

# ELECTRICAL ENGINEERING MATERIAL

ENEE 203

Lecture : 3  
Tutorial : 1  
Practical : 0

Year : II  
Part : I

## Course Objectives:

The objective of this course is to impart a foundational understanding of elementary quantum mechanics and solid-state theory, alongside essential knowledge of various materials utilized in electrical engineering.

- 1 Elementary Quantum Mechanics (6 hours)**
  - 1.1 Wave particle duality and De-Broglie relation, wave number and wave function
  - 1.2 Schrodinger equation and its significance, operators and its notation
  - 1.3 Quantum leak, effective mass of electron
  - 1.4 Crystalline structure, simple, body centered and face centered cubic structures
  
- 2 Modern Theory of Solids (8 hours)**
  - 2.1 Degenerated and density of states
  - 2.2 Fermi energy and its significance, contact potential, Seebeck effect
  - 2.3 Boltzmann and Fermi-Dirac statistics
  - 2.4 Population density and number of electrons, conduction in metals
  - 2.5 Thermionic emission: Richardson Dushman equation, Schottky effect
  - 2.6 Molecular orbital bonding theory and band theory of solids
  
- 3 Dielectric Materials (7 hours)**
  - 3.1 Matter polarization and relative permittivity: Electric dipole moment, polarization, local electric field and Lorentz equation, Clausius-Mossotti equation.
  - 3.2 Types of polarization: Electronic, Ionic, dipolar, interfacial
  - 3.3 Dielectric loss and its frequency dependence
  - 3.4 Dielectric strength, dielectric breakdown in solids and gases.
  - 3.5 Ferroelectricity, piezoelectricity and pyroelectricity

- 4 Magnetic Materials (8 hours)**
- 4.1 Magnetization of matter: Magnetic dipole moment, atomic magnetic moment, magnetization, relative permeability
  - 4.2 Classification of magnetic materials: Diamagnetism, paramagnetism, ferromagnetism, ferrimagnetism and anti-ferromagnetism
  - 4.3 Magnetic domains, domain wall motion, magnetostriction
  - 4.4 Hysteresis and Eddy current loss, demagnetization and deperming process
  - 4.5 Soft and hard magnetic materials: Examples and applications

- 5 Superconductivity (6 hours)**
- 5.1 Zero resistance, Meissner effect and isotope effect
  - 5.2 London equation and penetration depth
  - 5.3 Bardeen–Cooper–Schrieffer (BCS) theory and cooper pairs
  - 5.4 Critical current density and Silsbee rule
  - 5.5 Types of superconductors: Type I and II

- 6 Semiconductors (10 hours)**
- 6.1 Electron hole pair generation in semiconductors, generation and recombination in semiconductors
  - 6.2 Pure and impure semiconductors, types of doping and compensation doping
  - 6.3 Direct and Indirect band gap semiconductors, degenerate and non-degenerate semiconductors
  - 6.4 Diffusion and Einstein relationship
  - 6.5 PN junction: Expression of built in potential and depletion width, forward and reverse biased PN junction, band bending theory
  - 6.6 Introduction to wide band gap semiconductors: SiC and GaN

- Tutorial (15 hours)**
- 1. Problems involving Elementary quantum mechanics, Wave particle duality and De-Broglie relation, Schrodinger equation, effective mass of electron and crystalline structure.
  - 2. Problems on Modern theory of solids, Boltzmann and Fermi-Dirac statistics, conduction in metal
  - 3. Problems related to Dielectric Materials, Clausius-Mossotti equation, Dielectric loss, polarizability and dipole moment.
  - 4. Problems related to semiconductors.

## Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1	6	8
2	8	10
3	7	10
4	8	10
5	6	8
6	10	14
<b>Total</b>	<b>45</b>	<b>60</b>

\* There may be minor deviation in marks distribution.

## References

1. Kasap, S.O. (2007). Principles of electronic materials and devices. McGraw-Hill.
2. Colcaser, R.A., Diehl-Nagle, S. (1985). Materials and devices for electrical engineers and physicists. McGraw-Hill.
3. Bhattacharya, S.K. (2006). Electrical and electronics engineering materials (1st ed.). Khanna Publishers.
4. Pokharel, B.P., Karki, N.R. (2004). Electrical engineering materials. Sigma Offset Press.