CBCS SCHEME

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18EE45

Fourth Semester B.E. Degree Examination, Jan./Feb. 2023
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. Derive the relationship between rectangular and cylindrical coordinate system. **(05 Marks)**

b. Define the terms gradient and divergence. Give equations for them in rectangular coordinates. Mention their physical significance. **(09 Marks)**

c. Define scalar and vector. For a vectors $\vec{A} = 6\overline{a_x} + 2\overline{a_y} + 6\overline{a_z}$ and $\vec{B} = -2\overline{a_x} + 9\overline{a_y} - \overline{a_z}$

(i) Show that vectors $\vec{A}$ and $\vec{B}$ are perpendicular to each other.

(ii) Find $\vec{A} \times \vec{B}$ and show that $\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$ **(06 Marks)**

OR

2 a. State and prove the Gauss law. **(08 Marks)**

b. Three point charges $Q_1 = -1\mu c$, $Q_2 = -2\mu c$ and $Q_3 = -3\mu c$ are paced at the corners of an equilateral triangle of side 1m. Find the magnitude of electric field intensity at the point bisecting the line joining Q_1 and Q_2. **(06 Marks)**

c. Starting from Gauss theorem obtain Maxwell's equation in terms of flux density or point form of Gauss law. **(06 Marks)**

Module-2

3 a. Define the term electric potential. Obtain the expression for Absolute electric potential at a point due to point charge obtained from potential difference equation. **(12 Marks)**

b. Find the potential and volume charge density at point P(0.5, 1.5, 1) in the free space. Given the potential field $V = 2x^2 - y^2 - z^2$. **(08 Marks)**

OR

4 a. Explain the concept of "continuity equation" and hence show that

$$\nabla \cdot \vec{J} = -\frac{\partial \rho_v}{\partial t}$$ **(08 Marks)**

b. Derive an expression for capacitance of a parallel plate capacitor with dielectric interface ($\in_{r1}$ and $\in_{r2}$) parallel to the conducting plates. **(06 Marks)**

c. Let A = 120 cm^2, d = 5mm and $\in_R = 12$ for the parallel plate capacitor. Calculate the capacitance after connecting a 40 V battery across the capacitor, calculate E and total stored energy. **(06 Marks)**

Module-3

5 a. Starting from Gauss's law in integral form, derive Poisson's and Laplace equation. Write Laplace equation in all coordinate systems. **(09 Marks)**

b. Using Poisson's equation, obtain the expression for capacitance of a parallel plate capacitor. **(06 Marks)**

c. Derive an expression for capacitance between two concentric spherical shell having radius R_1 and R_2. ($R_2 > R_1$) **(05 Marks)**

OR

6 a. Derive an expression for Ampere's law. **(05 Marks)**

b. Evaluate both sides of Stoke's theorem for the field $\vec{H} = 10\sin\theta\, d\phi$ Ampere's/meter and the surface r = 3m, $0 \le \theta \le 90°$, $0° \le \phi \le 90°$. Let the surface has the $\hat{a}_r$ direction. What each side of Stoke's theorem represents? **(10 Marks)**

c. Find the magnetic field at point P(0.01, 0, 0) if current through a coaxial cable is 6A, which is along the z-axis and q = 3mm, b = 9mm, c = 11mm. **(05 Marks)**

Module-4

7 a. Derive an expression for the force acting between two conductors carrying current in opposite directions. **(08 Marks)**

b. A point charge of Q=−40μc is moving with a velocity of $\vec{V} = (-3\overline{a_x} - 4\overline{a_y} + 4.5\overline{a_z}) \times 10^6$ m/s. Find the magnitude of the vector force exerted on moving particle by the field:

i) $\vec{B} = 2\overline{a_x} - 3\overline{a_y} + 5\overline{a_z}$ mT

ii) $\vec{E} = 2\overline{a_x} + 3\overline{a_y} - 4\overline{a_z}$ kV/m

iii) Both B and E active together. **(08 Marks)**

c. Derive an expression for inductance of a solenoid. **(04 Marks)**

OR

8 a. Define magnetization, relative permeability and susceptibility. Derive the relation $\mu_r = (1 + \chi)$ **(09 Marks)**

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

c. An air cored toroid has a cross sectional area of 6 cm^2, a mean radius of 15 cm and is with 500turns and carries a current of 4 A. Find magnetic field intensity at the mean radius. **(05 Marks)**

Module-5

9 a. Derive the integral and differential form of Faraday's law. **(08 Marks)**

b. List Maxwell's equations in point form and in integral form. **(06 Marks)**

c. The circular loop conductor at z = 0 plane has a radius of 0.1 mt and resistance of 5Ω. Given $\vec{B} = 0.2\sin 10^3 t\, \overline{a_z}$ Tesla. Find current in the coil. **(06 Marks)**

OR

10 a. Modify the Ampere's circuital law to suit the time varying condition and hence obtain an expression for displacement current density. **(10 Marks)**

b. The magnetic field intensity of uniform plane wave in air is 20 A/m in $\hat{a}_y$ direction. The wave is propagating in $\hat{a}_z$ divides at an angular frequency of 2×10^9 rad/sec. Find (i) Phase Shift constant (ii) Wavelength (iii) Frequency (iv) Amplitude of electric field intensity. **(10 Marks)**

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