quantum theory of paramagnetism, paramagnetic susceptibility of conduction electrons
13	Kittel: pp. 321-339	Ferromagnetic order and magnons
14	Kittel: pp. 340-350	ferrimagnetic and Antiferromagnetic order
15	Kittel: pp. 351-360	ferromagnetic domains, single domain particles
16		Revision