INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTOR

Course Title	**ELECTRO MAGNETIC FIELD**				
Course Code	AEEB10				
Programme	B.Tech				
Semester	III	EEE			
Course Type	Professional Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr .B. Muralidhar Nayak, Assistant Professor, EEE				
Course Faculty	Mr .T. Anil Kumar, Assistant Professor, EEE Dr .B. Muralidhar Nayak, Assistant Professor, EEE				

I. COURSE OVERVIEW:

Electromagnetic theory field deals with vector algebra, principles and basic laws of electrostatics, characteristics and properties of conductors and dielectrics, behavior of static magnetic field and application of ampere law, determination of force in magnetic field and magnetic potential, concept of time varying fields and propagation of electro-magnetic waves.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AHSB02	I	Linear Algebra Calculus
UG	AHSB04	II	Waves And Optics

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Electromagnetic Field Theory	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✘	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five modules and module unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**			**Total Marks**
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz –Online Examination:
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT):
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts

the classroom into an effective learning centre. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

The AAT chosen for this course is given in section XI.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Assignment And Seminars
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Assignment And Seminars
PO 3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Assignment And Seminars

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO1	Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work.	2	Assignment And Seminars

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Demonstrate the concept of electrostatic field intensity and electric potential.
II	Illustrate polarization of dielectrics and the behavior of conductors and dielectrics in an electric field.
III	Understand the concept of field intensity and flux density in magnetic fields.
IV	Discuss forces in magnetic fields and laws of electromagnetic induction
V	Summarize the concept of time varying field and analyze propagation of electro-magnetic waves.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Determine the force and electric field intensity due various types of charge distribution with the help of vector calculus.	CLO 1	Analyze the force and electric field intensity in the electrostatic field with knowledge of vector algebra.
		CLO 2	Identify the characteristics of electrostatic fields in terms of definitions.

COs	Course Outcome	CLOs	Course Learning Outcome
		CLO 3	State different laws which defines characteristics of electrostatic fields.
CO 2	Estimate the capacitance of various configurations and study behaviour of charges in conductors and dielectrics.	CLO 4	Illustrate polarization of dielectrics and the behavior of conductors and dielectrics in electric field.
		CLO 5	Demonstrate the electric dipole and its effect on electric field.
		CLO 6	Estimate the capacitance of parallel plates, spherical and coaxial capacitors with composite dielectrics.
CO 3	Understand Bio-Savart's law and determine magnetic field intensity due different configuration of conductors, their other deductions.	CLO 7	Summarize the concept of magneto static and interrelate the terms of magnetic fields.
		CLO 8	Interpret the magnetic field intensity due to circular, square and solenoid current carrying wire.
		CLO 9	Use Ampere circuital law to determine magnetic field intensity due to an infinite sheet of current, a long current carrying filament and its applications.
CO 4	Calculate the magnetic force acting on body due to different configurations of conductors and deduce the magnetic potentials.	CLO 10	Predict the force due to moving charge in the magnetic field for different configuration of current carrying conductor.
		CLO 11	Demonstrate the magnetic dipole and its effect on magnetic field.
		CLO 12	Calculate the self inductance and mutual inductance for different configurations of wires and applications of permanent magnet.
CO 5	State Faraday's laws of electromagnetic induction in time varying fields and analyze wave propagation in electro-magnetic fields.	CLO 13	State the Faraday's laws of electromagnetic induction and nature of voltage induced in the coil.
		CLO 14	Derive and explain the differential and integral form of Maxwell's equation in time varying fields and fields varying harmonically with time.
		CLO 15	Discuss the electromagnetic wave propagation and its analysis.

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to	PO's Mapped	Strength of Mapping
AEE006.01	CLO 1	Analyze the force and electric field intensity in the electrostatic field with knowledge of vector algebra.	PO1,PO2	3
AEE006.02	CLO 2	Identify the characteristics of electrostatic fields in terms of definitions.	PO1	3
AEE006.03	CLO 3	State different laws which defines characteristics of electrostatic fields.	PO1	2
AEE006.04	CLO 4	Illustrate polarization of dielectrics and the behavior of conductors and dielectrics in electric field.	PO1	3
AEE006.05	CLO 5	Demonstrate the electric dipole and its effect on electric field.	PO1	2
AEE006.06	CLO 6	Estimate the capacitance of parallel plates, spherical and coaxial capacitors with composite dielectrics.	PO1,PO2, PO3	2
AEE006.07	CLO 7	Summarize the concept of magneto static and interrelate the terms of magnetic fields.	PO1	2
AEE006.08	CLO 8	Interpret the magnetic field intensity due to circular, square and solenoid current carrying wire.	PO1,PO2, PO3,	2
AEE006.09	CLO 9	Use Ampere circuital law to determine magnetic field intensity due to an infinite sheet of current, a long current carrying filament and its applications.	PO1,PO2, PO3	2

CLO Code	CLO's	At the end of the course, the student will have the ability to	PO's Mapped	Strength of Mapping
AEE006.10	CLO 10	Predict the force due to moving charge in the magnetic field for different configuration of current carrying conductor.	PO1,PO2	3
AEE006.11	CLO 11	Demonstrate the magnetic dipole and its effect on magnetic field.	PO1	2
AEE006.12	CLO 12	Calculate the self inductance and mutual inductance for different configurations of wires and applications of permanent magnet.	PO1,PO2	3
AEE006.13	CLO 13	State the Faraday's laws of electromagnetic induction and nature of voltage induced in the coil.	PO1	3
AEE006.14	CLO 14	Derive and explain the differential and integral form of Maxwell's equation in time varying fields and fields varying harmonically with time.	PO1	3
AEE006.15	CLO 15	Discuss the electromagnetic wave propagation and its analysis.	PO1,PO2, PO3	3
AEE006.16	CLO 16	Apply the concept of electromagnetic and electrostatic fields to solve real time world applications.	PO1,PO2, PO3	3
AEE006.17	CLO 17	Explore the knowledge and skills of employability to succeed in national and international level competitive examinations.	PO1,PO2, PO5, PO12	2

3 = High; 2 = Medium; 1 = Low

XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	**PO 2**	**PO 3**	**PSO1**
CO 1	2	3		2
CO 2	**2**	3	2	**2**
CO 3	1	3	2	2
CO 4	2	3		2
CO 5	2	3	**2**	**2**

XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CLO 1	3	2											2		
CLO 2	3												2		
CLO 3	2												3		
CLO 4	3												3		

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CLO 5	2												2		
CLO 6	2	2	3										3		
CLO 7	2												2		
CLO 8	2	3	2										3		
CLO 9	2	3	2										2		
CLO 10	2	3											2		
CLO 11	2														
CLO 12	2	3											3		
CLO 13	3												3		
CLO 14	3												2		
CLO 15	2	3											2		
CLO 16	3	3	2										3		
CLO 17	3	3			2							2	2		

3 = High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1,PO2, PO3	SEE Exams	PO1,PO2, PO3	Assignments	PO1,PO2, PO3	Seminars	PO1,PO2, PO3
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIV. ASSESSMENT METHODOLOGIES – INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

MODULE-I	**ELECTROSTATICS**
Introduction to Cartesian, cylindrical and spherical co-ordinates. Conversion of one type of co-ordinates to another; 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.	

MODULE-II	CONDUCTORS AND DIELECTRICS
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.	
MODULE-III	**MAGNETOSTATICS**
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. 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.	
MODULE-IV	**FORCE IN MAGNETIC FIELD AND MAGNETIC POTENTIAL**
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; 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.	
MODULE-V	**TIME VARYING FIELDS AND FINITE ELEMENT METHOD**
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. Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in loss dielectrics, Propagation in good conductors, Skin effect. Poynting theorem.	
Text Books:	
1 K.B. Madhu Sahu, " Eelectromagnetic Fields", Scitech Ltd., 2nd Edition. 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 AS Mahajan , AA Rangwala "Electricity And Magnetism", McGraw Hill Publications, 1st Edition, 2000. 3 MS Naidu , V Kamaraju "High Voltage Engineering", McGraw Hill Publications, 3rd Edition, 2013. 4 William H Hayt, John A Buck, "Problems and Solutions in Electromagnetics", McGraw Hill Publications, 1st Edition, 2010.	

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No.	Topics to be covered	CLOS	Reference
1	Introduction to vector algebra..	CLO1	T1: 1.1-1.3 R4:1.1-1.8
2	Analysis if different types of co-ordinates.	CLO1	T1: 1.12 R4:1.1-1.8
3	Conversion of different types of co-ordinates.	CLO1	T1: 1.12 R4:1.1-1.8
4	Introduction to electro static fields and coulomb's law.	CLO3	T1: 2.1-2.3 R2:2.3
5	Calculation Of Electric field intensity due to line and surface charges.	CLO1	T1:2.4-2.5 R2:3.2
6	Derive the work done in moving a point charge in an electrostatic field.	CLO1	T1:2.15 R2:2.9
7-9	Define electric potential, properties of potential function, potential gradient.	CLO2	T1:2.16-2.17 R2:2.9-2.10
10	State Gauss's law and application of Gauss's law.	CLO3	T1:2.13-2.14 R2:2.11
11	Deduce Maxwell's first law.	CLO3	T1:2.20 R2:2.11
12	Derive the Laplace's and Poisson's equations.	CLO1	T1:2.21 R2:3.5
13	Determine the solution of Laplace's equation in one variable.	CLO1	T1:2.21 R2:3.5
14	Introduction to Dipole moment.	CLO5	T1:3.1 R2:3.7
15	Write the expression for potential and electric field intensity due to an electric dipole.	CLO5	T1:3.2-3.3 R2:3.7
16	Find torque on an electric dipole in an electric field.	CLO5	T1:3.4 R2:3.7
17	Study behavior of conductors in an electric field.	CLO4	T1:4.1-4.2 R2:4.1
18	Understand electric field inside a dielectric material.	CLO4	T1:4.3,4.5 R2:5.1
19	Discuss on polarization, conductor and dielectric.	CLO4	T1:4.3.2,4.3.3 R2:5.2
20	Derive dielectric boundary conditions.	CLO4	T1:4.6 R2:5.4
21	Calculate capacitance of parallel plate and spherical and coaxial capacitors with composite dielectrics.	CLO6	T1:3.5.2-3.5.5 R2:4.3-4.4
22	Estimate capacitance of parallel plate and spherical and coaxial capacitors with composite dielectrics.	CLO6	T1:3.5.2-3.5.51 R2:4.3-4.4
23	Derive the expressions for energy stored and energy density in a static electric field.	CLO6	T1:3.5.7-3.5.8 R2:4.5
24	Define current density, conduction and convection current densities.	CLO6	T1:4.7-4.8 R2:6.1
25	Deduce Ohm's law in point form, equation of continuity.	CLO6	T1:4.9-4.10 R2:6.2
26	Introduction to static magnetic fields.	CLO7	T1:5.1-5.2 R2:7.1-7.2
27	State Biot-Savart's law and magnetic field intensity.	CLO8	T1:5.3-5.4 R2:7.4
28	Determine magnetic field intensity due to a straight current carrying filament.	CLO8	T1:5.4-5.7 R2:7.4

Lecture No.	Topics to be covered	CLOS	Reference
29	Determine magnetic field intensity due to circular.	CLO8	T1:5.4-5.7 R2:7.4
30	Find magnetic field for square and solenoid current carrying wire.	CLO8	T1:5.4-5.7 R2:7.4
31	Relation between magnetic flux, magnetic flux density and magnetic field intensity.	CLO7	T1:5.2.7 R2:7.3
32	Deduce Maxwell's second equation, div (B)=0.	CLO8	T1:5.8 R2:7.3
33	Determine magnetic field intensity due to an infinite sheet of current and a long current carrying filament.	CLO8	T1:6.3-6.4
34	Find magnetic field intensity due to an infinite sheet of current and a long current carrying filament.	CLO8	T1:6.3-6.4 R2:7.4
34-A	State point form of Ampere's circuital law.	CLO9	T1:6.1 R2:7.7
35	Deduce Maxwell's third equation, Curl (H)=Jc	CLO9	T1:6.2 R2:6.3
36	Estimate field due to a circular loop, rectangular and square loops.	CLO9	T1:6.3-6.4 R2:7.8
37	Determine field due to a circular loop, rectangular and square loops.	CLO9	T1:6.3-6.4 R2:7.8
38	Expression for force due to Moving charges in a magnetic field, Lorentz force equation.	CLO10	T1:7.1-7.4 R2:8.1
39-40	Expression for force on a current element in a magnetic field, force on a straight and a long current carrying conductor in a	CLO10	T1:7.3,7.5-7.7 R2:8.6
41	Find force between two straight long and parallel current carrying conductors.	CLO10	T1:7.5-7.7 R2:8.6
42	Explain magnetic dipole and dipole moment, a differential current loop as a magnetic dipole.	CLO11	T1:7.8 R2:8.6
43	Derive torque on a current loop placed in a magnetic field.	CLO11	T1:7.9 R2:8.7
44	Define vector magnetic potential and its properties.	CLO11	T1:8.2 R2:7.12-7.13
45	Define vector magnetic potential due to simple configurations.	CLO11	T1:8.2 R2:7.12-7.13
46	Explain Poisson's equations, self and mutual inductance.	CLO12	T1:8.3-8.4 R2:9.4-9.5
47	Derive Neumann's formula, determination of self-inductance of a solenoid, toroid.	CLO12	T1:8.5,8.3-8.4 R2:7.11
48	Determination of mutual inductance between a straight long wire and a square loop of wire in the same plane.	CLO12	T1:8.6 R2:7.11
49	Calculate energy stored and density in a magnetic field.	CLO12	T1:8.7-8.8 R2:7.11
50	Study characteristics and applications of permanent. magnets.	CLO12	T1:8.1
51	State Faraday's laws of electromagnetic induction.	CLO 13	T1:9.2,9.4 R2:9.1
52	Deduce integral and point forms.	CLO14	T1:9.3 R2:9.2
53	Derive Maxwell's fourth equation.	CLO14	T1:9.6 R2:9.2
54	Derive Curl (E)=∂B/∂t, statically and dynamically induced emf.	CLO14	T1:9.4 R2:12.2
55	Modification of Maxwell's equations for time varying fields.	CLO14	T1:9.8 R2:12.2
56	Define displacement current.	CLO14	T1:9.5 R2:12.1
57	Analysis of wave equation in phasor form.	CLO15	R4:11.1
58	Behavior of plane waves in homogeneous material.	CLO15	R4:11.1

Lecture No.	Topics to be covered	CLOS	Reference
59	Deducing wave equation in conductors and dielectrics.	CLO15	R4:11.2
60	Deducing wave equation in conductors and dielectrics.	CLO15	R4:11.2
61	State skin effect and derive pointing theorem.	CLO15	R4:11.4

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S. No	Description	Proposed Actions	Relevance With POs	Relevance With PSOs
1	Complete behavior of dielectrics.	Seminars / NPTEL	PO1, PO2	PSO1
2	Analytical calculations of magnetic field in air gap.	NPTEL	PO1, PO2	PSO1

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