SARDAR RAJA COLLEGE OF ENGINEERING, ALANGULAM

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

MICRO LESSON PLAN

SUBJECT : ELECTROMAGNETIC FIELDS

CODE : EC 2253

CLASS : II Year / IV SEM

STAFF: Ms. M. SYED FATHIMUTHU, Asst. Prof,

DEPT. OF ECE

EC 2253 ELECTROMAGNETIC FIELDS 3 1 0 4

UNIT I STATIC ELECTRIC FIELDS 9

Introduction to Co-ordinate System – Rectangular – Cylindrical and Spherical Co-ordinate System – Introduction to line, Surface and Volume Integrals – Definition of Curl, Divergence and Gradient – Meaning of Stokes theorem and Divergence theorem

Coulomb's Law in Vector Form – Definition of Electric Field Intensity – Principle of Superposition – Electric Field due to discrete charges – Electric field due to continuous charge distribution - Electric Field due to charges distributed uniformly on an infinite and finite line – Electric Field on the axis of a uniformly charged circular disc – Electric Field due to an infinite uniformly charged sheet.

Electric Scalar Potential – Relationship between potential and electric field - Potential due to infinite uniformly charged line – Potential due to electrical dipole - Electric Flux Density – Gauss Law – Proof of Gauss Law – Applications.

UNIT II STATIC MAGNETIC FIELD 9

The Biot-Savart Law in vector form – Magnetic Field intensity due to a finite and infinite wire carrying a current I – Magnetic field intensity on the axis of a circular and rectangular loop carrying a current I – Ampere's circuital law and simple applications.

Magnetic flux density – The Lorentz force equation for a moving charge and applications – Force on a wire carrying a current I placed in a magnetic field – Torque on a loop carrying a current I – Magnetic moment – Magnetic Vector Potential.

UNIT III ELECTRIC AND MAGNETIC FIELDS IN MATERIALS 9

Poisson's and Laplace's equation – Electric Polarization-Nature of dielectric materials-Definition of Capacitance – Capacitance of various geometries using Laplace's equation – Electrostatic energy and energy density – Boundary conditions for electric fields – Electric current – Current density – point form of ohm's law – continuity equation for current.

Definition of Inductance – Inductance of loops and solenoids – Definition of mutual inductance – simple examples. Energy density in magnetic fields – Nature of magnetic materials – magnetization and permeability - magnetic boundary conditions.

UNIT IV TIME VARYING ELECTRIC AND MAGNETIC FIELDS 9

Faraday's law – Maxwell's Second Equation in integral form from Faraday's Law – Equation expressed in point form.

Displacement current – Ampere's circuital law in integral form – Modified form of Ampere's circuital law as Maxwell's first equation in integral form – Equation expressed in point form. Maxwell's four equations in integral form and differential form.

Poynting Vector and the flow of power – Power flow in a co-axial cable – Instantaneous Average and Complex Poynting Vector.

UNIT V ELECTROMAGNETIC WAVES 9

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 lossy dielectrics – Propagation in good conductors – Skin effect.

Linear, Elliptical and circular polarization – Reflection of Plane Wave from a conductor – normal incidence – Reflection of Plane Waves by a perfect dielectric – normal and oblique incidence. Dependence on Polarization. Brewster angle.

TUTORIAL 15 TOTAL : 60

TEXTBOOKS

1. W H.Hayt & J A Buck : "Engineering Electromagnetics" TATA McGraw-Hill, 7th Edition 2007 (Unit I,II,III).
2. E.C. Jordan & K.G. Balmain "Electromagnetic Waves and Radiating Systems." Pearson Education/PHI 4nd edition 2006. (Unit IV, V).

REFERENCES

1. Matthew N.O.Sadiku: "Elements of Engineering Electromagnetics" Oxford University Press, 4th edition, 2007
2. Narayana Rao, N : "Elements of Engineering Electromagnetics" 6th edition, Pearson Education, New Delhi, 2006.
3. Ramo, Whinnery and Van Duzer: "Fields and Waves in Communications Electronics" John Wiley & Sons ,3rd edition 2003.
4. David K.Cheng: "Field and Wave Electromagnetics - Second Edition-Pearson Edition, 2004.
5. G.S.N. Raju, Electromagnetic Field Theory & Transmission Lines, Pearson Education, 2006

SUBJECT DESCRIPTION AND OBJECTIVES

AIM

To familiarize the student to the concepts, calculations and pertaining to electric, magnetic and electromagnetic fields so that an in depth understanding of antennas, electronic devices, Waveguides is possible.

OBJECTIVES

- To analyze fields a potentials due to static changes
- To evaluate static magnetic fields
- To understand how materials affect electric and magnetic fields
- To understand the relation between the fields under time varying situations
- To understand principles of propagation of uniform plane waves.

DESCRIPTION

An electromagnetic field (also EMF or EM field) is a physical field produced by moving electrically charged objects. It affects the behavior of charged objects in the vicinity of the field. The electromagnetic field extends indefinitely throughout space and describes the electromagnetic interaction. It is one of the four fundamental forces of nature (the others are gravitation, the weak interaction, and the strong interaction).

The field can be viewed as the combination of an electric field and a magnetic field. The electric field is produced by stationary charges, and the magnetic field by moving charges (currents); these two are often described as the sources of the field. The way in which charges and currents interact with the electromagnetic field is described by Maxwell's equations and the Lorentz force law.

MICRO LESSON PLAN

Hours	LECTURE TOPICS	READING
UNIT I STATIC ELECTRIC FIELDS		
1	Subject introduction & Review of vectors	T1
2	Introduction to Co-ordinate System - Rectangular –,Cylindrical and Spherical Co-ordinate System	T1
3	Introduction to line, Surface and Volume Integrals , Definition of Curl, Divergence and Gradient	T1
4	Meaning of Stokes theorem and Divergence theorem	T1
5	Coulomb's Law in Vector Form , Definition of Electric Field Intensity ,Principle of Superposition (AV Class)	T1
6	Electric Field due to discrete charges , Electric field due to continuous charge distribution ,Electric Field due to charges distributed uniformly on an infinite and finite line	T1
7	Electric Field on the axis of a uniformly charged circular disc, Electric Field due to an infinite uniformly charged sheet. (AV Class)	T1
8	Electric Scalar Potential – Relationship between potential and electric field	T1
9	Potential due to infinite uniformly charged line , Potential due to electrical dipole	T1
10	Electric Flux Density ,Gauss Law – Proof of Gauss Law	T1
11	Applications of Gauss Law (AV Class)	T1
12	Problems	T1
UNIT II STATIC MAGNETIC FIELD		
13	The Biot-Savart Law in vector form	T1
14	Magnetic Field intensity due to a finite and infinite wire carrying a current I	T1
15	Magnetic field intensity on the axis of a circular and rectangular loop carrying a current I	T1
16	Ampere's circuital law proof	T1
17	simple applications of Ampere's circuital law	T1
18	Magnetic flux density – The Lorentz force equation for a moving charge and applications (AV Class)	T1
19	Force on a wire carrying a current I placed in a magnetic field	T1
20	Torque on a loop carrying a current I	T1
21	Magnetic moment – Magnetic Vector Potential.	T1
22	Problems	T1
23		
24		

UNIT III ELECTRIC AND MAGNETIC FIELDS IN MATERIALS		
25	Poisson's and Laplace's equation	T1
26	Electric Polarization-Nature of dielectric materials- Definition of Capacitance	T1
27	Capacitance of various geometries using Laplace's equation (AV Class)	T1
28	Electrostatic energy and energy density	T1
29	Boundary conditions for electric fields	T1
30	Electric current – Current density – point form of ohm's law	T1
31	continuity equation for current	T1
32	Definition of Inductance – Inductance of loops and solenoids	T1
33	Definition of mutual inductance – simple examples (AV Class)	T1
34	Energy density in magnetic fields – Nature of magnetic materials	T1
35	magnetization and permeability	T1
36	magnetic boundary conditions	T1
37	Problems	T1
UNIT IV TIME VARYING ELECTRIC AND MAGNETIC FIELDS		
38 39	Faraday's law – Maxwell's Second Equation in integral form from Faraday's Law – Equation expressed in point form. (AV Class)	T2
40	Displacement current – Ampere's circuital law in integral form	T2
41	Modified form of Ampere's circuital law as Maxwell's first equation in integral form – Equation expressed in point form	T2
42	Maxwell's four equations in integral form and differential form	T2
43	Poynting Vector and the flow of power	T2
44	Power flow in a co-axial cable	T2
45	Instantaneous Average and Complex Poynting Vector	T2
46,47 48,49	Problem	T2
UNIT V ELECTROMAGNETIC WAVES		
50	Derivation of Wave Equation (AV Class)	T2
51	Uniform Plane Waves	T2
52	Maxwell's equation in Phasor form – Wave equation in Phasor form	T2
53	Plane waves in free space and in a homogenous material.	T2
54	Wave equation for a conducting medium	T2
55	Plane waves in lossy dielectrics	T2
56	Propagation in good conductors – Skin effect	T2
57	Linear, Elliptical and circular polarization	T2
58	Reflection of Plane Wave from a conductor – normal incidence	T2
59 60	Reflection of Plane Waves by a perfect dielectric – normal and oblique incidence	T2 T2
61	Dependence on Polarization. Brewster angle	T2
62	Problems	T2

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DEPT. OF ECE

B.E./B.Tech. DEGREE EXAMINATIONS, NOV./DEC. 2011

Regulations 2008

Fourth Semester

Electronics and Communication Engineering

EC 2253 Electromagnetic Fields

Time: Three Hours Maximum: 100 marks

Answer ALL Questions

Part A – (10 x 2 = 20 marks)

1. State Coulomb's law of electrostatic charges.
2. A point charge +2 nC is located at the origin. What is the value of potential at P (1, 0, 0) m?
3. State Biot-Savart's law in vector form.
4. A negative point charge, Q = 40 nC is moving with a velocity of 6x 106 m/s in a direction specified by the unit vector av = 0.48ax 0.6ay + 0.64az. Find the magnitude of the vector force exerted on the moving particle by the field B = 2ax 3ay + 5az mT.
5. Express Laplace equation in spherical coordinates.
6. Define Magnetization.
7. Write down any two of the Maxwell's equations for free space in integral form.
8. What is the electric field and the power flow in the co-axial cable?
9. What is meant by skin effect? Mention its significance.
10. An EM wave has electric component given by, E = E0 sin(ωt -βz)(a x+ a y) V/m. Comment on the polarization of the wave.

Part B – (5 x 16 = 80 marks)

11. (a) (i) Assume a straight line charge extending along the z axis in a cylindrical coordinate system from 1 to 1. Determine the electric field intensity E at every point resulting from a uniform line charge density ?L C/m. (8)

(ii) Consider an infinite uniform line charge of 5 nC/m parallel to z axis at x = 4, y = 6. Find the electric field intensity at the point P(0, 0, 5) in free space. (8)

OR

11. (b) (i) The flux density within the cylindrical volume bounded by r = 2 m, z = 0 and z = 5 m is given by D = 30e?r ar 2z az C/m2. What i s the total outward flux crossing the surface of the cylinder. (8)

(ii) State and prove Gauss's law for the electric field. Also give the differential form of Gauss law. (8)

12. (a) (i) Find the magnetic field intensity due to a finite wire of carrying a current I and hence deduce an expression for magnetic field intensity at the centre of a square loop. (8)

(ii) A circular loop located on x2 + y2 = 4, z = 0 carries a direct current of 7 A along ba?. Find the magnetic field intensity at (0, 0,- 5). (4)

(iii) Using Ampere's circuital law determine the magnetic field intensity due to a infinite long wire carrying a current I. (4)

OR

12. (b) (i) Find the force on a wire carrying a current of 2 mA placed in the xy plane bounded by x = 1, x = 3, y = 0 and y = 2 as shown in figure. The magnetic field i s due to a long conductor, located in y-axis, carrying a current of 15 A as shown. (8)

(ii) A differential current element Idz baz is located at the origin in free space.Obtain the expression for vector magnetic potential due to the current element and hence find the magnetic field intensity at the point (ρ, φ, z). (8)

13. (a) (i) A metallic sphere of radius 10 cm has a surface charge density of 10 nC/m2. Calculate the energy stored in the system. (4)

(ii) State and explain the electric boundary conditions between two dielectrics with permittivities ε1 and ε 2. (8)

(iii) Derive the expression for continuity equation of current in differential form. (4)

OR

13. (b) (i) Derive an expression for inductance of a solenoid with N turns and l metre length carrying a current of I amperes. (6)

(ii) An iron ring of relative permeability 100 is wound uniformly with two coils of 100 and 400 turns of wire. The cross section of the ring is 4cm2. The mean circumference i s 50 cm. Calculate (10)

(1) the self inductance of each of the two coils

(2) the mutual inductance

(3) Total inductance when the coils are connected in series with flux in the same sense

(4) Total inductance when the coils are connected in series with flux in the opposite sense.

14. (a) (i) Derive an expression for displacement current density Jd. (6)

(ii) A rectangular loop of length a = 1 m and width b = 80 cm is placed in a uniform magnetic field. Calculate the maximum value of induced emf if the magnetic flux density B = 0.1 Wb/m2 is constant and the loop rotates with a frequency of 50 Hz. (6)

(iii) Give the physical interpretation of Maxwell's First and second equation. (4)

OR

14. (b) (i) State and prove Poynting theorem. (10)

(ii) In free space, E = 50 cos(ωt -βz) az V/m. Find the average power crossing a circular area of radius 2.5 m in the plane z = 0. Assume Em = Hmη0 and η0 = 120πΩ. (6)

15. (a) (i) From the Maxwell's equation, derive the electromagnetic wave equation in conducting medium for E and H fields. (10)

(ii) The Electric fields associated with a plane wave traveling in a perfect dielectric medium is given by Ez(z, t) = 10 cos[2π x 107 t - 0.1π x] V/m. Find the velocity of propagation, and intrinsic impedance. Assume μ = μ0. (6)

OR

15. (b) A uniform plane wave in free space i s normally incident on a dielectric having relative permittivity 4 and relative permeability 1. The electric field of incident wave i s given by E = E0 e^{-jz} ax to z < 0, where E0 is a real constant. Calculate (i) Frequency and wave length of incident and transmitted waves. (4)

(ii) Magnetic field of incident wave (3)

(iii) Transmission coefficient and the expression for the electric field of the transmitted wave (6)

(iv) Expression for the magnetic field of the transmitted wave. (3)