Electromagnetics and Transmission Lines(304184)

Teaching Scheme:
Lectures:3 Hrs/ Week
Tutorial: 1 Hr/Week

Examination Scheme:
In Semester Assessment:
Phase I : 30
End Semester Examination:
Phase II: 70

Course Objectives:

- To study Basic Electrostatic and Magneto static Laws, Theorems.
- To understand Maxwell's Equation and apply to the basic electromagnetic problem.
- To interpret the given problem, and solve it using Maxwell's equations.
- To analyze boundary conditions, and understand the field at the interface of two different media.
- To analyze time varying electric and magnetic fields, wave propagation in different types of media**.**
- To understand transmission line fundamentals and apply them to the basic problem.
- Tounderstand the fundamentals of electromagnetic theory and transmission lines.

Course Outcomes:

After successfully completing the course students will be able to

- Interpret the electromagnetic problem and solve using Maxwell's equations.
- Apply boundary conditions to different media, and formulate uniform plane wave equation, which is the basic of Antenna and wave propagation.
- Analyze the transmission line problem, use the Smith chart for impedance calculations

Unit I : Fundamentals of Electrostatic Fields 6L

Coulomb's Law & Electric Field Intensity, Electric Field due to point charge, line charge and surface charge distributions, Electric Flux Density, Gauss's Law and its Application to differential volume element, divergence, divergence theorem. Electric potential, Relationship between E & V, Potential Gradient. An electric dipole and flux lines.

Unit II: Fields in Material Space and Boundary-Value Problem 6L

Energy density in electrostatic field, Current and current Density, continuity equation, Polarization in dielectrics, capacitance, capacitance of parallel plate; spherical; cylindrical capacitors with multiple di-electrics, Boundary conditions, Poisson's and Laplace's equation, General procedures for Solving Poisson's and Laplace's equations.

Unit III : Magnetostatics 6L

Biot-Savart's Law, Ampere's Circuital Law and its Applications, magnetic flux density, Magnetic Scalar and vectors potentials, Derivations of Biot-savarts law and Ampere's law based on Magnetic Potential, Forces due to magnetic field, magnetic dipole,Classification of Magnetic Materials, Magnetic boundary conditions.

Unit IV :Time Varying Fields and Maxwell's equations 6L

Faraday's law, Displacement current, Maxwell's equations in point form and integral form, Power and Poynting theorem, Boundary conditionsfor time varying field,Retarded magnetic vector potential, Time harmonic field, Introduction to the concept of Uniform Plane Wave and Helmholtz equation.

Unit V : Transmission Lines 6L

Line parameters, inductance of a line of two parallel round conductors, coaxial line, skin effect, A line of cascaded T sections, general solution, physical significance of the equations; the infinite line, wavelength, velocity of propagation, the distortion less line, Inductance loading of telephone cables, Reflection on a line not terminated in Z_0, reflection coefficient, open and short circuited lines, reflection factor and reflection loss, T and π sections equivalent to lines.

Unit VI : The Line at Radio Frequency 6L

Voltages and currents on the dissipation less line, standing waves; nodes; standing wave ratio, Input impedance of dissipation less line, Input impedance of open- and short-circuited lines, Power and impedance measurement on lines, Reflection losses on the unmatched line, quarter-wave line; impedance matching, Single-stub impedance matching on a line, The circle diagram for the dissipation less line, Application of the circle diagram, The Smith circle diagram, Application of the Smith chart for calculating impedance and admittance.

Text Books:

1. Matthew N.O. Sadiku ,Principles of Electromagnetics, , 4th Edition, Oxford University Press, 2009.
2. J. D. Ryder, Networks, Lines and Fields, 2nd Edition, PHI.

Reference Books:

1. Edminister J.A, Electromagnetics, Tata McGraw-Hill.
2. Hayt& Buck, Engineering Electromagnetics, 7th Edition, Tata McGraw-Hill.
3. Kraus/Fleisch, Electromagnetics with applications, 5th Edition, McGraw Hill.

Electromagnetics

(Tutorial Assignments)

Tutorials must be conducted batch wise. Batch size should not be more than 20 students.

The main objective of this tutorial is to focus on the outcomes defined in the theory syllabus by solving the following assignments/problems based on paper work. 12 assignments have to be carried out covering entire syllabus.

- Find the Electric field intensity and electric flux density at a given point due to following charge distributions. (In all coordinate systems)
  1) Point charges
  2) Line charges (finite and infinite)
  3) Surface charges (finite and infinite)
  4) Mixed charges (Point charge, Line charge, Surface charge)
- Find the Electric potential due to different charge distributions (Point charge, Line charge, Surface charge), in different coordinate systems.
- Application of Gauss's law.
  1) Given ρ_v (volume charge density) in a particular region, find $\overline{D}$ (electric flux density) using Gauss's Law at the given location.
  2) Given ρ_s (surface charge density), find $\overline{D}$ (electric flux density) using Gauss's Law at the given location.
  3) Given $\overline{D}$ (electric flux density), find total charge enclosed by the surface(Q), ρ_v (volume charge density) using Gauss's Law.(In all coordinate systems)
  4) Given $\overline{D}$ (electric flux density), prove both sides of Divergences Theorem.
- Given ρ_v (volume charge density), and the region with reference potential, find the potential in a given region, using Poisson's equation.
- Using Laplace's equation, find capacitance between any two surfaces, if the boundary conditions are given.
- Find the electrostatic fields (Tangential and Normal) at the boundary between,
  1) Free space and dielectric medium
  2) Free space and conductor
  3) dielectric medium and conductor
  4) Two dielectric media.
  5) Two dielectric media when boundary is defined by a equation of plane.
- Find the capacitance of,
  1) Parallel plate capacitor with multiple dielectric layers.
  2) Spherical capacitor with multiple dielectric layers
  3) Cylindrical capacitor with multiple dielectric layers,

  Also find the total Energy stored within the region for all above mentioned capacitor.

- Find $\overline{H}$ (Magnetic field intensity) and $\overline{B}$ (Magnetic flux density) at a given point due to,
    1) Infinitely long current carrying conductor
    2) Finite current carrying conductor
    3) Infinite conducting surface
    4) Finite conducting surface
    5) Different current carrying configurations (i.e. thin conductor, surface all together)
- For the following current carrying configurations, find the $\overline{H}$ (Magnetic field intensity) in a given region (or point) using Ampere's circuital law.
    1) Infinitely long current carrying conductor
    2) Infinite cylindrical surfaces of different radii all centered at the same axis.
    3) Spherical surfaces of different radii all centered at a given point.
- Given the $\overline{H}$ (Magnetic field intensity) of a particular region, find current (I), current density ($\overline{J}$), enclosed by the given surface. (In all coordinate systems)
- Prove both sides of Stokes' theorem when $\overline{H}$ (Magnetic field intensity) is given in Cartesian, cylindrical and spherical coordinate system separately.
- Find the static magnetic fields(Tangential and Normal) at the boundary between,
    1) Two different magnetic media with nonzero surface current density($\overline{K}$)
    2) Two different magnetic media with zero surface current density($\overline{K}$)
    3) Two different magnetic media when boundary is defined by a equation of plane.
- Given $\overline{H}$ (or $\overline{E}$) and the region properties(like ε, μ, σ etc.), find $\overline{B}, \overline{D}$ and $\overline{E}$ (or $\overline{H}$) using Maxwell's equations. (In all coordinate systems)
- Given $\overline{H}$ (or $\overline{E}$) and the region properties(like $\varepsilon, \mu, \sigma, \eta$), the average power density in W/m^2, Total power crossing the given surface in watts using Poynting Theorem (In all coordinate systems)
- Given the primary constants (R, L, G, C) along with the generator specifications and termination, find secondary constants ($\alpha, \beta, \gamma, Z_0$) and other parameters like velocity, wavelength, received voltage, received power, reflection coefficient etc.
- Given secondary constants (γ, Z_0), find the primary constants (R, L, G, C) at the given frequency.
- Problems on Transmission Line Analysis.
- Problems on Impedance matching and design of stub matching using Smith Chart.