Course Title: Electrical Engineering Materials
Course Code: EEEG 207
Credit Hours: 3

Course Description:
The course provides basic understanding of the most commonly used materials in electrical and electronics engineering. The section on semiconductor materials will lay the foundation for understanding the solid state devices analysed and applied in later courses.

Course Contents:

Unit 1: Introduction
Overview of elementary concepts of materials science, Classification of material, Classification of electrical material, Classification of conductor, semiconductor and resistor material based on atomic structure, Crystal and amorphous structure, Properties of material, Application of material in the field of electrical and electronics engineering.

Unit 2: Fundamentals of Electron Theory
Behaviour of electrons in solid, Wave-particle duality; The Schrodinger equation, Solution of the Schrodinger equation for free electron, electron in a potential well, and tunnel effect; Electron in periodic field of a crystal (without detail derivation); Heisenberg uncertainty principle.

Unit 3: Conductivity of Metals and Superconductivity
Free electron theory and energy well model of a metal; Density of states function; Fermi-Dirac distribution function; Electrons in a crystal-energy band theory of solids- metals; Conductivity of metals-relaxation time, Collision time and mean free path; Effect of temperature on electrical conductivity of metals; Effect of impurities on conductivity of metals; Thermionic emission and work function; Contact potential., Superconductivity: Historical introduction, Properties of superconducting materials, Theories (qualitative description only), and applications

Unit 4: Semiconductors and Conduction Mechanism
Crystal structure of group- IV materials and band structure; Intrinsic semiconductors; Extrinsic semiconductors: Doping n-type and p-type Semi-conductor; Density of states in semiconductors; Fermi-Dirac distribution, Fermi factor and Fermi level; Effect of temperature on Fermi level; Law of mass action; Electrical neutrality; Mobile and immobile charges; Mobility, drift and diffusion; Conductivity in semiconductors; Hall effect; Continuity equation- injected minority carrier charge; Semi-conductor P-N junction: built in potential, Depletion width, P-N junction with no-bias, Forward-bias and reverse-bias conditions, Rectifier equation, Junction capacitance, junction diode switching times, and metal - semiconductor contact; Tunnel diode. Advantage and Disadvantages of Semi-conductor materials: Germanium, Silicon, Gallium arsenide and Silicon carbide, Overview of semiconductor fabrication

Unit 5: Magnetic Properties of Materials
Classification based on atomic dipoles- dia-, para-, ferro-, ferri-, and antiferro-magnetism; Origin of permanent magnetic dipole in matter; Curie-Weiss Law; Hysteresis and eddy-current loss in magnetic materials; Permeability and Susceptibility; Applications of magnetic materials

Unit 6: Optical Properties of Materials

Linear and Non-linear optical properties; Optical properties of metal and non-metal; Refractive index, Penetration depth, Absorbance, Reflectivity, and transmissivity; Electro-optical effect, Photoelectric and photovoltaic effect, Photo Emissivity, Photo luminescence, Electro luminescence, Light amplification by stimulated emission of radiation, Optical absorption.

Unit 7: Insulating and Dielectric Materials

Definition of Insulating and Dielectric Materials, Classification of insulating material, Characteristic of good insulating materials, Effect of moisture on insulation and protection against moisture, Insulation breakdown. Polarisation and dielectric constant- ionic, electronic and orientational polarisation; Frequency and temperature dependence of polarizability (qualitative discussion only); Active and Passive Dielectrics, Dielectric losses, Dielectric breakdown, Dielectric constant and relative permittivity, Behaviour of dielectric in ac and dc field, Application of dielectric material.

Unit 8: Piezoelectric, Pyro-electric and Ferroelectric materials

Piezoelectric crystal, piezoelectric properties, piezoelectric effect, piezoelectric device and application, Pyro-electric material: definition, types, characteristics and application, Ferroelectric material: definition, types, characteristics and application

Unit 9: Special Purpose Materials

Thermocouple material, Soldering materials, Fuse material, Contact materials, Refractory materials, Fluorescent and phosphorescent materials, Radioactive materials

References:

1. R.E. Hummel, *Electronic Properties of Materials*, 2nd Ed., Narosa Publishing House
2. B.G. Streetman, *Solid State Electronic Devices*, PHI.
3. A.J. Dekkar, *Electrical Engineering Materials*, PHI.
4. J. Millman and C.C. Halkias, *Integrated Electronics*, Tata McGraw Hill.

Evaluation:

In-Semester Evaluation: 50%
End-Semester Evaluation: 50%