CBCS SCHEME

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18EE45

Fourth Semester B.E. Degree Examination, June/July 2024
Electromagnetic Field Theory

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. Given two vectors $\vec{R}_A = -a_x^{\wedge} - 3a_y^{\wedge} - 4a_z^{\wedge}$ and $\vec{R}_B = 2a_x^{\wedge} + 2a_y^{\wedge} + 2a_z^{\wedge}$ and point C(1, 3, 4). Find i) $\vec{R}_{AB}$ ii) $|\vec{R}_A|$ iii) $a_A^{\wedge}$ iv) an unit vector directed from C to A. **(08 Marks)**

b. Given the two coplanar vectors $\vec{A} = 3a_x^{\wedge} + 4a_y^{\wedge} + 3a_z^{\wedge}$ and $\vec{B} = -6a_x^{\wedge} + 2a_y^{\wedge} + 4a_z^{\wedge}$. Obtain the unit vector normal to the plane containing the vectors $\vec{A}$ and $\vec{B}$. **(06 Marks)**

c. Given two points A(x = 2 , y = 3 , z = 1) and B(r = 4 , $\theta = 25^\circ$, $\phi = 120^\circ$). Find
i) Spherical Coordinates of A ii) Cartesian Coordinates of B
iii) Distance between A and B. **(06 Marks)**

OR

2 a. Using cylindrical coordinate system approach, derive the electric field of an infinitely long line charge extending along Z axis. **(08 Marks)**

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

c. Explain Coulomb's law of force between two point charges and find x, y, z components of forces on Q_1 if two point charges $Q_1 = 100\mu c$ and $Q_2 = 100\mu c$ are located at points (-1 , 1 , -3)m and (3, 1, 0)m respectively. **(06 Marks)**

Module-2

3 a. Determine the work done in moving a + 2C charge from (2, 0, 0)m to (0, 2, 0)m along the straight line path joining the two points if the field is $\vec{E} = 12xa_x^{\wedge} - 4ya_y^{\wedge}$ V/m. **(08 Marks)**

b. Show that electric field intensity is negative gradient of potential. **(06 Marks)**

c. An electrostatic potential is given by $V = \frac{60\sin\theta}{r^2}$ volts. Find $\vec{E}$ at (3, 60° , 25°). **(06 Marks)**

OR

4 a. Derive the boundary conditions at the interface between two dielectric with different permittivity's. **(08 Marks)**

b. Find the total current in outward direction from a cube of 1m, with one corner at the origin and edges parallel to the coordinate axes if $\vec{J} = 2x^2 a_x^{\wedge} + 2xy^3 a_y^{\wedge} + 2xy a_z^{\wedge}$ A/m^2. **(06 Marks)**

c. At the boundary between glass ($\varepsilon_r = 4$) and air, the lines of electric field make an angle of 40° with normal to boundary. If electric flux density in the air is 0.25μC/m^2, determine the orientation and magnitude of electric flux density in the glass. **(06 Marks)**

Module-3

5 a. Derive Poisson's and Laplace equation starting from point form of Gauss's law in Cartesian co-ordinates and write Laplace equation in Cylindrical and Spherical co-ordinates. **(08 Marks)**

b. Given the potential field $V = 3x^2yz + Ky^3z$ volts. Find
   i) K if potential field satisfies Laplace equation.
   ii) Find $\vec{E}$ at (1, 2, 3). **(06 Marks)**

c. Given the potential field $V = (A\rho^4 + B\rho^{-4}) \sin 4\phi$. Show that $\nabla^2 v = 0$. **(06 Marks)**

OR

6 a. State Ampere's Circuital law. Apply it to a co-axial cable with inner conductor of radius 'a' carrying current I. The outer conductor carries return current –I. the inner radius of outer conductor is 'b' and its outer radius is 'c'. Evaluate magnetic field intensity. **(08 Marks)**

b. Evaluate both sides of Stoke's theorem for the field $\vec{H} = 6xy\, a_x^{\wedge} - 3y^2\, a_y^{\wedge}$ A/m and rectangular path around the region , $2 \le x \le 5$, $-1 \le y \le 1$, $z = 0$. Le the positive direction of $d\vec{s}$ be $a_z^{\wedge}$. **(08 Marks)**

c. State and explain Biot – Savart law. **(06 Marks)**

Module-4

7 a. State and explain Lorentz force equation. Apply it to calculate the magnitude of force exerted on a point charge Q = 18nC, when $\vec{B}$ and $\vec{E}$ are acting together. Given $\vec{E} = -3a_x^{\wedge} + 4a_y^{\wedge} + 6a_z^{\wedge}$ KV/m and $\vec{B} = -3a_x^{\wedge} + 4a_y^{\wedge} + 6a_z^{\wedge}$ mT. The point charge has a velocity of 5×10^6 m/s in the direction , $a_v^{\wedge} = 0.6a_x^{\wedge} + 0.75a_y^{\wedge} + 0.3a_z^{\wedge}$. **(08 Marks)**

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

c. Derive the expression for the torque on a rectangular current loop carrying current 'I'. **(06 Marks)**

OR

8 a. Define Self inductance and Mutual inductance and derive the expression for inductance of a folenoid of 'N' turns carrying current 'I'. **(08 Marks)**

b. Obtain the expression for energy stored in magnetic field. **(06 Marks)**

c. Find the normal component of the magnetic field which traversed from medium 1 to medium 2 , having $\mu_{r1} = 2.5$ and $\mu_{r2} = 4$. Given that $\vec{H}_1 = -30a_x^{\wedge} + 50a_y^{\wedge} + 70a_z^{\wedge}$ V/m. **(06 Marks)**

Module-5

9 a. Starting from Ampere's circuital law, derive the expression for displacement current density for time varying fields. **(08 Marks)**

b. Derive Maxwell's equation in point form from Gauss's law for electric and magnetic fields. **(06 Marks)**

c. For the given medium $\varepsilon = 4 \times 10^{-9}$ F/m and $\sigma = 0$. Find K such that following pair of field satisfies Maxwell's equations. $\vec{E} = (20y - Kt)a_x^{\wedge}$ V/m ; $\vec{H} = (y + 2 \times 10^6 t)\, a_z^{\wedge}$ A/m. **(06 Marks)**

OR

10 a. What is Uniform Plane Wave? Explain the propagation of uniform plane wave in free space with necessary equations. **(08 Marks)**

b. State and prove Poynting theorem. **(08 Marks)**

c. Define Skin depth. **(04 Marks)**

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