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Question Paper Code : 77117

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2015.

Fourth Semester

Electronics and Communication Engineering

EC 6403 — ELECTROMAGNETIC FIELDS

(Regulation 2013)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define line charge density. Write its unit.
2. Write the equation for Gauss law.
3. Define current density at a given point.
4. Write the relation between perfect conductor and electrostatic field.
5. Define magnetic scalar potential.
6. Write the relation between magnetic flux and magnetic flux density.
7. Write an expression for torque in vector form.
8. Write the expressions for energy stored in magnetic field.
9. State Faraday's law for a moving charge in a constant magnetic field.
10. State Poynting theorem.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Transform $\vec{A} = y\vec{a}_x + x\vec{a}_y + \frac{x^2}{\sqrt{x^2+y^2}}\vec{a}z$ from cartesian to cylindrical co-ordinates. (8)

(ii) A charge $+Q$ is located at $A(-a,0,0)$ and another charge $-2Q$ is located at B(a,0,0). Show that the neutral point also lies on the x – axis, where $x = -5.83$a. (8)

Or

(b) (i) Derive coulomb's law starting from Gauss theorem. State any reasonable assumptions which you think are necessary for the derivation. (10)

(ii) What maximum charge can be put on a sphere of radius 1m, if the breakdown of air is to be avoided? For break down of air, $E = 3 \times 10^6$ V/m. (6)

12. (a) (i) Each of two dielectrics (of relative permittivities $\in r_1$ and $\in r_2$ respectively) occupies one-half the volume of the annular space between the electrodes of a cylindrical capacitor such that the interface plane between the dielectrics is a rz plane. Show that the two dielectrics act like a single dielectric having the average relative permittivity. (8)

(ii) If $\vec{J} = \frac{1}{r^3}(2\cos\theta\,\vec{a}_r + \sin\theta\,\vec{a}_\theta)$ A/m², calculate the currrent through

(1) a hemispherical shell of radius 20 cm

(2) a spherical shell of radius 10 cm. (8)

Or

(b) (i) A capacitor of capacitance C is charged to a voltage V. At a particular time, this capacitor is connected to a second capacitor also of value C, but containing no charge. What will be the final voltage? (10)

(ii) A wire of dia 1 mm and conductivity 5×10^7 S/m has 10^{29} free electronics/m³ when an E-field of 10 mV/m is applied. Find charge density of free electronics, current density and current in the wire. (6)

13. (a) (i) Magnetic vector potential $\vec{A} = \frac{-\rho^2}{4}\vec{a}_z$ Wb/m, calculate the total magnetic flux crossing the surface $\phi = \frac{\pi}{2}, 1 \le \rho \le 2m,\ 0 \le z \le 5m$. (8)

(ii) $\vec{H} = 3\cos x\vec{a}_x + z\cos x\,\vec{a}y$, A/m for $z \ge 0$ and $\vec{H} = 0$ for $z < 0$. This magnetic field is applied to a perfectly conducting surface in xy plane. Find current density on conductor surface. (8)

Or

(b) (i) Obtain the expression for magnetic field intensity at the centre of a circular wire. (8)

(ii) At a point $P(x, y, z)$ the components of vector magnetic potential $\vec{A}$ are given as $Ax = 4x + 3y + 2z$; $Ay = 5x + 6y + 3z$; $A_z 2x + 3y + 5z$. Find $\vec{B}$ at point P. (4)

(iii) Explain the magnetic field intensity due to a straight wire. (4)

14. (a) (i) A steady current with normal component J_n is flowing across the interface between the two conducting media of conductivities σ_1 and σ_2 and permittivities $\in_1$ and $\in_2$ respectively. Show that there must be a surface charge density on the interface. Find its magnitude. (6)

(ii) Find the magnetic field of current in a straight circular cylindrical conductor of radius "a", and express the magnetic field as a vector in terms of current density, $\vec{J}$. (10)

Or

(b) A composite conductor of cylindrical cross section used in overhead lines is made of a steel inner wire of radius R_i and an annular outer conductor of radius R_o, the two having electrical contact. Find the magnetic field within the conductors and the internal self inductance per unit length of the composite conductor. (16)

15. (a) (i) Is it possible to construct a generator of emf which is constant and does not vary with time by using the principle of EM inductor? Explain. (6)

(ii) In a parallel plate capacitor, a time-varying current $i(t) = I_m \cos wt$ flows through its leads. The places have the surface area S and the distance between them is d. show that the displacement current through the capacitor is exactly I_m coswt. Ignore the fringing effects. (10)

Or

(b) (i) If $\vec{D} = 20x\,\vec{a}_x - 15y\,\vec{a}_y + kz\,\vec{a}_z \mu C/m^2$, find the value of K to satisfy Maxwell's equations for region $\sigma = 0$ and $\rho_v = 0$. (4)

(ii) If $\vec{H} = (3x\cos(3 + 6y\sin\alpha))\vec{a}_z$, find $\vec{J}$ if fields are invariant with time. (4)

(iii) Derive the expression for total power flow in a coaxial cable. (8)