CBCS SCHEME

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18EE45

Fourth Semester B.E. Degree Examination, Dec.2024/Jan.2025
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. Obtain the relationship between Cartesian and cylindrical systems. **(08 Marks)**

b. Given the two vector, $\overline{A} = 2\hat{a}_x - 5\hat{a}_y - 4\hat{a}_z$ and $\overline{B} = 3\hat{a}_x + 5\hat{a}_y + 2\hat{a}_z$. Find the dot product and the angle between the two vectors. **(06 Marks)**

c. State and explain Coulomb's law. **(06 Marks)**

OR

2 a. Derive an expression for electric field intensity at a point due to infinite line charge using Coulomb's law. **(08 Marks)**

b. State and explain Gauss law. **(06 Marks)**

c. Given that $\overline{D} = \frac{5r^2}{4}\hat{a}_r c/m^2$, evaluate both sides of divergence theorem for the volume enclosed by r = 4 m and $\theta = \pi/4$. **(06 Marks)**

Module-2

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

b. Calculate potential difference V_{AB} for a line charge ρ_L = 5nc/m on the z-axis where $A[2m, \pi/2, 0]$ and $B[4m, \pi, 5m]$. **(06 Marks)**

c. Derive an expression for potential energy stored in electrostatic field. **(08 Marks)**

OR

4 a. Obtain the relationship between electric field intensity and potential gradient. **(06 Marks)**

b. Determine the capacitance of a capacitor consisting of two parallel plates 30 cm × 30 cm surface area separated by 5 mm in air. What is the total energy stored by the capacitor, if capacitor is charged to 500 V? What is the energy density? **(06 Marks)**

c. Obtain the boundary conditions at the interface between a dielectric material and a conductor in an electric field. **(08 Marks)**

Module-3

5 a. Explain Laplace and Poisson equation, and write equations in different co-ordinate system. **(06 Marks)**

b. Obtain expression for potential and capacitance of co-axial cable using Laplace equation. **(08 Marks)**

c. An infinitesmall length 10^{-3}m of wire is located at the point(1, 0, 0) and carries a current 2A in the direction of the unit vector $\hat{a}_x$. Find the magnetic field intensity due to the current element at the point (0, 2, 2)m using Biot-Savart law. **(06 Marks)**

OR

6 a. State and prove uniqueness theorem. **(06 Marks)**

b. Obtain expression for curl or Amperes law in point form. **(06 Marks)**

c. If the vector magnetic potential at a point in a space is given as $\bar{A} = 100\rho^{1.5}\hat{a}_z$ Wb/m, find the following : i) $\bar{H}$ ii) $\bar{J}$ and show that $\int \bar{H} \cdot d\bar{\ell} = 1$ for the circular path with $\rho = 1$. **(08 Marks)**

Module-4

7 a. Derive an expression force between two differential current elements. **(06 Marks)**

b. Find the force per meter length between two long parallel wires separated by 10 cm in air and carrying a current of 10 A in the same direction. **(06 Marks)**

c. A conductor of length 2.5 m in z = 0 and z = 4 m carries a current of 12 A in $-\hat{a}_y$ direction. Calculate the uniform flux density in the region, if the force on the conductor is 12×10^{-2} N in the direction specified by $\left[\frac{-\hat{a}_x + a_z}{\sqrt{2}}\right]$. **(08 Marks)**

OR

8 a. Explain Lorent'z force equation. **(05 Marks)**

b. Derive expression for inductance of co-axial cable. **(05 Marks)**

c. For region 1, $\mu_1 = 4$ μH/m and for region 2, $\mu_2 = 6$ μH/m. The regions are deparated by z = 0 plane. The surface current density at the boundary is $\bar{K} = 100\hat{a}_y$ A/m. Find $\bar{B}_2$ if $B_1 = 2\hat{a}_x - 3\hat{a}_y + \hat{a}_z$ mT for $z > 0$. **(10 Marks)**

Module-5

9 a. Obtain the expression for electric and magnetic fields for time varying fields using Faraday's law. **(06 Marks)**

b. List the Maxwell's equations for time varying fields in point and integral forms. **(06 Marks)**

c. Given $\bar{H} = H_m e^{j(wt-\beta z)} \hat{a}_x$ A/m in free space. Find electric field intensity $\bar{E}$. **(08 Marks)**

OR

10 a. Obtain expression for uniform plane wave in free space. **(08 Marks)**

b. State and explain poynting theorem in point and integral form. **(06 Marks)**

c. A 10 GHz plane wave travelling in a free space has an amplitude of $\bar{E}$ as $E_x = 10V/m$. Find β, η, v_p, λ and amplitude, direction of $\bar{H}$. **(06 Marks)**

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