



CBCS SCHEME

15EC36

Third Semester B.E. Degree Examination, Jan./Feb. 2021 Engineering Electromagnetics

Time: 3 hrs.

Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

- 1 a. A charge $Q_A = -20 \mu\text{C}$ is located at $A(-6, 4, 7)$ and a charge $Q_B = 50 \mu\text{C}$ is located at $B(5, 8, -2)$ in free space. If distances are given in meters, find the vector force exerted on Q_A by Q_B . (06 Marks)
- b. A charge of $-0.3 \mu\text{C}$ is located at $A(25, -30, 15)$ (in cm) and a second charge of $0.5 \mu\text{C}$ is located at $B(-10, 8, 12)$ cm. Find Electric field intensity (E) at
(i) the origin (ii) $P(15, 20, 50)$, cm. (08 Marks)
- c. Define electric flux density. (02 Marks)

OR

- 2 a. Calculate the total charge within the universe of $\rho_v = \frac{e^{-2r}}{r^2}$. (04 Marks)
- b. Infinite uniform line charges of 5 nC/m lie along the (positive and negative) x and y axes in free space. Find Electric field intensity (E) at $P_A(0, 0, 4)$ (04 Marks)
- c. Calculate Electric flux Density (D) in rectangular coordinates at point $P(2, -3, 6)$ produced by
(i) a point charge $Q_A = 55 \text{ mC}$ at $Q(-2, 3, -6)$;
(ii) a uniform line charge $\rho_{LB} = 20 \text{ mC/m}$ on the x-axis. (08 Marks)

Module-2

- 3 a. State and explain Gauss law in electrostatics. (04 Marks)
- b. Derive the expression for electric field intensity due to an infinite line charge using Gauss law. (04 Marks)
- c. In the region of free space that includes the volume $2 < x, y, z < 3$,
 $D = \frac{2}{z^2}(yza_x + xza_y - 2xya_z) \text{ c/m}^2$.
(i) Evaluate the volume integral side of the divergence theorem for the volume defines here. (08 Marks)
(ii) Evaluate surface integral side for the corresponding closed surface. (08 Marks)

OR

- 4 a. Derive an expression for continuity equation in point form. (04 Marks)
- b. If $\hat{E} = 120 a_p \text{ V/m}$, find the incremental amount of work done in moving a $50 \mu\text{C}$ charge a distance of 2 mm from (i) $P(1, 2, 3)$ toward $Q(2, 1, 4)$ (ii) $Q(2, 1, 4)$ toward $P(1, 2, 3)$. (05 Marks)
- c. Current density is given in cylindrical coordinates as $J = -10^6 z^{1.5} a_z \text{ A/m}^2$ in the region $0 \leq \rho \leq 20 \mu\text{m}$; for $\rho \geq 20 \mu\text{m}$ $J = 0$.
(i) Find the total current crossing the surface $z = 0.1 \text{ m}$ in the a_z direction.
(ii) If the charge velocity is $2 \times 10^6 \text{ m/s}$ at $z = 0.1 \text{ m}$, find ρ_v (volume charge density). (07 Marks)

Module-3

- 5 a. Starting from Gauss law, derive Poisson's and Laplace's equation. (04 Marks)
- b. Calculate numerical value for potential V and volume charge density ρ_v at $P\left(3, \frac{\pi}{3}, 2\right)$ if $V = 5\rho^2 \cos 2\phi$. (06 Marks)
- c. Given the spherically symmetric potential field in free space, $V = V_0 e^{-r/a}$, find:
(i) ρ_v at $r = a$ (ii) the electric field at $r = a$ (iii) total charge. (06 Marks)

OR

- 6 a. State and explain Ampere's law. (04 Marks)
- b. Evaluate both sides of Stoke's theorem for the field $H = 10 \sin \theta a_\phi$ and the surface $r = 3$, $0 \leq \theta \leq 90^\circ$, $0 \leq \phi \leq 90^\circ$. Let the surface have the a_r direction. (06 Marks)
- c. Using the concept of vector magnetic potential, find the magnetic flux density at a point due to long straight filamentary conductor carrying current 'I' in the a_z direction. (06 Marks)

Module-4

- 7 a. Derive an expression for the force on a differential current element placed in a magnetic field. (04 Marks)
- b. A point charge for which $Q = 2 \times 10^{-16}$ C and $m = 5 \times 10^{-26}$ kg is moving in the combined fields $E = 100 a_x - 200 a_y + 300 a_z$ V/m and $B = -3a_x + 2a_y - a_z$ mT. If the charge velocity at $t = 0$ is $V(0)$. $V(0) = (2a_x - 3a_y - 4a_z)10^5$ m/s.
(i) Give the unit vector showing the direction in which the charge is accelerating at $t = 0$.
(ii) Find the kinetic energy of the charge at $t = 0$. (06 Marks)
- c. A rectangular loop of wire in free space joins points A(1, 0, 1) to B(3, 0, 1) to C(3, 0, 4) to D(1, 0, 4) to A. The wire carries a current of 6 mA, flowing in the a_z direction from B to C. A filamentary current of 15A flows along entire z axis in the a_z direction.
(i) Find 'F' on side BC (ii) Find 'F' on side AB (iii) Find F_{total} on the loop. (06 Marks)

OR

- 8 a. Given a material for which $x_m = 3.1$ and within which $B = 0.4ya_z$ T, find:
(i) H (ii) μ (iii) μ_r (iv) M (v) J (04 Marks)
- b. Let $\mu_r = 2$ in region 1 defined by $2x + 3y - 4z > 1$ while $\mu_r = 5$ in region 2 where $2x + 3y - 4z < 1$. In region 1, $H_1 = 50a_x - 30a_y + 20a_z$ A/m. Find:
(i) H_{N_1} (ii) H_{t_1} (iii) H_{t_2} (iv) H_{N_2} (v) θ_1 the angle between H_1 and a_{N_2} (08 Marks)
- c. Obtain an expression for the total energy stored in a steady magnetic field in which 'B' is linearly related to 'H'. (04 Marks)

Module-5

- 9 a. Write Maxwell's equations in integral and point forms. (06 Marks)
- b. Using Faraday's law, deduce Maxwell's equation, to relate time varying electric and magnetic fields. (06 Marks)
- c. Explain the displacement current and displacement current density. (04 Marks)

OR

- 10 a. Derive wave equations for uniform plane wave in free space. (06 Marks)
- b. Derive an expression for propagation constant intrinsic impedance and phase velocity for a uniform plane wave propagating in a conducting media. (06 Marks)
- c. In free space $E(x, t) = 50 \cos(\omega t - \beta x)a_y$ V/m. find the average power crossing a circular area of radius 5m in the plane $x = \text{constant}$. (04 Marks)