*Total number of printed pages – 4*

**B. Tech**

**CPEE 5307**

## Sixth Semester Examination – 2009

## ELECTROMAGNETIC THEORY

**Full Marks – 70**

**Time : 3 Hours**

*Answer Question No. 1 which is compulsory and any **five** from the rest.*

*The figures in the right-hand margin indicate marks.*

1. Explain the followings : 2×10

   (a) Vector $A = a_r 3\cos\phi - a_\varphi 2r\,\frac{1}{2} + a_z r\varphi$ is given.

   (i) Transform the vector to Cartesian co-ordinates.

   (ii) Find the scalar components of vector in spherical co-ordinates.

   (b) Find $\nabla . A$ at $(R = 2, \theta = 30°, \varphi = 90°)$ for the vector field $A = a_R\ 0.2\ R^3 \phi \sin^2\theta + a\theta\, 0.2R^3\phi\sin^2\theta + a\phi\, 0.2R^3\phi\sin^2\theta$

**P.T.O.**

(c) Verify the divergence theorem for $A = a_x 4x - a_y 2y^2 - a_z 2z^2$ for the region bounded by $x^2 + y^2 = 9$ and $z = -2$, $z = 2$ by evaluating the volume and surface integrals.

(d) If the general vector field $A = 5e^{-r}\cos\varphi a_r - 5\cos\varphi a_z$ in cylindrical co-ordinates, find curl A at $(2, 3\pi/2, 0)$.

(e) What are magnetic scalar and vector potential functions ?

(f) Show the relationship between magnetic susceptibility and magnetic permeability.

(g) Note down the time harmonic source free Maxwell's equations.

(h) What is the significance of TE and TM waves ?

(i) State the difference between phase and group velocities.

(j) What is a Poynting vector and what is its physical interpretation ?

2. A coaxial capacitor with inner radius 5 mm, outer radius 6 mm and length 500 mm has a dielectric for which $\varepsilon_r = 6.7$ and an applied voltage $250 \sin 377t$ (v). Determine this displacement current $i_D$ and compare with conduction current $i_C$. 10



3. An interface between two general materials contains both a current density given as $J_s = a_x\ 10^5$ A/m and a uniform surface charge density given as $\rho_s = 10^{-9}$ C/m$^2$. The static magnetic field intensity and static electric field intensity in materials (1) are given as : 10

$H_1 = a_x\ 10^5 + a_y\ 10^5 - a_z\ 10^5$ [A/m]

$E1 = a_x\ 100 + a_y\ 20 - a_z\ 100$ [V/m]

For material properties given ($\mu_1 = 2\mu_0$, $\mu_2 = \mu_0$, $\varepsilon_1 = 4\varepsilon_0$ and $\varepsilon_2 = 2\varepsilon_0$) find :

(a) The electric field intensity in material (2)

(b) The magnetic flux density in material (2)

4. (a) If the electric field $E = 2xa_x - 4ya_y$ (V/m). Find the work done in moving a point charge +2C : 5

(i) From (2, 0, 0)m to (0, 0, 0) and then from (0, 0, 0) to (0, 2, 0)

(ii) From (2, 0, 0) to (0, 2, 0) along the straight line path joining the two points.

(b) Find the potential at $r_A = 5$ m with respect to $r_B = 15$ m due to a point charge Q = 500 pC at the origin and zero reference at infinity. 5

5. In spherical co-ordinate V = −25v on a conductor at r = 2 cm and V = 150v at r = 35 cm. The space between the conductors is a dielectric for which $\varepsilon_r$ = 3.12. Find the surface charge densities on the conductors. 10

6. For a lossy dielectric, prove that the intrinsic impedance is given by,

$$\eta = \frac{j\omega\mu}{\gamma} = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\epsilon}} \ [\Omega]. \qquad 10$$

7. What do you mean by polarization of plane waves ? Explain elliptical and circular polarization with suitable diagrams. 10

8. Write short notes on any *two* : 5×2

(a) Radiation Resistance

(b) Bandwidth

(c) Efficiency

(d) Directivity.