Code No. : 3274

FACULTY OF ENGINEERING
B.E. 2/4 (ECE) I Semester (Main) Examination, December 2010
ELECTROMAGNETIC THEORY

Time : 3 Hours] [Max. Marks : 75

Note : 1) Answer all questions from Part – A.

2) Answer five questions from Part – B.

PART – A (25 Marks)

1. Write the expression for $\nabla \times \vec{A}$ in cylindrical co-ordinates. 2

2. Write the expression for the Dirac delta function $\delta(\vec{r} - \vec{r_0})$ in cylindrical and spherical co-ordinate systems. 3

3. For a two dimensional system in which $r = \sqrt{x^2 + y^2}$. Write the expression for $\nabla^2 V$. 3

4. A scalar function V is independent of 'x' and 'z'. The gradient of V is '20 y' in the y-direction. Given V = 10 at y = 0, find 'V'. 3

5. Determine the divergence and curl of $\vec{A} = x^2 \vec{a_x} - y^2 \vec{a_y}$ where $\vec{a_x}$, $\vec{a_y}$ are unit vectors along x and y axis respectively. 3

6. A circular loop of 10 cm radius is located in the x – y plane in a $\vec{B}$ field given by $\vec{B} = (0.5 \cos 37\ t)(3\vec{a_y} + 4\vec{a_z})$ (T1 determine the voltage induced in the loop). 3

7. Express the magnetic vector potential directly in terms of source current. 2

8. A losses dielectric has $\in_r = 10, \mu_r = 1, \sigma = 20n\ S/m$. An electric field $\vec{E} = 200 \sin \omega t\ \vec{a_z}(V/m)$ exists in the dielectric. At what frequency will the conduction current density and the displacement current density have equal amplitudes ? 2

9. Show that for a sinusoidally varying field, the conduction current and the displacement current are always displaced from each other by 90° in time. 2

10. The electric and magnetic fields in free space in a spherical co-ordinate system are

$$\vec{E} = \frac{10}{r} \sin\theta \cos\left(\omega t - \frac{4\pi}{3}\right) \vec{a_\theta}\ V/m$$

$$\vec{H} = \frac{10}{120\pi r} \sin\theta \cos\left(\omega t - \frac{4\pi}{3}\right) \vec{a_\phi}\ A/m$$

Determine the instantaneous power flow. 2

PART – B **(50 Marks)**

11. a) Determine by integration, the volume 'V' of a region defined in a cylindrical co-ordinate system as $1 \le r \le 2m$, $0 \le \phi \le \frac{\pi}{3}$ radians, and $0 \le z \le 1$ m. Sketch the appropriate figure. 5

b) Derive the identity $\text{div}\left(g\vec{F}\right) = g\ \text{div}\ \vec{F} + (\text{grad}\ g) \cdot \vec{F}$ where $\vec{F}$ is any vector field and 'g' is any scalar field. 5

12. a) A circular disk of radius 3 m carries a uniformly distributed charge of $450\pi\,\mu C$. Calculate the force on a $75\,\mu C$ charge located on the axis of the disk and 4 m from its centre. Draw the appropriate figure. 5

b) Obtain an expression for the capacitance of an isolated sphere of radius 'R'. 5

13. a) Derive a set of solutions to Laplace's equation in cylindrical co-ordinates starting with $V = R\phi$. 5

b) A very long conducting cylinder of radius 'a' has a charge 'q' Coulombs/meter distributed along its length. Find the electric field strength $\vec{E}$ in air normal to the surface of the cylinder. 5

14. a) Obtain an expression for the magnetic field intensity $\vec{H}$ at a distance 'r' from the center within a conductor carrying a current I. The radius of the wire is 'R'. The current density is constant across the cross-section of the conductor. 5

b) From the expression $r = \sqrt{j\omega\mu(\sigma + j\omega\varepsilon)}$ derive the expressions for α, β. The expression symbols have their usual meaning. 5

15. a) Prove for parallel polarization that $\frac{E_r}{E_i} = \frac{\tan(\theta_1 - \theta_2)}{\tan(\theta_1 + \theta_2)}$. The symbols have their usual meanings. 5

b) Determine the reflection co-efficient for an electromagnetic wave incident normally on a sheet of iron. The corresponding parameters are :

Frequency (f) = 1 MHz

σ (iron) = 1×10^6 m hos/m.

$\mu = 1000\ \mu_0$

$\mu_0 = 4\pi \times 10^{-7}$ henry / m. 5

16. a) A point charge 'q' is located at a distance 'h' above an infinite ground plane which is a conductor. Find the displacement density normal to the plane. Obtain an expression for surface charge density on the plane. 5

b) An infinitely long cylinder of radius 'a' is filled with a charge of uniform density 'ρ'. If the potential on the surface of the cylinder is V_0, what is the potential within the cylinder ? 5

17. a) Evaluate the line integral of the vector field $\vec{F} = \vec{a}_x + 2\vec{a}_y + \vec{a}_z$ along a circular arc of unit radius from (1, 0, 1) to (0, 1, 1). 5

b) Using the statement of ampere's work law for elemental area in cylindrical co-ordinates derive the expansion for $\nabla \times \vec{H}$ in these co-ordinates. 5