



CBCS SCHEME

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17EC36

Third Semester B.E. Degree Examination, Dec.2019/Jan.2020 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. Obtain an expression for electric field intensity at any given point due to 'n' number of point charges. (04 Marks)
- b. Four 10 nC positive charges are located in the z = 0 plane at the corners of a square 8 cm on a side. A fifth 10 nC positive charge is located at a point 8 cm distant from the other charges. Calculate the magnitude of the total force on this fifth charge for $\epsilon = \epsilon_0$. (08 Marks)
- c. Find the total charge contained in a 2 cm length of the electron beam for $2 \text{ cm} < z < 4 \text{ cm}$, $\rho = 1 \text{ cm}$ and $\rho_v = -5 e^{-100\rho z} \mu\text{C/m}^3$. (08 Marks)

OR

- 2 a. Define electric flux and electric flux density, and also, obtain the relationship between electric flux density and electric field intensity. (06 Marks)
- b. Infinite uniform line charges of 5 nC/m lie along the (positive and negative) x and y axes in free space, Find \vec{E} at P(1, 2, 3). (10 Marks)
- c. Given a 60 μC point charge located at the origin, find the total electric flux passing through:
 - (i) That portion of the sphere $r = 26 \text{ cm}$ bounded by $0 < \theta < \frac{\pi}{2}$ and $0 < \phi < \frac{\pi}{2}$.
 - (ii) The closed surface defined by $\rho = 26 \text{ cm}$ and $z = \pm 26 \text{ cm}$. (04 Marks)

Module-2

- 3 a. State and obtain mathematical formulation of Gauss law. (07 Marks)
- b. Given $\vec{D} = 6\rho \sin\left(\frac{\phi}{2}\right) \hat{a}_\rho + 1.5\rho \cos\left(\frac{\phi}{2}\right) \hat{a}_\phi \text{ C/m}^2$. Evaluate both sides of divergence theorem for the region bounded by $\rho = 2\text{m}$, $\phi = 0$, $\phi = \pi \text{ rad}$, $z = 0$ and $z = 5\text{m}$. (08 Marks)
- c. Derive the point form of current continuity equation. (05 Marks)

OR

- 4 a. Given the non-uniform field $\vec{E} = y\hat{a}_x + x\hat{a}_y + 2\hat{a}_z \text{ V/m}$, determine the work expended in carrying 2C from B(1, 0, 1) to A(0.8, 0.6, 1), along the shorter arc of the circle; $x^2 + y^2 = 1$, $z = 1$. (07 Marks)
- b. Derive the expression for potential field resulting from point charge in free-space. (07 Marks)
- c. Find the value of volume charge density at p($r = 1.5 \text{ m}$, $\theta = 30^\circ$, $\phi = 50^\circ$), when $\vec{D} = 2r \sin \theta \cos \phi \hat{a}_r + r \cos \theta \cos \phi \hat{a}_\theta - r \sin \phi \hat{a}_\phi \text{ C/m}^2$. (06 Marks)

Module-3

- 5 a. Using Gauss law derive Poisson and Laplace equations. (05 Marks)
- b. State and prove uniqueness theorem. (10 Marks)
- c. Calculate ΔH_2 at $P_2(4, 2, 0)$ resulting from $I_1 \Delta L_1 = 2\pi \hat{a}_z \mu\text{Am}$ at $P_1(0, 0, 2)$. (05 Marks)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

OR

- 6 a. Show that $\nabla^2 V = 0$, for $V = (5\rho^4 - 6\rho^{-4})\sin 4\phi$. (05 Marks)
- b. Evaluate both sides of Stoke's theorem for the field $\vec{H} = 6xy\hat{a}_x - 3y^2\hat{a}_y$ A/m and the rectangular path around the region, $2 \leq x \leq 5$, $-1 \leq y \leq 1$, $z = 0$. Let positive direction of $d\vec{s}$ be \hat{a}_z . (08 Marks)
- c. State and explain Ampere's circuital law. Using the same, obtain the expression for \vec{H} at any given point due to the infinite length filamentary conductor, carrying current I. (07 Marks)

Module-4

- 7 a. Obtain an expression for Lorentz force equation. (05 Marks)
- b. Obtain the relationship between magnetic fields at the boundary of two different magnetic media. (09 Marks)
- c. Derive the expression for force between two infinitely long, straight, parallel filamentary conductors, separated by distance d, carrying equal and opposite currents, I. (06 Marks)

OR

- 8 a. Given a ferrite material which operates in a linear mode with $B = 0.05$ T, calculate values for magnetic susceptibility, magnetization and magnetic field intensity. Given $\mu_r = 50$. (05 Marks)
- b. Obtain expressions for magneto motive force (mmf) and reluctance in magnetic circuits by making use of analogy between electric and magnetic circuits. (08 Marks)
- c. Two differential current elements, $I_1\Delta\vec{L}_1 = 3(10^{-6})\hat{a}_y$ Am at $P_1(1, 0, 0)$ and $I_2\Delta\vec{L}_2 = 3(10^{-6})(-0.5\hat{a}_x + 0.4\hat{a}_y + 0.3\hat{a}_z)$ Am at $P_2(2, 2, 2)$ are located in free space. Find vector force exerted on $I_2\Delta\vec{L}_2$ by $I_1\Delta\vec{L}_1$. (07 Marks)

Module-5

- 9 a. Explain the inadequacy of Ampere's circuital law for time-varying fields. Obtain a suitable correction for the same, which will remain consistent for both time and non-time-varying fields. (05 Marks)
- b. Let $\mu = 10^{-5}$ H/m, $\epsilon = 4 \times 10^{-9}$ F/m, $\sigma = 0$ and $\rho_v = 0$. Find K (including units) so that the following pair of fields satisfy Maxwell's equations: $\vec{E} = (20y - Kt)\hat{a}_x$ V/m, $\vec{H} = (y + 2 \times 10^6 t)\hat{a}_z$ A/m. (05 Marks)
- c. Starting from Maxwell's curl equation, obtain the equation of Poynting's theorem and interpret the same. (10 Marks)

OR

- 10 a. Express Maxwell's equations in phasor form as applicable to free-space. Using the same, obtain vector Helmholtz equation in free space. (09 Marks)
- b. Obtain an expression for skin depth when an electromagnetic wave enters a conducting medium. Also, calculate the skin depth when a 160 MHz plane wave propagates through aluminum of conductivity 10^5 S/m, $\epsilon_r = \mu_r = 1$ (05 Marks)
- c. Starting from equation of Faraday's law, obtain the point form of Maxwell's equation concerning spatial derivative of \vec{E} and time derivative of \vec{H} . (06 Marks)
