2/4 B.Tech - FOURTH SEMESTER

EC4T4 Electromagnetic Fields and Waves Credits: 3

Lecture: 3 Periods/week **Internal assessment: 30 marks**
Tutorial: 1 Periods//week **Semester end examination: 70 marks**

Prerequisites: Engineering Mathematics – I(EC1T1), Engineering Physics(EC1T3)

Course Objectives:

- To provide the basic skills required to understand, develop, and design various engineering applications involving electromagnetic fields.
- To lay the foundations of electromagnetism and its practice in modern communications such as wireless, guided wave principles such as fiber-optics and electronic electromagnetic structures.
- To develop an understanding of the fundamental concepts of electromagnetic fields, with an emphasis on wave propagation.

Course Outcomes:
Student will be able to

- Apply the concepts of Vector calculus to solve the problems of Electromagnetic Fields in designing systems using the laws associated with Electrostatic and Magnetostatic Fields.
- Interpret the behaviour of Electrostatic and Magnetostatic Fields in Materials and apply these concepts in designing systems.
- Analyze Maxwell's equations in different forms (differential and integral) and apply them in solving practical electromagnetic fields problems.
- Analyze and interpret the behaviour of electromagnetic wave propagation in various media and apply these in the design of systems related to electromagnetic fields.

UNIT- I

Review of Orthogonal Co-ordinate Systems: Rectangular, Cylindrical, and Spherical Co-ordinate systems.
Vector Algebra: Scalars and Vectors, Vector Addition, Subtraction, Multiplication, Scalar triple product, Vector triple product.
Vector Calculus: Differential elements. Line, Surface, and Volume Integrals. Del Operator, Gradient, Divergence and Divergence theorem, Curl and Stokes theorem. Laplacian of scalar. Scalar fields, Vector fields, Conservative and Non-conservative fields.

UNIT- II

Electrostatic Fields: coulomb's Law of Force, Electric Field Intensity. Electric Field Intensity due to line, surface and volume charge distributions. Electric Flux density. Gauss's Law – First Maxwell equation. Applications of Gauss's Law. Electric Potential, Relationship between Electric Potential and Electric Field Intensity- Second Maxwell Equation. Electric Dipole and Flux Lines. Energy Density in Electrostatic Fields. Applications of Electrostatic Fields.

Electric Fields in Material Space: Properties of Materials. Convection and Conduction currents. Conductors. Dielectrics – Polarization, Dielectric constant and strength. Linear, Isotropic, Homogeneous Dielectrics. Continuity Equation and Relaxation time. Poisson's and Laplace's Equations. Resistance. Capacitance – Parallel-plate, Co-axial, and Spherical capacitors.

UNIT- III

Magnetostatic Fields: Biot-Savart's Law, Ampere's Circuit Law – Third Maxwell Equation, Applications of Ampere's law. Magnetic Flux Density- Fourth Maxwell Equation. Magnetic Scalar and Vector Potentials.
Magnetic Forces, Materials, and Devices: Forces due to Magnetic Fields, Magnetic Torque and Moment, Magnetic Dipole, Magnetization in materials, Classification of Magnetic materials. Inductors and Inductances- Concepts of self-inductance and mutual inductance. Magnetic Energy.

UNIT- IV

Maxwell's Equations: Faraday's Law, Transformer and Motional EMF, Inconsistency of Ampere's Law, Displacement current Maxwell's Equations- for static fields, Time- varying fields, and Time- Harmonic fields, and their word statements. Boundary Conditions for Electric and Magnetic for different interfaces

UNIT- V

Electromagnetic Waves: Wave Equation, Uniform Plane Waves: Relation between **E** and **H**, Uniform plane wave propagation in Lossless medium, conducting medium, good conductors, and good dielectrics - Expressions for Attenuation and phase constants, wavelength, wave velocity, intrinsic impedance. Skin Depth, Polarization – Linear, Elliptical, and Circular. Power and Poynting Vector, Reflection and Refraction of plane waves at Normal Incidence and Oblique Incidence.

Learning Resources

Text Books:
1. Principles of Electromagnetics – Matthew N.O. Sadiku, Oxford Univ. Press, 4th Ed., 2010.
2. Electromagnetic Waves and Radiating Systems – E.C. Jordan and K.G. Balmain, PHI, 2nd Ed, 2009.

References:
1. Engineering Electromagnetics – W H Hayt, J A Buck, Tata Mc Graw Hill, 7th Ed, 2006
2. Engineering Electromagnetics – Nathan Ida, Springer India 2nd Ed, 2008.
3. Electromagnetic waves – R K Shevgaonkar, Tata Mc-Graw Hill 1st Ed, 2005

Web Resources:
1. http://nptel.ac.in/syllabus/syllabus.php?subjectId=117103065
2. http://ocw.mit.edu/resources/res-6-001-electromagnetic-fields-and-energy-spring-2008/
3. http://nptel.ac.in/syllabus/syllabus.php?subjectId=117101057