14/07/2019

Solid State Physics
86-370-01

Lecturer: Prof. Efrat Shimshoni
Course type: Lecture + Practice

Date: 2019-2020 **semester:** B **weekly hours:** 4L + 2P

Aim of the course:

This course aims to provide an introduction to the electric, thermal and magnetic properties of materials in their solid state, and to the research methods employed to study them. In particular, the course will emphasize the key role of the crystal structure, and of the quantum nature of electrons and crystal vibrations, which dominate the behavior of solids and lead to their classification according to their conduction properties (metals, insulators and semi-conductors).

Details of subjects to be covered:

1. TRANSPORT PHENOMENA IN SOLIDS

Drude's theory for conductivity in metals; Conductivity tensor; Electric and Heat Transport. Electrons in magnetic field: magneto-resistance and Hall Effect; Failure of the classical Drude model and Sommerfeld's quantum theory.

2. CRYSTAL STRUCTURES

Crystal Lattices in Solids; Structural Factor; Bravais Lattices; Reciprocal Lattices; Brillouin Zones.

3. LATTICE VIBRATIONS

Specific heat of crystals at high and low temperatures; Lattice vibrations in the harmonic approximation; Quantum theory of the harmonic crystal: normal modes and phonons; Acoustic and optical phonons in one-dimension; Dispersion Laws and density of states; Phonons in 3D lattices; Thermodynamics of phonons and the analogy with black body radiation.

4. ELECTRONS IN SOLIDS

Electrons in a periodic potential: Bloch's theorem; Crystal momentum and band structure; Dispersion Laws and Fermi Surfaces; The tight binding and nearly free electron approximations; Effective mass; Density of states and van Hove singularities; Semi-metals and Dirac materials.

5. SEMICONDUCTORS

Homogeneous semiconductors: band structure; Electrons and holes; Donors and acceptors; Conduction and optical properties; Inhomogeneous semiconductors: the P-N junction and its applications.

6. MAGNETISM IN SOLIDS

Origin of magnetic interactions in solids: direct, super and itinerant exchange; Spin models; Paramagnetism; Ferromagnetism and Curie's law.

Course mandatories:

Submission of homework assignments (20%), Final exam (80%).

Bibliography:

1. N.W. Ashcroft and N.D. Mermin, Solid State Physics, W.B. Saunders, Philadelphia, 1976.
2. C. Kittel, Introduction to Solid State Physics, 7th edition, John Wiley & Sons, New York, 1996.
3. J.M. Ziman, Principles of the Theory of Solids, 2nd edition, Cambridge University Press, Cambridge, England, 1972.