22EE240	ELECTROMAGNETIC FIELDS

Category	L	T	P	Credit
PC	2	1	0	3

Preamble

The Course is designed to impart knowledge of fundamentals of vector calculus, concept of electric and magnetic fields (both static and time varying) applicable to electrical engineering. The course exposes the students to the concept of resistance, capacitance, and Inductance. Students will get an idea about behaviour of field in materials (magnetic, conducting, insulating materials) at the interface of two different materials and their applications to Electrical Engineering. Force, torque, generator and transformer working principles are explained with Electromagnetic Fields.

Prerequisite

: Physics

: Engineering Mathematics – I

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the coordinate systems and vector calculus applicable to electric and magnetic fields.	TPS2	70	70
CO2	Compare the behavior of Electric and Magnetic field in free space and in material space using basic laws.	TPS2	70	70
CO3	Relate Voltage, Current and basic circuit laws using Electric fields	TPS3	70	70
CO4	Demonstrate Resistance, Inductance and capacitance with materials of different resistivity/Permeability /Permittivity and of different dimensions with the help of electric fields.	TPS3	70	70
CO5	Explain the force on a current carrying conductor and torque on a current loop subjected to magnetic fields	TPS2	70	70
CO6	Relate dynamic electric and magnetic fields with help of Faraday's Law and Maxwell's Equation, and, their applications to electrical machines	TPS3	70	70

*** Weightage depends on Bloom's Level, number of contact hours,

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests		Assignment		Terminal Examination
	1	**2**	1	2	
Remember	20	20			10
Understand	60	40			50
Apply	20	40	100	100	40
Analyze					
Evaluate					
Create					

Syllabus

Mathematical Foundation

Scalar, Vector, Vector addition, Subtraction and Multiplication, Coordinate Systems, Differential elements, Del operator, Gradient, Divergence and Curl of a vector, Divergence and Stoke's Theorem.

Electrostatic Fields

Coulomb's Law, Charge density, Electric field intensity, Electric flux density, Gauss law, Potential, Potential Difference, Basic circuit laws - verifications.

Material Characteristics - Current, Current Density, Conductivity/ Resistance of materials. Continuity equation and time constant. Permittivity / Dielectric Strength of materials and application to capacitance & electrical insulation. Multiple Dielectrics and field behavior at the interfaces. Calculation of capacitance for various applications and energy storage. Capacitance of Transmission lines and cables. Simulation of Electric Fields using FEM packages.

Magneto static Fields

Biot – Savart's Law and Ampere's Law, Magnetic flux density and Magnetic field Intensity, Field behaviour at interface of magnetic materials, Inductance, application to Energy Storage and Magnetic Circuits. Inductance of Transmission lines and cables. Simulation of Magnetic Fields using FEM packages.

Force and Torque

Force on a current carrying conductor subjected to a magnetic field, Torque on a current loop subjected to a magnetic field and working principle of motor.

Dynamic Fields

Faraday's Law of Electromagnetic Induction, Principle of operation of generator and transformer, Displacement current , Maxwell's equations, Poynting Theorem.

ASSIGNMENTS

1. Simulation of Electrical and Magnetic Fields using FEM packages.
2. Demonstration of Electric and Magnetic fields using simple experiments
3. Seminar on practical applications of electric and magnetic fields like working of copier machine, MRI Scan .

Learning Resources

1. William Hayt Jr. and John A. Buck , "Engineering Electromagnetics", TMH publishing co. ltd., 7th Edition, 2006.
2. John D. Kraus, "Electromagnetics", Mcgraw – Hill International Editions, 4th Edition, 1992.
3. Mathew N.O. Sadiku, "Principles of Electromagnetic Fields", 4th Edition, Oxford University Press, 2010.

4. K.A. Gangadhar and P.M. Ramanathan, "Electromagnetic Field Theory (Including Antennas and Wave Propagation)" Khanna Publishers– 2012

Course Contents and Lecture Schedule

Module No.	Topics	No. of Lecture Hours	Course Outcome
1.0	**Vector Calculus**		
1.1	Scalar, Vector, Vector addition, Subtraction and Multiplication	2	CO1
1.2	Coordinate Systems, Differential elements	2	CO1
1.3	Del operator, Gradient, Divergence and Curl of a vector, Divergence and Stoke's Theorem.	3	CO1
2.0	**Electrostatic Field**		
2.1	Coulomb's Law, Charge density, Electric field intensity,	2	CO2
2.2	Electric flux density, Gauss law and its applications	2	CO2
2.3	Potential, Potential Difference, Basic circuit laws - verifications	2	CO3
2.4	Material Characteristics - Current, Current Density, Conductivity of materials	3	CO3
2.5	Permittivity, Dielectric Strength of materials and application to capacitance & insulation	3	CO4
2.6	Multiple Dielectrics and field behavior at the interfaces.	1	CO4
2.7	Calculation of capacitance for various application and energy storage. Simulation of electric fields	3	CO4
2.8	Calculation of capacitance of transmission lines and cables.	1	CO4
3.0	**Magneto static Fields**		
3.1	Biot – Savart's Law and Ampere's Law, Magnetic flux density and Magnetic field Intensity, Field behaviour at the interface of magnetic materials	3	CO2
3.2	Inductance, application to Energy Storage and Magnetic Circuits	2	CO4
3.3	Inductance of a Transmission line and Cable	1	CO4
3.4	Simulation of magnetic fields	1	CO6
4.0	**Force and Torque**		
4.1	Force on a Current carrying conductor subjected to magnetic field.	1	CO5
4.2	Torque on a current carrying loop subjected to magnetic field, working principle of a motor	1	CO5
5.0	**Dynamic Fields**		
5.1	Faraday's Law, Principle of operation of generator and transformer.	1	CO6
5.2	Displacement current and Maxwell's equations	1	CO6
5.3	Poynting Theorem	1	CO6
	Total	**36**	

Course Designers:

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