Subject : Electromagnetic Field Theory
Subject Code : ECE306
Full marks 100 (80+20)
L T P
3 0 2

Course Objective: To familiarize the student to the concepts and calculations pertaining to electric, magnetic and electromagnetic fields so that an in depth understanding of transmission line, waveguides, antenna and other electronic devices are possible.

Course Outcome:

1. Ability to state and apply the principles of Coulombs Law and the Superposition Principle to electric fields in the Cartesian, cylindrical and spherical coordinate systems.
2. Ability to determine the electric field intensity resulting from various configurations of charge distributions.
3. Ability to apply Gauss' Law to highly symmetric charge distributions.
4. Ability to determine the electric potential and its relation to electric field intensity.
5. In depth understanding of Ohms Law, conductivity, and current in conductors, as well as an understanding of electric fields in dielectric and conducting materials.
6. In depth study of capacitance and capacitors, and calculations of various geometries.
7. In depth study of electrostatic boundary-value problems by application of Poisson's and Laplace's equations.
8. Ability to analyze and classify magnetic materials, and solve magneto static field problems using Biot-Savart law and Ampere's circuit law with the associated boundary conditions.
9. In depth understanding of time-varying electromagnetic field as governed by Maxwell's equations. 10. Ability to understand the general electromagnetic wave propagation.
11. Ability to interpret the effects of lossy and low loss dielectrics upon the propagation of EM waves.
12. In depth understanding of plane wave reflection and transmission at conductor and dielectric boundaries.

Syllabus

1. STATIC ELECTRIC FIELD (12 hrs)

Topics: Introduction to Co-ordinate System – Rectangular – Cylindrical and Spherical Co- ordinate System – Introduction to line, Surface and Volume Integrals – Definition of Curl, Divergence and Gradient – Meaning of Stokes theorem and Divergence theorem Coulomb's Law in Vector Form – Definition of Electric Field Intensity – Principle of Superposition – Electric Field due to discrete charges – Electric field due to continuous charge distribution – Electric Field due to charges distributed uniformly on an infinite and finite line – Electric Field on the axis of a uniformly charged circular disc – Electric Field due to an infinite uniformly charged sheet.

Electric Scalar Potential – Relationship between potential and electric field – Potential due to infinite uniformly charged line – Potential due to electrical dipole – Electric Flux Density – Gauss Law – Proof of Gauss Law – Applications.

2. STATIC MAGNETIC FIELD (08 hrs)

Topics: The Biot-Savart Law in vector form – Magnetic Field intensity due to a finite and infinite wire carrying a current I – Magnetic field intensity on the axis of a circular and rectangular loop carrying a current I – Ampere's circuital law and simple applications. Magnetic flux density – The Lorentz force equation for a moving charge . – Force on a wire carrying a current I placed in a magnetic field – Torque on a loop carrying a current I – Magnetic moment – Magnetic Vector potential

3. ELECTRIC AND MAGNETIC FIELDS IN MATERIALS (10 hrs)

Topics: Poisson's and Laplace's equation – Electric Polarization-Nature of dielectric materials- Definition of Capacitance – Capacitance of various geometries using Laplace's equation – Electrostatic energy and energy density – Boundary conditions for electric fields – Electric current – Current density – point form of ohm's law – continuity equation for current. Definition of Inductance – Inductance of loops and solenoids – Definition of mutual inductance– simple examples. Energy density in magnetic fields– Nature of magnetic materials– magnetization and permeability– magnetic boundary conditions.

4. TIME VARYING ELECTRIC AND MAGNETIC FIELDS (06 hrs)

Topics: Faraday's law – Maxwell's first Equation in integral form from Faraday's Law – Equation expressed in point form. Displacement current – Ampere's circuital law in integral form – Modified form of Ampere's circuital law as Maxwell's second equation in integral form – Equation expressed in point form. Maxwell's four equations in integral form and differential form. Pointing theorem .Instantaneous Average and Complex Pointing Vector.

5. ELECTROMAGNETIC WAVE (06 hrs)

Topics: Derivation of Wave Equation – Uniform Plane Waves – Maxwell's equation – Wave equation – Plane waves in free space and in a homogenous material. Wave equation for a conducting medium – Plane waves in lossy dielectrics – Propagation in good conductors – Skin effect. Linear, Elliptical and circular polarization – Reflection of Plane Wave from a conductor – normal incidence – Reflection of Plane Waves by a perfect dielectric – normal and oblique incidence. Dependence on Polarization, Brewster angle.

Text Books:

1 Fundamentals of Electromagnetic for Engineering, N.N. Rao, Pearson education, New Delhi. Reference Books:

1 Engineering electromagnetic, William H. Hayt, TMH, and New Delhi.

2 Elements of Electromagnetic, Mathew N.O Sadiku, Oxford University press, New Delhi

3 Electromagnetic , Joseph A. Edminister, TMH, New Delhi

4 Electromagnetic waves and radiating system, E.C Jordan and K.G Balman, Pearson Education, New Delhi. Evaluation

Subject : Electromagnetic Field Theory Lab
Subject Code : ECE310

List of Experiments for EMF Theory:

Expt 1: Measurement of electrical field pattern between two circular plates

Expt 2: Electrical Field and Potential inside the Parallel Plate Capacitor

Expt 3: Capacitance and Inductance of two parallel lines at fixed distance

Expt 4: Simulation of Electric Field and Potential Inside Capacitors.

Expt 5: Magnetic Field outside a Straight Conductor.

Expt 6 : Measurement of Magnetic Field of Coils.

Expt 7 : Magnetic Force on a Current Carrying Conductor.

Expt 8. : Experiment on filled measurement around solenoid

Expt 9 : Experiment on Magnetic Induction through transformer

Expt 10 : Hertz's experiment to demonstrate production and reception of radio waves

Expt 11 : E.M Wave Radiation and Propagation of a radiating conductor such as Antenna.

Expt 12 : Experiment on directivity and radiating pattern around conductor carrying current

Expt 13 : Experiment on simple AM Transmitter and Receiver

Expt 14 : E.M Wave Transmission and Reflection measurement experiment.

MATLAB / Software Based Experiments through its toolbox

Lab 1 Time domain reflectometry

Lab 2 SWR measurements using slotted waveguide

Lab 3 Method of moments (MoM) applied to electrostatics

Lab 4 Finite difference time domain (FDTD) method in 2D

Lab 5 Microwave power measurement

Lab 6 Reflection of plane waves

Lab 7 Modes of a rectangular waveguide

Lab 8 Antenna measurements