

USN

--	--	--	--	--	--	--	--	--	--

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  $\rho_v = -5 e^{-100} \text{ pC/m}^3$ . (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 E at P(1, 2, 3). (10 Marks)
- c. Given a 60 JAC 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  $0 < \phi < \frac{\pi}{2}$ . (04 Marks)
  - (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 form of Gauss law. (07 Marks)
- b. Given  $\vec{D} = 6\rho \sin \frac{\pi}{2} \hat{a}_\rho + \rho \cos \frac{\pi}{2} \hat{a}_\phi \text{ C/m}^2$ . Evaluate both sides of divergence theorem for the region bounded by  $\rho = 2\text{m}$ ,  $\sin \theta = 0$ ,  $(1) = \pi \text{ rad}$ ,  $z = 0$  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  $\vec{E} = y^2 \hat{x} + x^2 \hat{y} + 2xy \hat{z} \text{ V/m}$ , 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  $\rho(r = 1.5 \text{ in}, \theta = 30^\circ, \phi = 50^\circ)$ , when  $\vec{D} = 2r \sin \theta \cos \phi \hat{a}_r + r \cos \theta \sin \phi \hat{a}_\theta - r \sin \theta \cos \phi \hat{a}_\phi \text{ C/m}^2$ . (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 A and I at  $P_2(4, 2, 0)$  resulting from  $\vec{I} = 2r \cos \theta \hat{a}_r + 1.1 \text{ Am}$  at  $P_1(0, 0, 2)$ . (05 Marks)

**17EC36**
**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  $\mathbf{H} = 6xy^2 \mathbf{a}_y - 3y^2 \mathbf{a}_x$  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  $\mathbf{d}$ ; be  $\mathbf{a}_z$ . (08 Marks)
- c. State and explain Ampere's circuital law. Using the same, obtain the expression for  $\mathbf{H}$  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  $\mathbf{B} = 0.05$  T, calculate value of  $\mu_r$  for magnetic susceptibility, magnetization and magnetic field intensity. Given  $\mathbf{J} = 50$ . (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,  $I_1 d\mathbf{L}_1 = 3(10^{-6}) \mathbf{a}_y$  Am at  $P_1(1, 0, 0)$  and  $I_2 d\mathbf{L}_2 = 3(10^{-6})(-0.5\mathbf{a}_x + 0.4\mathbf{a}_y + 0.3\mathbf{a}_z)$  Am at  $P_2(2, 2, 2)$  are located in free space. Find vector force exerted on  $I_1 d\mathbf{L}_1$  by  $I_2 d\mathbf{L}_2$ . (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  $\rho_t = 10^{-5}$  H/m,  $\mathbf{E} = 4x \mathbf{e}^y$  F/m,  $\rho_v = 0$  and  $\rho_m = 0$ . Find  $K$  (including units) so that the following pair of fields satisfy Maxwell's equations:  $\mathbf{E} = (20y - Kt)\mathbf{a}_x$  V/m,  $\mathbf{H} = (y + 2x \cdot 10^6 t) \mathbf{a}_z$ , A/m. (05 Marks)
- e. 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  $10^5$  U/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  $\mathbf{E}$  and time derivative of  $\mathbf{H}$ .