CBCS SCHEME

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18EC55

Fifth Semester B.E. Degree Examination, Jan./Feb. 2021
Electromagnetic Waves

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. State and explain Coulomb's law in vector form. **(05 Marks)**

b. Derive the relationship between dot products between unit vectors of the three coordinate systems. Transform the following vectors to spherical system at the point given :
   i) $10a_x$ at P(3, 2, 4)
   ii) $10a_y$ at Q(5, 30°, 4) **(07 Marks)**

c. Four 10nc positive charges are located in z = 0 plane at the corners of a square 8cm on a side. A fifth 10nc charge is located at a point 8cm distant from other charges. Calculate the magnitude of total force on this fifth charge for $E = E_0$. **(08 Marks)**

OR

2 a. Using Coloumb's law, derive the expression for electric field Intensity 'E' due to an infinite sheet of charge of surface charge density ρ_s c/m^2. **(08 Marks)**

b. Four uniform sheets of charge are located as 20 Pc/m^2 at y = 7 ; −8 Pc/m^2 at y = 3 ; 6 P c/m^2 at y = −1 ; −18Pc/m^2 at y = −4. Find E at i) P_A (2, 6, -4) ii) P_B (10^6, 10^6, 10^6). **(06 Marks)**

c. Find the net outward flux (ψ) through the surface of a cube 2m on an edge centered at origin if $D = 5x^2a_x + 10za_z$ c/m^2. (The edges of cube are parallel to coordinate axes). **(06 Marks)**

Module-2

3 a. State and prove Gauss law in Integral form. **(05 Marks)**

b. Find the volume charge density at the points indicated if

   i) $D = 4\rho z \sin\phi\, a_\rho + 2\rho z \cos\phi\, a_\phi + 2\rho^2 \sin\phi\, a_z$ c/m^2 at $P_A\left(1, \frac{\pi}{2}, 2\right)$

   ii) $D = \sin\theta \cos\phi\, a_r + \cos\theta \cos\phi\, a_\phi - \sin\phi\, a_\phi$ c/m^2 at $P_B\left(2, \frac{\pi}{3}, \frac{\pi}{6}\right)$ **(07 Marks)**

c. Evaluate both sides of Divergence Theorem if $D = \frac{5r^2}{4} a_r$ c/m^2 in spherical co-ordinate for the volume enclosed between r = 1m and r = 2m. **(08 Marks)**

OR

4 a. Find the work done in moving a 5μc charge from origin to P(2, −1, 4) through $E = 2xyza_x + x^2 2a_y + x^2 y\, a_z$ V/m via the path :
   i) Straight line segments (0, 0, 0) to (2, 0, 0) to (2, −1, 0) to (2, −1, 4)
   ii) Straight line x = −2y ; z = 2x. **(08 Marks)**

b. Find 'E' at P(3, 60°, 25°) in free space, given $V = \frac{60\sin\theta}{r^2}$ V. **(06 Marks)**

c. Derive equation of continuity. Given $J = -10^6 z^{1.5}\, a_z$ A/m^2 in a region $0 \le \rho \le 20\mu$m, find the total current crossing a surface z = 0.1m. **(06 Marks)**

Module-3

5 a. Derive the expression for capacitance of a cylindrical capacitor using Laplace equation. (08 Marks)

b. Assume $V = V_0$ at $\rho = a$ and $V = 0$ at $\rho = b$, $b > a$.
In spherical co-ordinate $V = 865$ V at $r = 50$cm and $E = 748.2\ a_r$ at $r = 85$cm. Determine the location of voltage reference if potential depends only on 'r'. (08 Marks)

c. Verify whether the potential function $V = 2x^2 - 3x^2 + z^2$ satisfies Laplace equation. (04 Marks)

OR

6 a. Derive the expression for magnetic field intensity 'H' at the centre of a square current carrying loop of I amps with side 'L' meters using Biot Savart's law. (08 Marks)

b. Given $H = \frac{x+2y}{z^2}a_y + \frac{2}{z}a_z$ A/m. find J. Use J to find total current passing through the surface $z = 4$, $1 \le x \le 2$, $3 \le y \le 5$. (08 Marks)

c. Explain the concept of scalar and vector magnetic potential. (04 Marks)

Module-4

7 a. The point charge $Q = 18$nc has a velocity of 5×10^6m/s in the direction $a_v = 0.6\ a_x + 0.75a_y + 0.3a_z$. Calculate the magnitude of the force exerted on the charge by the field.

i) $B = -3a_x + 4a_y + 6a_z$ mT

ii) $E = -3a_x + 4a_y + 6a_z$ kV/m (08 Marks)

b. The magnetization in a magnetic material for which $\chi_m = 8$ is $150z^2\ a_x$ A/m. At $z = 4$cm, find the magnitude of i) J ii) J_T iii) J_B. (06 Marks)

c. Derive the expression for the force between two differential current elements. (06 Marks)

OR

8 a. Derive the expression for the boundary conditions between two magnetic medias. (06 Marks)

b. Let the permitivity be 5μH/m in region A where $x < 0$ and 20 μH/m in region B where $x < 0$. and 20 μH/m in region B where $x > 0$. If $K = 150a_y - 200a_z$ A/m at $x = 0$ and $H_A = 300a_x - 400a_y + 500a_z$ A/m. Find : i) $|H_{tA}|$ ii) $|H_{NA}|$ iii) $|H_tB|$ iv) $|H_{NB}|$. (08 Marks)

c. A circular loop of radius 10cm radius is located in x – y plane in a magnetic field $B = 0.5 \cos(377t)(3a_y + 4a_z)$ T. Determine the voltage induced in the loop. (06 Marks)

Module-5

9 a. What is the inconsistency of Ampere's law with continuity equation? Derive the modified Ampere's law by Maxwell for time varying fields. (06 Marks)

b. Given $E = E_m \sin(\omega t - \beta z)\ a_y$ V/m, find i) D ii) B iii) H. sketch E and H at $t = 0$. (08 Marks)

c. Prove that the conduction current is equal to the displacement current between the two plates for $V = V_0 e^{j\omega t}$ in a parallel plate capacitor. (06 Marks)

OR

10 a. Show that the intrinsic impedance of the perfect dielectric $\eta = \frac{|E|}{|H|} = \sqrt{\frac{\mu}{E}}$ and show that its value in free space is 377Ω. (08 Marks)

b. A uniform plane wave of a frequency 300MHz travels in +x direction in a lossy medium with $E_r = 9$, $\mu_r = 1$ and $\sigma = 10$ mhos/m. Calculate γ, α, β and η. (06 Marks)

c. State and prove Poynting theorem. (06 Marks)

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