2/4 B.Tech - FOURTH SEMESTER

EC4T4 Electromagnetic Field Theory Credits: 4

Lecture : 4 periods/week **Internal assessment: 30 marks**
Tutorial: 1 period /week **Semester end examination: 70 marks** -------
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Course Objectives:

- To understand the basic laws in Electrostatics and Magnetostatics
- To understand the Maxwell's equations and boundary conditions for electric and magnetic fields
- To understand the characteristics of EM wave in free-space , conductors & dielectrics
- To understand the Reflection and Refraction phenomenon of EM waves at different media interfaces

Learning Outcomes:

- Students will be aware of the laws related to Electrostatics and Magnetostatics.
- Students will be able to develop Maxwell's Equations for static and time varying electro-magnetic fields.
- Students will be aware of boundary conditions for electric fields and magnetic fields.
- Students will be aware of the propagation characteristics of electromagnetic waves in homogeneous, isotropic, linear unbounded & bounded media.

UNIT- I

Co-ordinate Systems, Vector Algebra & Vector Calculus: Review of Co-ordinate Systems.

Vector Algebra: Scalar and Vectors, Scalar and Vector components, Point and Unit vector transformations, Vector Addition, Subtraction, Multiplication, Scalar triple product, Vector triple product. **Vector Calculus:** Differential length, Surface area & Volume. 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

Electrostatics –I: Electrostatic Fields: coulomb's Law of Force, Electric Field Intensity. Electric Field Intensity due to line charge, surface charge 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.

UNIT- III

Electrostatics –II: 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- IV

Magnetostatics –I: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.

UNIT- V

Magnetostatics –II: 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- VI

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

UNIT- VII

Electromagnetic Waves – I: Wave Equation. -for any medium, Lossless medium (perfect Dielectric), and conducting medium. Uniform Plane Waves: Relation between **E** and **H** (Both Magnitude and Phase). Uniform plane wave propagation in Lossless, conducting medium, good conductors, and good dielectrics. Expression for Attenuation and phase constants, wavelength, wave velocity, intrinsic impedance. Skin Depth. Polarization – Linear, Elliptical, and Circular.

UNIT- VIII

Electromagnetic Waves – II: Plane wave in arbitrary direction- Concept of direction cosines. Reflection and Refraction of Plane waves for Oblique incidence and Normal incidence: at Perfect Dielectric - Perfect Dielectric interface, Perfect Dielectric - Perfect Conductor interface. Incident, Reflected and Transmitted fields, Reflection coefficients, and Transmission coefficients. Brewster angle, Critical angle. Total Internal Reflection. Surface Impedance. Poynting Theorem – Instantaneous, Average. Power Loss in a plane conductor.

Learning Resources

Text Books:

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

References:

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