CBCS SCHEME

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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 $Q_A = -20\ \mu C$ is located at A(−6, 4, 7) and a charge $Q_B = 50\ \mu C$ 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 μC is located at A(25, −30, 15) (in cm) and a second charge of 0.5 μC 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 QA = 55 mC at Q(−2, 3, −6);
(ii) a uniform line charge ρ_{LB} = 20 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, $D = \frac{2}{z^2}(yza_x + xza_y - 2xya_z)$ c/m^2.
(i) Evaluate the volume integral side of the divergence theorem for the volume defines here.
(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 $\hat{E} = 120\ a_\rho$ V/m, find the incremental amount of work done in moving a 50 μC 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 $J = -10^6\ z^{1.5} a^z$ A/m^2 in the region $0 \le \rho \le 20\ \mu m$; for $\rho \ge 20\ \mu m$ J = 0.
(i) Find the total current crossing the surface z = 0.1 m in the a_z direction.
(ii) If the charge velocity is 2×10^6 m/s at z = 0.1m, 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, $0 \le \theta \le 90°$, $0 \le \phi \le 90°$. 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 $\mu_{r_1} = 2$ in region 1 defined by $2x + 3y - 4z > 1$ while $\mu_{r_2} = 5$ 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_{N21} **(08 Marks)**

c. Obtain an expression for the total energy stored in a steady magnetic filed 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 = constant. **(04 Marks)**