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.

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.

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 $\in = \in_0$. **(08 Marks)**

c. Find the total charge contained in a 2 cm length of the electron beam for 2 cm < z < 4 cm, $\rho = 1$ cm and $\rho_v = -5\, e^{-100\rho z}$ $\mu c/m^3$. **(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 cm bounded by $0 < \theta < \frac{\pi}{2}$ and $0 < \phi < \frac{\pi}{2}$.

(ii) The closed surface defined by $\rho = 26$ cm and $z = \pm 26$ cm. **(04 Marks)**

Module-2

3 a. State and obtain mathematical formulation of Gauss law. **(07 Marks)**

b. Given $\vec{D} = 6\rho \sin\left(\frac{\phi}{2}\right)\hat{a}_\rho + 1.5\rho\cos\left(\frac{\phi}{2}\right)\hat{a}_\phi$ C/m². Evaluate both sides of divergence theorem for the region bounded by $\rho = 2$m, $\phi = 0$, $\phi = \pi$ rad, z = 0 and z = 5m. **(08 Marks)**

c. Derive the point form of current continuity equation. **(05 Marks)**

OR

4 a. Given the non-uniform field $\vec{E} = y\hat{a}_x + x\hat{a}_y + 2\hat{a}_z$ 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 m, θ = 30°, φ = 50°), when $\vec{D} = 2r\sin\theta\cos\phi\,\hat{a}_r + r\cos\theta\cos\phi\,\hat{a}_\theta - r\sin\phi\,\hat{a}_\phi$ C/m². **(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 $\Delta\vec{H}_2$ at P₂(4, 2, 0) resulting from $I_1\Delta\vec{L}_1 = 2\pi\hat{a}_z$ μAm at P₁(0, 0, 2). **(05 Marks)**

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, $2 \le x \le 5$, $-1 \le y \le 1$, $z = 0$. Let positive direction of $\vec{ds}$ 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 ℧/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)**

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