[This question paper contains 2 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5786 **K**

Unique Paper Code : 2512013502

Name of the Paper : Electromagnetics

Name of the Course : **B.Sc. (H) Electronics (CORE)**

Semester : V

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. There are **seven** questions in all, out of which you have to attempt any **five** questions.
3. **All** questions carry equal marks.
4. **First** Question is Compulsory.

1. Attempt any *six*.

   a) State Gauss's law. Deduce Coulomb's law from Gauss's law.

   b) Show that net effect of the dielectric on the electric field E is to increase the electric flux density D inside it by an amount P (polarization).

   c) Let $\boldsymbol{A} = \frac{20}{\rho}\, \boldsymbol{a_\rho}$ be an arbitrary field. Does it represent either electrostatic or magnetostatic field in free space?

   d) If $\boldsymbol{Q_s} = e^{jx}\,(\boldsymbol{a_x} - \boldsymbol{a_z})\sin(\pi y)$, determine its instantaneous form.

   e) Explain the term loss tangent. How is it related to the permittivity of the medium? What is its significance?

   f) If $\boldsymbol{J} = \frac{1}{r^2}\,(2\cos\theta\, \boldsymbol{a_r} + \sin\theta\, \boldsymbol{a_\theta})\ A/m^2$, calculate the current passing through a spherical shell of radius 10 cm.

   g) Show that a Plane electromagnetic wave travels in free space as transverse electromagnetic wave. (6 × 3)

2. (a) Use Gauss's theorem to find the electric field intensity E and Electric flux density D due to a uniformly charged sphere having uniform charge density ρ_v, at a point
   (i) outside the sphere and
   (ii) inside the sphere. (6)

   (b) Derive the continuity of the current equation. Solve the equation to obtain an expression for the volume charge density in terms of relaxation time. Explain why a charge inside a good dielectric remains wherever placed. (8)

   (c) The region between two concentric right circular cylinders contains a uniform charge density ρ_v. Find potential between the cylinders. (4)

3. (a) The *xy*-plane serves as the interface between two different media. Medium 1 ($z < 0$) is filled with a material whose $\mu_r = 6$ and medium 2 ($z > 0$) is filled with a material whose $\mu_r = 4$. If the interface carries current $(1/\mu_0)\boldsymbol{a_y}\ mA/m$, and $\boldsymbol{B_2} = 5\boldsymbol{a_x} + 8\boldsymbol{a_z}\ mWb/m^2$, Find $\boldsymbol{H_1}$ and $\boldsymbol{B_1}$. (9)

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(b) Obtain an expression for magnetic flux density due a magnetic dipole. Draw the magnetic flux density lines.

Given the magnetic vector potential $\boldsymbol{A} = \frac{-\rho^2}{4}\,\boldsymbol{a_z}$ Wb/m, calculate the total magnetic flux crossing the surface $\emptyset = \frac{\pi}{2}, 1 \leq \rho \leq 2\,m, 0 \leq z \leq 5\,m$. (9)

4. a) State and prove uniqueness theorem. (5)

b) Given the vector field

$\boldsymbol{C} = (16xy - z)\boldsymbol{a_x} + 8x^2\,\boldsymbol{a_y} - x\,\boldsymbol{a_z}$

(i) Is $\boldsymbol{C}$ irrotational? (ii) Find the net flux of $\boldsymbol{C}$ over the cube $0 < x, y, z < 1$. (7)

c) Find the current density J to the magnetic vector potential $\boldsymbol{A} = \frac{10}{\rho^2}\,\boldsymbol{a_z}$ Wb/m^2. (6)

5. a) What is Lorentz condition for potentials? Derive wave equation for electric scalar potential and magnetic vector potential. (8)

b) The electric field and magnetic field in free space are given by

$$E = \frac{50}{\rho}\cos(10^6 t + \beta z)\,\boldsymbol{a_\phi}\ V/m$$

$$H = \frac{H_0}{\rho}(10^6 t + \beta z)\,\boldsymbol{a_\rho}\ A/m$$

Express these in phasor form and determine the constants H_0 and β such that the fields satisfy Maxwell's equations. (10)

6. a) Derive wave equation for electromagnetic wave propagating in free space. Find the expressions for propagation constant, wave velocity and intrinsic impedance. (9)

b) A lossy dielectric has intrinsic impedance of $200\angle 30^0\ \Omega$ at a particular frequency. If, at that frequency, the plane wave propagating through the dielectric has magnetic field component

$$\boldsymbol{H} = 10e^{-\alpha x}\cos\left(\omega t - \frac{1}{2}x\right)\,\boldsymbol{a_y}\quad A/m$$

Find $\boldsymbol{E}$ and α. Determine the skin depth and wave polarization. (9)

7. a) What is meant by polarization of a wave? Two orthogonal linearly polarized waves of the same frequency are combined. State the conditions under which the resultant will be

(i) another linearly polarized wave (ii) an elliptically polarized wave. (8)

b) A conductor with cross-sectional area of 10 cm^2 carries a conduction current $0.2\,sin10^9 t$ mA . Given that $\sigma = 2.5 \times 10^6$ S/m and $\varepsilon_r = 6$, calculate the magnitude of the displacement current density. (6)

c) Show that a plane wave travelling through a conductor suffers exponential damping. How does skin depth vary with frequency of the wave? (4)

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