Course Name: Field Theory
Course Code: EE 302
Credit: 4

Prerequisites:

Sl. No.	Subject	Description	Level of Study
01	Mathematics	Co-ordinate System, Vector Calculus	Class XII, 1st Sem
02	Physics	Electrostatics, Electromagnetism	1st Sem, 2nd Sem

Course Objective:

- To introduce students with different coordinate systems.
- To familiarize the students with the different concepts of electrostatic, magneto static and time varying electromagnetic systems.
- To expose the students to the ideas of electromagnetic waves and structure of transmission line.

Course Outcomes:

At the end of the course, a student will be able to:

1. **Define** and **recognize** different co-ordinate systems to describe the spatial variations of the physical quantities dealt in electromagnetic field theory as they are functions of space and time. Apply different techniques of vector calculus to understand different concepts of electromagnetic field theory.

2. **Explain** fundamental laws governing electromagnetic fields and evaluate the physical quantities of electromagnetic fields (Field intensity, Flux density etc.) in different media using the fundamental laws.

3. **Determine** the electromagnetic force exerted on charged particles, current elements, working principle of various electric and electromagnetic energy conversion devices are based on this force.

4. **Design** electromagnetic energy storage devices like capacitor, inductor which are frequently used in electrical systems and choose suitable materials required to assemble such electromagnetic energy storage devices.

5. **Deduce** and justify the concepts of electromagnetic waves, means of transporting energy or information, in the form of radio waves, TV signals, radar beams and light rays.

6. **Generalize** the concepts of guided structures like transmission line, means of transporting energy or information, commonly used in power distribution and communication.

CO- PO mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	2	1	1	1	-	-	2	-	-	-	-	2
2	3	-	2	2	-	1	2	1	1	-	1	2
3	2	1	2	1	-	-	2	-	1	-	-	2
4	1	2	2	2	-	2	1	1	-	-	-	2
5	2	2	2	1	1	1	2	-	1	1	2	3
6	2	2	2	-	2	2	3	-	-	1	-	2

Correlation levels 1, 2 or 3 as defined above: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and "-" if there is no correlation.

Syllabus Indicating CO:

Module No.	Content	Relevant CO's
1	Introduction: Co-ordinate systems and transformation, Cartesian coordinates, Circular cylindrical coordinates, Spherical coordinates & their transformation. Differential length, area and volume in different coordinate systems. Solution of problems	**CO1**
2	Introduction to Vector calculus: DEL operator, Gradient of a scalar, Divergence of a vector & Divergence theorem, Curl of a vector & Strokes theorem, Laplacian of a scalar, Classification of vector fields, Helmholtz's theorem. Solution of problems	**CO1**
	Electrostatic field: Coulomb's law, field intensity, Gauss's law, Electric potential and Potential gradient, Relation between	

3	E and V, an Electric dipole and flux lines. Energy density in electrostatic field. Boundary conditions: Dielectric-dielectric, Conductor – dielectric, Conductor-free space. Poisson's and Laplace's equation, General procedure for solving Poisson's and Laplace's equation. Solution of problems	**CO2, CO3, CO4**
4	Magneto static fields: Biot- savart law, Ampere's circuit law, Magnetic flux density, Magnetic static and Vector potential, Forces due to magnetic field, Magnetic torque and moments, Magnetisation in material, Magnetic boundary condition, Inductor and Inductances, Magnetic energy, Force on magnetic material. Solution of problems	**CO2, CO3, CO4**
5	Electromagnetic fields: Faraday's law, Transformer and motional emf, Displacement current, Maxwell's equations, Time varying Potential, Time harmonic fields. Solution of problems	**CO2, CO3, CO4**
6	Electromagnetic wave propagation: Wave equation, Wave propagation in lossy dielectric, Plane waves in loss less dielectric, Plane wave in free space, Plane wave in good conductor, Skin effect, Skin depth, Power & Poynting vector, Reflection of a plane wave at normal incidence, reflection of a plane wave at oblique incidence, Polarization. Solution of problems	**CO5**
7	Transmission line: Concept of lump & distributed parameters, Line parameters, Transmission line equation & solutions, Physical significance of solutions, Propagation constants, Characteristic impedance, Wavelength, Velocity of propagation. Solution of problems	**CO6**

Gaps in Syllabus:

Sl. No.	Gap	Action taken	Relevance to POs
1	**Line, surface & volume integrals:** *these integrals are very useful in evaluating different properties of electromagnetic field, but not mentioned in the syllabus.* **Topics covered:** line integral along a curve, line integral along a closed contour i.e. circulation, surface integral or flux, surface integral over a closed surface i.e. net outward flux, volume integral.	The various topics are addressed by **lecture classes and by solving numerical problems.**	**PO1**
2	**Convection & conduction currents, polarization:** *This topic gives the idea of different current densities, polarization in dielectrics. These concepts are very important but unfortunately missing in the syllabus.* **Topics covered:** Convection & conduction current densities, conductors, polarization in dielectrics, dielectric constant and strength, continuity equation & relaxation time.	Additional **lecture classes** are organized to cover the topics.	**PO 1, PO2, PO3, PO4, PO12**
3	**Uniqueness theorem, capacitance:** *Solution to Laplace's equation is unique, determination of resistance and capacitance is very useful and therefore imperative to deal with.* **Topics covered:** Uniqueness theorem, resistance, capacitance of parallel plate capacitor, coaxial capacitor, spherical capacitor.	Additional **lecture classes** are organized to cover the topics in continuation with solutions of Laplace's and Poisson's equation. The students are **given assignments** for solving problems	**PO2, PO3, PO7, PO12**
4	**Magnetic dipole:** *Magnetic dipole is formed by circular motion of current in a loop. This concept is very important but not covered in the syllabus.* **Topics covered:** Magnetic dipole, comparison between electric & magnetic dipole.	This topic is covered in continuation with magnetization in materials **by lectures.**	**PO 1, PO2, PO3**
5	**Input impedance, standing wave ratio and power:** *This topic describes how different parameters of transmission line can be obtained, but unfortunately not covered in the syllabus.* **Topics covered:** Voltage reflection co-efficient, current reflection co-efficient, shorted line, open-circuited line, matched line	Additional **lecture classes** are organized to and **practical problems are given** for better understanding and developing the real-life problem solving ability.	**PO3, PO6, PO7, PO12**

Lecture Plan:

Sl. No.	Date	Topics	Remarks
1		Introduction to Co-ordinate systems, Cartesian coordinates.	
2		Circular cylindrical coordinates and transformation.	
3		Spherical coordinates and transformation.	
4& 5		Differential length, area and volume in different coordinate systems.	Problems to be solved

6		Line, surface and volume intergrals	Problems to be solved
7		Introduction to Vector calculus: DEL operator, Gradient of a scalar,	Problems to be solved
8 & 9		Divergence of a vector & Divergence theorem,	Problems to be solved
10 & 11		Curl of a vector & Stokes theorem,	Problems to be solved
12		Laplacian of a scalar, Classification of vector fields, Helmholtz's theorem.	
13		Electrostatic field: Coulomb's law, field intensity.	Problems to be solved
14		Gauss's law and its applications.	
15		Electric potential and Potential gradient,Relation between E and V.	
16		An Electric dipole and flux lines.	Problems to be solved
17		Energy density in electrostatic field.	
18& 19		Boundary conditions: Dielectric-dielectric, Conductor –dielectric, Conductor-free space.	Problems to be solved
20&21		Poisson's and Laplace's equation, General procedure for solving Poisson's and Laplace's equation.	Problems to be solved
22		Magneto static fields: Biot- savart law.	
23		Ampere's circuit law.	
24		Magnetic flux density, Magnetic static and Vector potential.	
25		Forces due to magnetic field.	Problems to be solved
26		Magnetic torque and moments,Magnetisation in material.	

27		Magnetic boundary condition.	Problems to be solved
28		Inductor and Inductances, Magnetic energy, Force on magnetic material.	Problems to be solved
29		Electromagnetic fields: Faraday's law, Transformer and motional emf.	Problems to be solved
30		Displacement current, Maxwell's equations.	
31		Time varying Potential, Time harmonic fields.	
32		Electromagnetic wave propagation: Wave equation.	
33		Wave propagation in lossy dielectric, Plane waves in loss less dielectric, Plane wave in free space,	Problems to be solved
34		Plane wave in good conductor,Skin effect, Skin depth,	Problems to be solved
35		Power &Poynting vector.	Problems to be solved
36		Reflection of a plane wave at normal incidence.	
37		Reflection of a plane wave at oblique incidence, Polarisation.	
38		Transmission line: Concept of lump & distributed parameters, Line parameters.	
39		Transmission line equation & solutions, Physical significance of solutions.	
40		Propagation constants, Characteristic impedance, Wavelength, Velocity of propagation.	Problems to be solved

Recommended Books:

1. Elements of Electromagnetic, Mathew N.O. Sadiku, 4th edition, Oxford University Press.
2. Electromagnetic field theory fundamentals, Guru & Hizroglu, 2nd edition, Cambridge University Press..
3. Electromagnetic with application, Krause, 5th Edition, TMH.