ROLL NO. _____

Code: AE63 Subject: ELECTROMAGNETICS & RADIATION SYSTEMS

AMIETE – ET (Current Scheme)

Time: 3 Hours **JUNE 2015 - SPECIAL** **Max. Marks: 100**

PLEASE WRITE YOUR ROLL NO. AT THE SPACE PROVIDED ON EACH PAGE IMMEDIATELY AFTER RECEIVING THE QUESTION PAPER.

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q.1 must be written in the space provided for it in the answer book supplied and nowhere else.**
- **The answer sheet for the Q.1 will be collected by the invigilator after 45 Minutes of the commencement of the examination.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or the best alternative in the following: (2×10)

a. Displacement current density J_D _____ current passing through a capacitor

(A) Represents **(B)** Does not represent
(C) Is same as **(D)** None of these

b. Plane z = 10 m carries charge 20 nC/m^2. The electric field intensity at the origin is_____

(A) $-10\pi a_z V/m$ **(B)** $-18\pi a_z V/m$
(C) $-72\pi a_z V/m$ **(D)** $-360\pi a_z V/m$

c. A potential field is given by V = $3x^2y$ – yz. Which of the following is not true?_____

(A) At point (1, 0, - 1), V and E vanish
(B) $x^2y = 1$ is an equipotential line on the xy-plane
(C) The equipotential surface V = - 8 passes through point P(2,-1,4)
(D) The electric field at P is $12a_x - 8a_y - a_z$ V/m

d. Which of the following potentials does not satisfy Laplace's equation?

(A) V = 2x + 5 **(B)** V= 10 xy
(C) V = r cos Ø **(D)** $V = \rho\cos\phi + 10$

e. In cylindrical coordinates, equation

$$\frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\rho\frac{\partial\psi}{\partial\rho}\right)+\frac{1}{\rho^2}\frac{\partial^2\psi}{\partial\phi^2}+\frac{\partial^2\psi}{\partial z^2}+10=0$$ is called _____

(A) Poisson's equation **(B)** Laplace's equation
(C) Helmholtz's equation **(D)** Equation of continuity

f. One of these equations is not Maxwell's equation for a static electromagnetic field in a linear homogeneous medium_____

(A) $\oint \overline{B} \cdot \overline{dL} = \mu_0 I$ **(B)** $\nabla^2 A = -\mu_0 \overline{J}$

(C) $\nabla \cdot \mathbf{B} = 0$ **(D)** $\oint \mathbf{D} \cdot d\mathbf{S} = Q$

g. Which of these formulas is wrong

(A) $B_{1n} = B_{2n}$ **(B)** $B_2 = \sqrt{B_{2n}^2 + B_{2t}^2}$

(C) $H_1 = H_{1n} + H_{1t}$ **(D)** $\mathbf{a}_{n21} \times (\mathbf{H}_1 - \mathbf{H}_2) = \mathbf{K}$,

where a_{n21} is a unit vector normal to the interface and directed from region 2 to region 1

h. In a certain medium, $E = 10\cos(10^8 t - 3y)\overline{a_x}\, V/m$. What type of medium is it?

(A) Free space **(B)** Perfect conductor
(C) Perfect dielectric **(D)** Lossless dielectric

i. Given that H = 0.5 $e^{-0.1x}$ sin (10^6t - 2x) a_y A/m, which of these statements are incorrect_____

(A) The wave travels along a_x **(B)** $\omega = 10^6$rad/s
(C) β = -2 rad/m **(D)** α = 0.1 Np/m

j. VSWR for a perfectly matched load is

(A) 0 **(B)** 1
(C) ∞ **(D)** none of these

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. Given a vector field $D = r\sin\phi a_r - \frac{1}{r}\sin\theta\cos\phi a_\theta + r^2 a_\phi$ **(6)**

Determine
(i) D at P(10, 150°,330°)
(ii) The component of D tangential to the spherical surface r = 10 at P
(iii) A unit vector at P perpendicular to D and tangential to the cone θ = 150°

b. Given W = x^2y^2 + xyz. Compute ∇W and the direction derivative *dW/dl* in the direction $3a_x + 4a_y + 12a_z$ at (2,-1,0) **(4)**

c. If $G(r) = 10e^{-2z}(\rho\overline{a_\rho} + \overline{a_z})$. Determine the flux of G out of that entire surface of the cylinder ρ = 1, 0 ≤ z ≤ 1. Confirm the result using the divergence theorem **(6)**

Q.3 a. A charge distribution with spherical symmetry has density $\rho_V = \begin{cases} \frac{\rho_0 r}{R}, & 0 \le r \le R \\ 0, & r > R \end{cases}$.

Determine E everywhere. **(8)**

b. Given the potential $V = \frac{10}{r^2}\sin\theta\cos\phi$ **(8)**

(i) Find the electric flux density D at (2, π/2, 0).

(ii) Calculate the work done in moving a 10-μC charge from point A (1, 30° 120°) to B(4, 90°, 60°).

Q.4 a. The potential field $V = 2x^2yz - y^3z$ exists in a dielectric medium having $\varepsilon = 2\varepsilon_0$ **(6)**

(i) Does V satisfy Laplace's equation?

(ii) Calculate the total charge within the unit cube 0<x, y, z, < 1m.

b. Conducting spherical shells with radii a = 10 cm and b = 30 cm are maintained at a potential difference of 100 V such that V(r = b) =0 V(r-a) = 100V. Determine V and E in the region between the shells. If $\varepsilon_r = 2.5$ in the region, determine the total charge induced on the shells and the capacitance of the capacitor. **(6)**

c. Derive Poisson's and Laplace's equation. **(4)**

Q.5 a. State and Explain Biot-Savart Law for magnetic field. Using this law derive expression for magnetic field intensity at a point due to a finite length current element carrying current 'I' lying on z-axis in cylindrical co-ordinates. **(6)**

b. A circular loop located on $x^2 + y^2 = 9$, z = 0 carries a direct current of 10A along a_ϕ. Determine H at (0, 0, -4). **(6)**

c. Planes z = 0 and z = 4 carry current $K = -10a_x$ A/m and $K = 10a_x$ A/m, respectively. Determine H at **(4)**

(i) (1, 1, 1)

(ii) (0, -3, 10)

Q.6 a. A rectangular loop carrying current I_2 is placed parallel to an infinitely long filamentary wire carrying current I_1 as shown in figure 1. Show that the force experienced by the loop is given by $F = -\frac{\mu_0 I_1 I_2 b}{2\pi}\left[\frac{1}{\rho_0} - \frac{1}{\rho_0 + a}\right]a_\rho N$ **(8)**

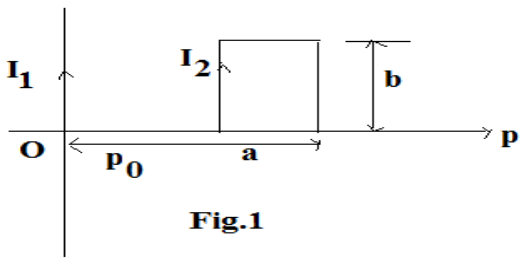

Fig.1

b. Given that $H_1 = -2a_x + 6a_y + 4a_z$ A/m in region $y - x - 2 \leq 0$ where $\mu_1 = 5\mu_0$ calculate
(i) M_1 and B_1
(ii) H_2 and B_2 in region $y - x - 2 \geq 0$ where $\mu_2 = 2\mu_0$ **(8)**

Q.7 a. Let $\mu = 3\times10^{-5}\ H/m$, $\in = 1.2\times10^{-10}$ F/m and $\sigma = 0$ everywhere. If $\overline{H} = 2\cos\left(10^{10}t - \beta x\right)\overline{a_z}$ A/m use Maxwell's equations to obtain $\overline{B}$, $\overline{D}$ and $\overline{E}$.

(6)

b. The electric field and magnetic field in free space are given by $E = \frac{50}{\rho}\cos\left(10^6 t + \beta z\right)a_\phi$ V/m

$$H = \frac{H_0}{\rho}\cos\left(10^6 t + \beta z\right)\overline{a_\rho} A/m$$

Express these in phasor from and determine the constants H_0 and β such that the fields satisfy Maxwell's equations. **(6)**

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

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

Find E and α. Determine the skin depth and wave polarization. **(4)**

Q.8 a. Show that the directive gain of the Hertzian dipole is

$$G_d(\theta,\phi) = 1.5\sin^2\theta$$

and that of the half – wave dipole is

$$G_d(\theta,\phi) = 1.64\frac{\cos^2\left(\frac{\pi}{2}\cos\theta\right)}{\sin^2\theta}$$ **(8)**

b. The radiation intensity of a certain antenna is

$$U(\theta,\phi) = \begin{cases} 2\sin\theta\sin^3\phi, & 0 \leq \theta \leq \pi, 0 \leq \phi \leq \pi \\ 0, & elsewhere \end{cases}$$

Determine the directivity of the antenna. **(8)**

Q.9 Write a note on: **(4×4)**
(i) Skip distance
(ii) Maximum Usable Frequency
(iii) Critical Frequency
(iv) Ionospheric Layers