CBCS SCHEME

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15EE45

Fourth Semester B.E. Degree Examination, Dec.2023/Jan.2024
Electromagnetic Field Theory

Time: 3 hrs. Max. Marks: 80

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 the two point charges. Also indicate the units of quantities in the force equation. **(05 Marks)**

b. Electric charge lies in the plane at Z = -4m in the form of a square sheet prescribed by $-2 \le x \le 2m$, $-2 \le y \le 2m$. Charge density $\rho_s = 2(x^2 + y^2 + 16)^{3/2}$ ηc/m^2. Determine electric field intensity 'E' at origin. **(06 Marks)**

c. Find: i) Electric field intensity ii) Electric flux density at the origin due to $Q_1 = 0.35\mu c$ at (0, 4, 0)m and $Q_2 = -0.55\mu c$ at (3, 0, 0)m. **(05 Marks)**

OR

2 a. Define electric field intensity. Obtain an expression for the electric field intensity $(\bar{E})$ due to an infinite line charge along Z axis having a uniform charge density ρ_L c/m, using Coulomb's law. **(08 Marks)**

b. If $\bar{D} = 10e^{-2z}(\rho\bar{a}_\rho + \bar{a}_z)c/m^2$, determine the flux of $\bar{D}$ out of the entire surface of the cylinder $\rho = 1$, $0 \le z \le 1$, confirm the result by using divergence theorem. **(08 Marks)**

Module-2

3 a. Find the work done in moving a charge Q = 5μc in the electric field given by $E = 4x\bar{a}_x - 3y\bar{a}_y$ v/m from
i) (3, 0, 0) to $(0, 3, 0)_m$ and from (0, 0, 0) to (0, 3, 0)m
ii) From (3, 0, 0) to (0, 3, 0) along the st-line path. **(06 Marks)**

b. With usual notation prove that $\bar{E} = -\nabla v$. **(06 Marks)**

c. A 15ηc charge is located at origin in free space. Calculate V_p if P is located at P(-2, 3, -1) and V = 0 at infinity. **(04 Marks)**

OR

4 a. Derive an expression for energy expended in moving a point charge in an electric field. **(06 Marks)**

b. For a line charge $\rho_L = 10^{-9}/2$ c/m on the z-axis, find V_{AB} where A is (2m, π/2, 0) and B is (4m, π, 5m). **(05 Marks)**

c. Evaluate the capacitance of two concentric spherical conducting shells of radius 'a' and 'b' with b > a. **(05 Marks)**

Module-3

5 a. Derive Poisson's and Laplace equation starting from point form of Gauss law and write the equation in three coordinate systems. **(08 Marks)**

b. Determine whether or not the following potential field satisfy the Laplace equations:

i) $V = x^2 - y^2 + z^2$

ii) $V = r\cos\phi + z$

iii) $V = r\cos\theta + \phi$

iv) $V = 2x + 5y - z$. **(08 Marks)**

OR

6 a. Show that curl H = J in a steady magnetic field. **(08 Marks)**

b. Derive the expression for $\overline{H}$ on the axis of a circular loop. **(08 Marks)**

Module-4

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

b. Calculate the inductance of solenoid of 200 turns wound tightly on a cylindrical tube of length 60cm and diameter of 6cm. Given that medium is air. **(04 Marks)**

c. Explain the terms magnetization and permeability. **(06 Marks)**

OR

8 a. Obtain the boundary conditions at the interface between two magnetic materials. **(06 Marks)**

b. Derive the equation for force between two differential current carrying elements. **(06 Marks)**

c. Define self inductance and mutual inductance with suitable formulae. **(04 Marks)**

Module-5

9 a. State Faraday's law and obtain point and integral form of electromagnetic induction. **(06 Marks)**

b. Write a note on retarded potential. **(06 Marks)**

c. For a electromagnetic wave, show that E and H is mutually perpendicular to each other. **(04 Marks)**

OR

10 a. State and prove Pointing theorem. **(06 Marks)**

b. Discuss the following i) Standing wave ii) Standing wave ratio. **(06 Marks)**

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

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