# MANGALORE UNIVERSITY
## Department of Physics
## MSc Physics

**PHS 506: CONDENSED MATTER PHYSICS II**

**(52 Hrs.)**

**Course outcome**

CO1 The student will have understanding of Band theory of solids,

CO2 Good understanding of Transport properties.

CO3 Will be exposed to Semiconductors.

CO4 Will have a good knowledge of Basics of semiconductor alloys and heterostructures

Unit I Band theory of solids

Bloch theorem. Nearly Free electron approximation. Tight binding approximation.

Applications of the tight binding method to cubic crystals: width of energy bands,

the effective mass of electrons in a simple cubic lattice based on tight binding approximation. The shape of constant surfaces and Fermi surfaces, Density of states curve for the simple cubic lattice. Construction of Brillouin zones for a two-dimensional square lattice. General expression for density of states function and calculation of density of states curve for the simple cubic lattice based on tight binding approximation. Overlapping of energy bands and Jones explanation of structural phase transitions in binary alloys. [13 hrs]

Quantization of electron orbits in magnetic fields. Experimental methods in Fermi surface studies - de Haas – Van Alphven effect in Fermi surface determination.

Unit II Transport properties

Boltzmann transport equation. Electrical conductivity. Thermal conductivity, Thermoelectric effects and thermopower power. Scattering of electrons. Temperature variation of electrical resistance. Linearized Boltzmann transport equation. AC conductivity of metals. Hall effect, High field effects and magnetoresistance. Cyclotron resonance. Plasma frequency and plasmons. [13 hrs]

Unit III Semiconductors I

Extrinsic semiconductors. Impurity ionization energy Fermi energy - variation with impurity density and temperature. Electrical conductivity. Cyclotron resonance in semiconductors.

Excess carriers. Quasi-Fermi levels. Recombination of carriers. Continuity equation.

P-N junctions: Abrupt and graded junctions. Junction space charge, electric field, electric potential and width. Rectification process. Derivation of ideal current voltage characteristics. P-n junction capacitance.

Metal semiconductor contacts: Formation of rectifying/ Schottky contacts, Depletion layer, Interface states and Fermi level pinning. Current transport processes, Derivation of ideal current voltage characteristics of schottky diodes based on thermionic emission theory. Capacitance of Schottky diodes.Ohmic contacts. [13 hrs]

Unit IV Semiconductors II: Low-dimensional Semiconductor structures: Basics of semiconductor alloys and heterostructures. Basics of Fundamentals of quantum wells, quantum wires and quantum dots. Two-dimensional electron gas in uniform electric and magnetic field –Landau levels. Quantum Hall and Shubnikov de Haas effect (qualitative).

Degenerate semiconductor. Esaki diode.

Optolectronic devices: Photodetectors: Introduction. Photoconductor. Photodiodes: P-N and P-I-N Photodiodes.Heterojunction Photodiodes. Metal-Semiconductor Photodiodes. Avalanche photodiodes (APDs). Phototransitors. Quantum well Infra-Red Photodetectors (QWIPs). Solar cells. Light emitting diodes. Semiconductor Lasers- Heterostructure and quantum well lasers.

Amorphous semiconductor (Qualitative aspects only): Introduction, Band structures and density of states. Structure of amorphous semiconductors and structural models. Electrical and Optical properties.

Organic Semiconductors (Qualitative aspects only): Introduction, and doping, electrical and optical properties. Organic semiconductor Devices. [13 hrs]

**Reference Books:**


1. Kittel C, 'Introduction to Solid State Physics', IV Edn. (Wiley Eastern, 1974), VII Ed (John Wiley, 1995)
2. Ibach H and Luth H, 'Solid State Physics' II Edn. (Springer, 1996)
3. Ziman J M, 'Principles of the Theory of Solids' II Edn. (Vikas Publ., 1979)
4. Mckelvey J P, 'Solid State and Semiconductor Physics' (Robert E Kreiger, 1982)
5. Sze S M, 'Semiconductor Devices Physics and Technology' (John Wiley, 1985, 2003)
6. S. M, Sze and K. K. Ng, 'Physics of Semiconductor Devices' (3rdEdition, Wiley 2006).
7. B. G. Streetman and S. Banerjee, 'Solid State Electronic Devices' 4rd to 6th Edition (PHI)
8. P. Bhattacharya, 'Semiconductor Optoelectronic Devices, 2nd Edition (PHI, 2009).
9. J. H. Davies, 'The Physics of Low-diemnsional Semiconductors: An Introduction, (Cambidge University Press, 1998).
10. M. Li, 'Modern Semiconductor Quantum Physics' (World Scientific, 1994).
11. J. Singh and K. Shimakawa, Advances in Amorphous Semiconductors, (Advances in condensed matter science, Vol.5, D. D. Sharma, G. KotliarandY. Tokura. Taylor&Fransis, 2003).
12. S. R. Elliot, 'Physics of Amorphous Materials, 2nd Ed. (Longman Scientific & Technical, London).