926 Condensed Matter Physics

Credit Hours: 3-0

Prerequisite: None

Objectives and Goals: The course covers structure of solids and other phases of condensed matter. The first part will introduce materials which are solid, or crystalline. The remainder of the course will be focused on providing a basic understanding of the electrical, thermal, and magnetic properties of solids, and in particular metals and semiconductors. The aim is to give a firm grounding in the core concepts.

Core Contents: Amorphous and crystalline materials, crystal structure, space groups, scattering, phonons, magnetism, semiconductors, and metals.

Detailed Course Contents: Crystalline solids, two dimensional Bravais lattices, symmetry

three dimensional monoatomic lattices, lattices with bases and their classification by symmetries, symmetries of lattices with bases, macroscopic implication of microscopic symmetries, introduction to crystal scattering theory of scattering from crystals, experimental methods of crystal scattering, features of scattering experiment, the free fermi gas, density of states, statistical mechanics of noninteracting electrons, noninteracting electrons in a periodic potential, Bloch's theorem in three dimensions, Kronig-Penny model, rotational symmetry classes and character, nearly free electrons, Brillouin zones, nearly free electrons fermi surfaces, tight bound electrons, Wannier functions, tight binding model, Metal, insulator and semiconductors, brief survey of periodic table, vibrations of crystal lattices, normal modes, and lattices with basis, vibrations of quantum mechanical lattices, phonons specific heat, Einstein and Debye models, thermal expansion, classical theories of magnetism and ordering, magnetic dipoles, ferromagnets, ferrimagnets, anti-ferromagnets, mean field theory, Ising model

Course Outcomes: On successful completion of this course, students will relate crystal structure and degree of ordering to atom binding and packing, classify condensed matter upon its degree of order, with emphasis on scattering experiments, explain the thermal properties in solids in particular heat capacity, classify condensed matter upon its electrical, magnetic and transport properties, apply the obtained concepts to challenges in condensed matter physics.

Textbook: Michael P Marder, Condensed Matter Physics, 2nd ed. John Wiley & sons 2015.

Reference books: Neil W. Ashcroft, N. David Mermin, Solid State Physics, Harcourt College Publishers 1976.

Weekly Breakdown		
Week	***Section***	***Topics***
1	Sec. 1.1-1.3	Crystalline Solids, two dimensional Bravais lattices, Symmetry
2	Sec. 2.1-2.4	Three dimensional monoatomic lattices, lattices with bases and their classification by symmetries
3	Sec. 2.5, 2.6, 3.1	Symmetries of lattices with bases, macroscopic implication of microscopic symmetries, introduction to crystal scattering
4	Sec. 3.2	Theory of scattering from crystals
5	Sec. 3.3-3.4	Experimental methods of crystal scattering, features of scattering experiment
6	Sec. 6.1-6.5	The free fermi gas, density of states, statistical mechanics of noninteracting electrons
7	Sec. 7.1, 7.2	Noninteracting electrons in a periodic potential, Bloch's theorem in three dimensions
8	Sec. 7.3	Kronig-Penny model, Rotational symmetry classes and character
9	Sec. 8.1-8.3	Nearly free electrons, Brillouin zones, nearly free electrons fermi surfaces
10	Sec. 8.4	Tight bound electrons, Wannier functions, tight binding model
11	Sec. 10.3, 10.4	Metal, insulator and semiconductors, brief survey of periodic table
12	Sec. 13.1, 13.2	Vibrations of crystal lattices, normal modes, and lattices with basis
13	Sec.13.3	Vibrations of quantum mechanical lattices, phonons specific heat, Einstein and Debye models, thermal expansion
14	Sec. 24.1-24.3	Classical theories of Magnetism and ordering, magnetic dipoles, ferromagnets, ferrimagnets, anti-ferromagnets
15	Sec. 24.4	Mean field theory, Ising model, revision