PHY-423 Solid State Physics-II

Credit Hours: 3-0

Pre-requisite: Solid State Physics I

Course Objectives: It is an undergraduate core course and an extension to core course: Condensed Matter I. The aim of this course is to make students understand the basic physics behind superconductivity, diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, to insight of optical processes, dielectric and ferroelectric properties of materials, to introduce nanostructures, non-crystalline solids and point defects in crystals.

Core Contents: Superconductivity, diamagnetism, paramagnetism, ferromagnetic order, antiferromagnetic order, optical processes, dielectrics, ferroelectrics, nanostructures, point defects, non-crystalline solids.

Detailed Course Contents: 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, optical processes and excitons, optical reflectance, Kramers-Kronig relations, Conductivity of collision less electron gas, electronic interband transitions, excitons, Frenkel excitons, alkali halides, molecular crystals, Mott-Wannier exciton, Raman effects in crystals, electron spectroscopy with x-rays, dielectrics and ferroelectrics, Maxwell equations, polarization, macroscopic electric field, local electric field at an atom, dielectric constant and polarizability, structural phase transitions, ferroelectric crystals, displacive transitions, Nanostructures, Imaging techniques for nanostructures, Electronic structure of 1D systems, electronic structure of 0D systems, point defects, lattice vacancies, diffusion, color centers, F centers, other centers in alkali halides, non-crystalline solids, diffraction pattern of non-crystalline solids, monoatomic amorphous materials, radial distribution function, structure of vitreous Silica, Glasses, amorphous ferromagnets, amorphous semiconductors, low energy excitation in amorphous solids, heat capacity calculation, thermal conductivity.

Course Outcomes: On completion of this course, student will have knowledge and skill to:

- Explain the significance and value of condensed matter physics, both scientifically and in the wider community
- Critically analyze and evaluate experimental strategies, and decide which is most appropriate for answering specific questions
- Research and communicate scientific knowledge in the context of a topic related to condensed matter physics, in either a technical or non-specialist format
- Apply key analysis techniques to typical problems encountered in the field
- Gain and apply discipline-specific knowledge, including self-directed research into the scientific literature.

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

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

Weekly Breakdown		
Week	Section	Topics
1	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
2	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
3	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
4	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
5	Kittel: pp. 321-339	Ferromagnetic order, magnons, ferrimagnetic order
6	Kittel: pp. 340-356	Antiferromagnetic order, ferromagnetic domains, single domain particles
7	Kittel: pp. 427-435	Optical processes and excitons, optical reflectance, Kramers-Kronig relations, Conductivity of collisionless electron gas, electronic interband transitions
8	Kittel: pp. 436-448	Excitons, Frenkel excitons, alkali halides, molecular crystals, Mott-Wannier exciton, Raman effects in crystals, electron spectroscopy with x-rays
		Midterm Exam
9	Kittel: pp. 453-466	Dielectrics and ferroelectrics, Maxwell equations, polarization, macroscopic electric field, local electric field at an atom, dielectric constant and polarizability
10	Kittel: pp. 467-481	Structural phase transitions, ferroelectric crystals, displacive transitions
11	Kittel: pp. 515-527	Nanostructures, Imaging techniques for nanostructures,
12	Kittel: pp.	Electronic structure of 1D systems, electronic structure of 0D

	528-533, 551-557	systems
13	Kittel: pp. 583-595	Point defects, lattice vacancies, diffusion, color centers, F centers, other centers in Alkali Hallides
14	Kittel: pp. 565-572	Noncrystalline solids, diffraction pattern of non crystalline solids, monoatomic amorphous materials, radial distribution function, structure of vitreous Silica
15	Kittel: pp. 573-580	Glasses, amorphous ferromagnets, amorphous semiconductors, low energy excitation in amorphous solids, heat capacity calculation, thermal conductivity