CBCS SCHEME

USN

17EC36

Third Semester B.E. Degree Examination, July/August 2022
Engineering Electromagnetics

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 in vector form. Also explain how force due to many charges can be determined. **(10 Marks)**

b. Point charges of 50 nC 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 exerted on the charge at A. **(10 Marks)**

OR

2 a. Define the term Electric field intensity and derive the expression for the electric field intensity at any point due to an infinite line charge of density ρ_L C/m distributed along Z-axis. **(10 Marks)**

b. Calculate the flux density $\vec{D}$ at point P(2, –3, 6) produced by:
(i) Point charge $Q_A = 55$ mC at (–2, 3, 6)
(ii) A uniform line charge $\rho_L = 200$ mC/m on X-axis
(iii) A uniform surface charge $\rho_S = 120\ \mu c/m^2$ on the plane Z = –5 m. **(10 Marks)**

Module-2

3 a. State and explain Gauss's law. **(05 Marks)**

b. A surface charge of density ρ_S C/m^2 is uniformly spread over an infinite plane. Apply Gauss law to determine the electric field intensity at any point due to this charge distribution. **(07 Marks)**

c. Calculate the divergence of vector $\vec{D}$ at a point P due to charge distribution defined by the equation.
(i) $\vec{D} = \frac{1}{2}[10xyz\,\hat{a}_x + 5x^2z\,\hat{a}_y + [2z^3 - 5x^2y]\hat{a}_z]$ at P(–2, 3, 5)
(ii) $\vec{D} = 5z^2\,\hat{a}_\rho + 10\rho z\,\hat{a}_z$ at P(3, –45°, 5) **(08 Marks)**

OR

4 a. Show that electric field intensity is equal to negative gradient of electric potential :
$\vec{E} = -\nabla V$ **(05 Marks)**

b. Three identical point charges of 4PC each are located at the corners of an equilateral triangle of 0.5 mm on a side in free space. How much work must be done to move one charge to a point equidistant from the other two and on the line joining them? **(08 Marks)**

c. Obtain the expression for continuity equation of current and what is its significance. **(07 Marks)**

Module-3

5 a. Derive Laplace's and Poisson's equations form Gauss's law. **(05 Marks)**

b. Using Laplace's equation, derive the expression for the capacitance of a coaxial cable. Assume suitable boundary conditions. **(08 Marks)**

c. Given the potential field $V = [A\rho^4 + B\rho^{-4}]\sin 4\phi$:
   (i) Show that $\nabla^2 V = 0$
   (ii) Select A and B such that V = 100 V and |E| = 500 V/m at P(1, 22.5°, 2) **(07 Marks)**

OR

6 a. Derive the expression for the magnetic field intensity due to a long conductor carrying a steady current 'I'. **(07 Marks)**

b. Evaluate on both sides of the Stoke's theorem for the field $\vec{H} = 6xy\hat{a}_x - 3y^2\hat{a}_y$ A/m and on the rectangular path around the region [2 ≤ x ≤ 5]; [−1 ≤ y ≤ 1] and z = 0. Let the positive direction of $\vec{ds}$ be $\hat{a}_z$. **(08 Marks)**

c. Compare scalar and vector magnetic potentials. **(05 Marks)**

Module-4

7 a. Derive Lorentz force equation and mention the application of its solution. **(06 Marks)**

b. Derive an expression for the force between two differential current elements carrying steady currents I_1 and I_2 respectively. **(06 Marks)**

c. Point charge Q = 18 nC has a velocity 5 × 10^6 m/s in the direction :
   $\hat{a}_v = 0.6\hat{a}_x + 0.75\hat{a}_y + 0.3\hat{a}_z$
   Calculate the magnetic force exerted on the charge by the field
   (i) $\vec{B} = [-3\hat{a}_x + 4\hat{a}_y + 6\hat{a}_z]$ mT (ii) $\vec{E} = [-3\hat{a}_x + 4\hat{a}_y + 6\hat{a}_z]$ KV/m
   (iii) When both $\vec{B}$ and $\vec{E}$ acting together. **(08 Marks)**

OR

8 a. Derive the magnetic boundary conditions at the interface between two different magnetic materials. **(08 Marks)**

b. Obtain the expression for the magnetic force exerted on a magnetic material. **(06 Marks)**

c. Given a magnetic material for which $X_m = 3.1$ and within which $\vec{B} = 0.4y\,\hat{a}_z$ T. Find $\vec{H}$, μ, μ_r, $\vec{M}$ and $\vec{J}$. **(06 Marks)**

Module-5

9 a. Using Faraday's law, deduce the Maxwell's equation to relate time varying electric and magnetic fields. **(08 Marks)**

b. What is displacement current? For a harmonically varying field, show that the conduction and displacement currents densities are in phase quadrature. **(06 Marks)**

c. Let $\mu = 3 \times 10^{-5}$ H/m, $\epsilon = 1.2 \times 10^{-10}$ F/m and σ = 0 everywhere, if $\vec{H} = 2\cos(10^8 t - \beta x)\,\hat{a}_z$ A/m. Use Maxwell's equations to obtain the expressions for $\vec{B}$, $\vec{D}$, $\vec{E}$ and β. **(06 Marks)**

OR

10 a. Derive the wave equation interms of $\vec{E}$ and $\vec{H}$ for a general medium. **(08 Marks)**

b. State and explain Poynting theorem. **(06 Marks)**

c. The $\vec{H}$ field in free space is given by $\vec{H}(x,t) = 10\cos(10^8 t - \beta x)\,\hat{a}_y$ A/m. Find β, λ and $\vec{E}(x,t)$. **(06 Marks)**

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