CBCS SCHEME

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 cm < z < 4 cm, $\rho = 1$ cm and $\rho_v = -5e^{-100\rho z}$ $\mu c/m^3$. **(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/m^2. 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/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 $\Delta\vec{H}_2$ at $P_2(4, 2, 0)$ resulting from $I_1\Delta\vec{L}_1 = 2\pi\hat{a}_z$ μAm at $P_1(0, 0, 2)$. **(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, $\vec{H} = (y + 2\times10^6 t)\hat{a}_z$ 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)

* * * * *