Reg. No. | | | | | | | | | | |

Question Paper Code: 55334

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 6×10^6 m/s in a direction specified by the unit vector $\overline{a}_v = -0.48\overline{a}_x - 0.6\overline{a}_y + 0.64\overline{a}_z$. Find the magnitude of the vector force exerted on the moving particle by the field $\overline{B} = 2\overline{a}_x - 3\overline{a}_y + 5\overline{a}_z$ 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, $E = E_0 \sin(\omega t - \beta z)(\overrightarrow{a}_x + \overrightarrow{a}_y)$ 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 $-\infty$ to ∞. Determine the electric field intensity $\overline{E}$ at every point resulting from a uniform line charge density ρ_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 $\overline{D} = 30e^{-r}\,\overline{a_r} - 2z\,\overline{a_z}$ C/m^2. What is 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)

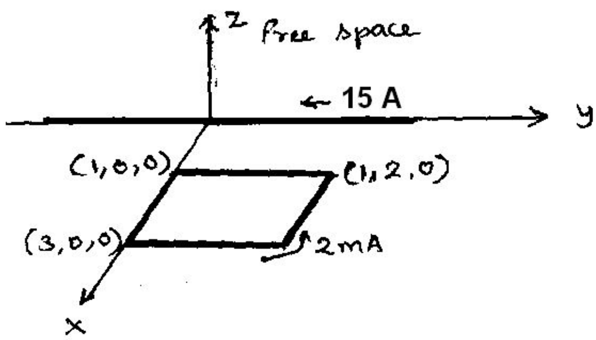
12. (a) (i) Find the magnetic field intensity due to a finite wire of carrying a current I and hence deduce an expression for magnetic field intensity at the centre of a square loop. (8)

(ii) A circular loop located on $x^2 + y^2 = 4, z = 0$ carries a direct current of 7 A along $\widehat{a}_\emptyset$. 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 is due to a long conductor, located in y-axis, carrying a current of 15 A as shown. (8)



(ii) A differential current element $Idz\,\widehat{a}_z$ 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/m^2. Calculate the energy stored in the system. (4)

(ii) State and explain the electric boundary conditions between two dielectrics with permittivities ε_1 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 $4cm^2$. The mean circumference is 50 cm. Calculate

(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. (10)

14. (a) (i) Derive an expression for displacement current density J_d. (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 $B = 0.1\ Wb/m^2$ 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, $\overline{E} = 50\cos(\omega t - \beta z)\ \overline{a_x}$ V/m. Find the average power crossing a circular area of radius 2.5 m in the plane $z = 0$. Assume $E_m = H_m \eta_0$ and $\eta_0 = 120\pi\ \Omega$. (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 $E_x(z,t) = 10\cos[2\pi \times 10^7\ t - 0.1\pi\ x]$ V/m. Find the velocity of propagation, and intrinsic impedance. Assume $\mu = \mu_0$. (6)

OR

15. (b) A uniform plane wave in free space is normally incident on a dielectric having relative permittivity 4 and relative permeability 1. The electric field of incident wave is given by $\overline{E} = E_0\ e^{-j z}\ \overline{a}_x$ to $z < 0$, where E_0 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)

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