[This question paper contains **4** printed pages.]

Your Roll No……

Sr. No. of Question Paper : 15065

Unique Paper Code : 2942822402

Name of the Paper : Electromagnetic Theory (EMT)

Name of the Course : **B. Tech. (ECE)**

Semester : IV

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. Attempt **five** questions in all, including question no. 1 which is compulsory.
3. Non – programmable scientific calculator is allowed.
4. **All** questions carry equal marks.

(3 × 6 = 18)

1. (a) Given the vector field F = $\frac{4a_r}{r^2}$ express F in rectangular coordinates.

   (b) A dipole has dipole moment $p = 2a_x + 6a_y - 4a_z$ μC. m. If the dipole is located in free space at (2, 3, –1), find the potential at (4, 0, 1).

(c) Derive expressions for phase velocity, group velocity, and guide wavelength in a waveguide.

(d) Assume that E and H waves travelling in free space are generally incident on an interface with a perfect dielectric of ε_r=3. Determine the magnitude of incident, reflected, and transmitted E and H waves at the interface.

(e) Explain lossless and distortionless transmission lines.

(f) A telephone line operating at 1 kHz has R = 6.8 V/mi, L = 3.4 mH/mi, C = 8.4 nF/mi, and G = 0.42 μS/mi. Find (i) Z and γ, (ii) phase velocity, (iii) wavelength.

$(9 \times 2 = 18)$

2. (a) Define magnetic vector potential and discuss its importance in electromagnetic field analysis, including its relationship with magnetic flux density. Also, derive Poynting's theorem and explain its physical significance in electromagnetic systems.

(b) Find the Laplacian of the following scalar fields and compute the value at the specified point

$$V_2 = \rho z^2 \sin 2\phi$$
$$V_3 = r^2(1 + \cos\theta \sin\phi)$$

Show that the vector field $D = (5\rho^2 + 1) \cos \varphi a_z$ is solenoidal.

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(9 × 2 = 18)

3. (a) Derive the expression for the attenuation constant, phase constant and intrinsic impedance for a uniform plane wave in a good conductor.

   (b) Briefly explain about the wave incident obliquely to the surface of perfect conductor. Derive Brewster angle for perpendicular polarization.

(9 × 2 = 18)

4. (a) A lossy transmission line of length 1.8 m has characteristic impedance of 60 + j40. When the line is short-circuited, the input impedance is 24 – j6. (a) Determine α and β. (b) Find the input impedance when the short circuit is replaced by $Z_L = 30 + j20$.

   (b) A lossless 50 Ω line is terminated by a load $Z_L = 75 + j60$ Ω. Using a Smith chart, determine (a) the reflection coefficient Γ, (b) the standing wave ratio s, (c) the input impedance at 0.2λ from the load.

(9 × 2 = 18)

5. (a) In an air-filled rectangular waveguide, a TE mode operating at 6 GHz has

$$E_y = 5 \sin\left(\frac{2\pi x}{a}\right) \cos\left(\frac{\pi y}{b}\right) \sin(\omega t - 12z) \text{ V/m}$$

   Determine (a) the mode of operation, (b) the cutoff frequency, (c) the intrinsic impedance, and (d) H_x.

(b) Derive the field equations for TE modes in a rectangular waveguide and obtain the expression for cutoff frequency.

(9 × 2 = 18)

6. (a) The radiated power density of an antenna at far-zone is given by

$$\mathcal{P}_{ave} = \frac{\alpha \sin^2\theta \sin^3\phi}{r^2}\mathbf{a}_\phi, \quad 0 < \theta < \pi, 0 < \phi < \pi$$

where α is a constant. Determine the directive gain and directivity.

(b) A half-wave dipole antenna is driven by a 24 V, 200 MHz source having an internal impedance of 40 Ω. Find the average power radiated by the antenna, given that $Z_{in} = 73 + j42\ \Omega$.

(300)