# ELECTROMAGNETIC FIELD THEORY

<table>
<tr><td colspan="9">III Semester: EEE</td></tr>
<tr><th>Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AEE006</td><td rowspan="2">Foundation</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>3</td><td>1</td><td>-</td><td>4</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: 45</td><td>Tutorial Classes: 15</td><td colspan="4">Practical Classes: Nil</td><td colspan="3">Total Classes: 60</td></tr>
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## I. COURSE OVERVIEW:

This course will equip the students with good understanding of underlying principles and laws in electromagnetic fields and waves. The concepts of vector algebra, principles and basic laws of electro- statics, characteristics and properties of conductors and dielectrics, behavior of static magnetic field and application of Ampere's law, determination of force in magnetic field and magnetic potential, concept of time varying fields and propagation of electro-magnetic waves.

## II. OBJECTIVES:

**The course should enable the students to:**

| | |
|---|---|
| I | The behavior of charge under rest with static electric field in terms of electric fieldintensity, electric displacement and electric potential. |
| II | The charge distribution in conductors, dielectrics and condensers. |
| III | The sources to study the effect of static and dynamic fields in terms of magnetic field intensity, displacement and potential. |
| IV | The nature of electromagnetic wave propagation in free space, conductors anddielectric materials. |

## III. COURSE OUTCOMES:

**After successful completion of the course, students should be able to:**

| | | |
|---|---|---|
| CO 1 | **Make use of** Vector Calculus, Coulomb's Law and Gauss Law for obtaining electric field intensity, Potential and behavior of electrostatic field | Apply |
| CO 2 | **Calculate** the capacitance of different physical configuration based on the behavior of the conductors and dielectric materials. | Apply |
| CO 3 | **Demonstrate** Biot-Savart law and Ampere circuital law for derivation of magnetic field intensity due to different currentcarrying conductors. | Understand |
| CO 4 | **Predict** the force due to moving charge/current in the static magnetic field, thereby obtaining the inductance for different configurations of wires and energy stored in the coil | Understand |
| CO 5 | **Apply** the Faraday's law of Electromagnetic induction and Maxwell Equations to produce a wave equation for the free- space,insulators and conductors for propagation of electromagnetic waves. | Apply |

## IV. SYLLABUS:

| UNIT - I | ELECTROSTATICS | Classes: 10 |
|---|---|---|
| Electrostatic fields: Coulomb's law, electric field intensity due to line and surface charges, work done in moving a point charge in an electrostatic field, electric potential, properties of potential function, potential gradient, Gauss's law, application of Gauss's law, Maxwell's first law, Laplace's and Poisson's equations, solution of Laplace's equation in one variable. | | |
| **UNIT - II** | **CONDUCTORS AND DIELECTRICS** | **Classes: 09** |
| Electric dipole: Dipole moment, potential and electric field intensity due to an electric dipole, torque on an electric dipole in an electric field, behavior of conductors in an electric field, electric field inside a dielectric material, polarization, conductor and dielectric, dielectric boundary conditions, capacitance of parallel plate and spherical and coaxial capacitors with composite dielectrics, energy stored and energy density in a static electric field, current density, conduction and convection current densities, Ohm's law in point form, equation of continuity. | | |

| UNIT - III | MAGNETOSTATICS | Classes: 08 |
|---|---|---|
| Static magnetic fields: Biot-Savart's law, magnetic field intensity, magnetic field intensity due to a straight current carrying filament, magnetic field intensity due to circular, square and solenoid current carrying wire, relation between magnetic flux, magnetic flux density and magnetic field intensity, Maxwell's second equation, div(B)=0.<br><br>Ampere's circuital law and it's applications: Magnetic field intensity due to an infinite sheet of current and a long current carrying filament, point form of Ampere's circuital law, Maxwell's third equation, Curl (H)=Jc, field due to a circular loop, rectangular and square loops. | | |
| **UNIT - IV** | **FORCE IN MAGNETIC FIELD AND MAGNETIC POTENTIAL** | **Classes: 09** |
| Magnetic force: Moving charges in a magnetic field, Lorentz force equation, force on a current element in a magnetic field, force on a straight and a long current carrying conductor in a magnetic field, force between two straight long and parallel current carrying conductors, magnetic dipole and dipole moment, a differential current loop as a magnetic dipole, torque on a current loop placed in a magnetic field; Scalar magnetic potential and its limitations: Vector magnetic potential and its properties, vector magnetic potential due to simple configurations, Poisson's equations, self and mutual inductance, Neumann's formula, determination of self-inductance of a solenoid, toroid and determination of mutual inductance between a straight long wire and a square loop of wire in the same plane, energy stored and density in a magnetic field, characteristics and applications of permanent magnets. | | |
| **UNIT - V** | **TIME VARYING FIELDS AND FINITE ELEMENT METHOD** | **Classes: 09** |
| Time varying fields: Faraday's laws of electromagnetic induction, integral and point forms, Maxwell's fourth equation, curl (E)=∂B/∂t, statically and dynamically induced EMFs, modification of Maxwell's equations for time varying fields, displacement current; Numerical methods: Finite difference method (FDM), finite element method (FEM), charge simulation method (CSM), boundary element method, application of finite element method to calculate electrostatic and magneto static fields. | | |

**Text Books:**


1. William H Hayt, John A Buck, "Engineering Electromagnetics", McGraw-Hill Publications, 8th Edition, 2012.
2. David J Griffiths, "Introduction to Electrodynamics", Pearson Education Ltd., 4th Edition, 2014.
3. Sunil Bhooshan, "Fundamentals of Engineering Electromagnetics", Oxford University Press, 1st Edition, 2012.
4. E Kuffel, W S Zaengl, J Kuffel, "High Voltage Engineering Fundamentals", Newnes, 2nd Edition, 2000.


**Reference Books:**


1. Matthew N O Sadiku, S V Kulkarni, "Principles of Electromagnetics", Oxford University Press, 6th Edition, 2015.
2. J D Krauss, Fleish, "Electromagnetics with Applications", McGraw-Hill Publications, 5th Edition, 1999.
3. Matthew N O Sadiku, "Numerical Techniques in Electromagnetics", CRC Press, 2nd Edition, 2001.
4. William H Hayt, John A Buck, "Problems and Solutions in Electromagnetics", McGraw-Hill Publications, 1st Edition, 2010.


**Web References:**

1. https://www.calvin.edu/~pribeiro/courses/engr315/EMFT_Book.pdf
2. https://www.web.mit.edu/viz/EM/visualizations/coursenotes/modules/guide02.pdf
3. https://www.nptel.ac.in/courses/108106073/
4. https://www.iare.ac.in

**E-Text Books:**

1. https://www.bookboon.com/en/electromagnetism-for-electronic-engineers
2. https://www.books.google.co.in/books/.../Fundamentals of Electromagnetic Fields
3. https://www.aliexpress.com/item/EBOOK...Electromagnetic-Fields-2

**Course Home Page:**