CBCS SCHEME

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21EC54

Fifth Semester B.E. Degree Examination, Dec.2023/Jan.2024
Electromagnetic Waves

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. State and explain coulomb's law of force between two point charges in vector form. **(06 Marks)**

b. Convert point P(1, 3, 5) to cylindrical and spherical co-ordinates. Also write the equations for differential surface, differential volume for rectangular, cylindrical and spherical systems. **(06 Marks)**

c. Find electric field intensity at P(1, 1, 1) caused by 4 identical 3nc charges are located at $P_1(1, 1, 0)$, $P_2(-1, 1, 0)$, $P_3(-1, -1, 0)$ and $P_4(1, -1, 0)$. **(08 Marks)**

OR

2 a. Define electric field intensity. Derive an expression for electric field intensity due to infinite line charge. **(08 Marks)**

b. A point charge of 50nc each are located at A(1, 0, 0), B(-1, 0, 0), C(0, 1, 0) and D(0, -1, 0) in free space. Find the total force on the charge at A. Also find $\overline{E}$ at A. **(06 Marks)**

c. A uniform line charge ρ_L = 25nc/m lies on the line x = -3m, y = 4m in freespace. Find electric field intensity at a point (2, 3, 15)m. **(06 Marks)**

Module-2

3 a. State and prove Gauss's law. **(06 Marks)**

b. Evaluate both sides of the divergence theorem for the defined plane in which $1 \le x \le 2$, $2 \le y \le 3$, $3 \le z \le 4$, if $\overline{D} = 4x\,\hat{a}_x + 3y^2\,\hat{a}_y + 2z^3\,\hat{a}_z\ c/m^2$. **(10 Marks)**

c. Derive the point form of continuity of current equation. **(04 Marks)**

OR

4 a. Obtain the expression for the work done in moving a point charge in an electric field. **(06 Marks)**

b. Given that the field $\overline{D} = \frac{5\sin\theta\ \cos\phi}{r}\hat{a}_r\ c/m^2$. Find : i) Volume charge density ii) The total electric flux leaving the surface of the spherical volume of radius 2m. **(08 Marks)**

c. Define potential difference. Derive the expression for potential field of a point charge. **(06 Marks)**

Module-3

5 a. State and prove uniqueness theorem. **(08 Marks)**

b. Define Stoke's theorem. Use this theorem to evaluate both sides of the theorem for the field $\overline{H} = 6xy\,\hat{a}_x - 3y^2\,\hat{a}_y$ A/m and the rectangular path around the region, $2 \le x \le 5$, $-1 \le y \le 1$ and z = 0. Let the positive direction of ds be $\hat{a}_z$. **(12 Marks)**

OR

6 a. Solve the Laplace's equation for the potential field in the homogeneous region between the two concentric conducting spheres with radii 'a' and 'b' such that b > a, if potential v = 0 at r = b and v = v_0 at r = a. Also find the capacitance between concentric spheres. **(08 Marks)**

b. Derive the expression for magnetic field intensity due to infinite long straight conductor using Biot-Savart's law. **(06 Marks)**

c. Determine whether or not the following potential fields satisfy the Laplace's equation:
i) $V = 2x^2 - 3y^2 + z^2$ ii) $V = r\cos\theta + \phi$ **(06 Marks)**

Module-4

7 a. Derive an expression for Lorentz Force equation. **(06 Marks)**

b. If $\overline{B} = 0.05x\,\hat{a}_y$ Tesla in a material for which $\pi_m = 2.5$, Find: i) μ_r ii) μ iii) $\overline{H}$ iv) $\overline{M}$ v) $\overline{J}$ vi) $\overline{J}_b$. **(08 Marks)**

c. Derive the expression for the force between two differential current elements. **(06 Marks)**

OR

8 a. Derive the expression for the boundary conditions between two magnetic medias. **(10 Marks)**

b. Calculate the magnetization in magnetic material where:
i) $\mu = 1.8 \times 10^5$ H/m and M = 120 A/m
ii) $\mu_r = 22$, there are 8.3×10^{28} Atoms/m^3 and each atom has a dipole moment of 4.5×10^{-27} A/m^2
iii) B = 300 μT and $\chi_m = 15$. **(06 Marks)**

c. Briefly explain the forces on magnetic materials. **(04 Marks)**

Module-5

9 a. List and explain Maxwell's equations in point form and integral form. **(08 Marks)**

b. Given $\overline{E} = E_m \sin(wt - \beta z)\hat{a}_y$ v/m. Find: i) $\overline{D}$ ii) $\overline{B}$ iii) $\overline{H}$. Sketch $\overline{E}$ and $\overline{H}$ at t = 0. **(08 Marks)**

c. Find the frequency at which conduction current density and displacement current density are equal in a medium with $\sigma = 2 \times 10^{-4}$ mho/m and $\epsilon_r = 81$. **(04 Marks)**

OR

10 a. State and prove Poynting theorem. **(08 Marks)**

b. For the given medium $\epsilon = 4 \times 10^{-9}$ F/m and σ = 0, find 'K' so that $\overline{E} = (20y - kt)\hat{a}_x$ v/m and $\overline{H} = (y + 2\times10^6 t)\,\hat{a}_z$ A/m. **(06 Marks)**

c. A uniform plane wave of frequency 10MHz travels in positive direction in a lossy medium with $\epsilon_r = 2.5$, $\mu_r = 4$ and $\sigma = 10^{-3}$ ℧/m. Calculate α, β, γ and η, λ. **(06 Marks)**

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