



CBCS SCHEME

USN

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 $Q(5, 30^\circ, 4)$ (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 $\rho_s \text{ c/m}^2$. (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 $y = -1$; -18 Pc/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 $D = 5x^2a_x + 10za_z \text{ c/m}^2$. (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) $D = 4\rho z \sin \phi a_\rho + 2\rho z \cos \phi a_\phi + 2\rho^2 \sin \phi a_z \text{ c/m}^2$ at $P_A\left(1, \frac{\pi}{2}, 2\right)$
ii) $D = \sin\theta \cos \phi a_r + \cos\theta \text{ Cos}\phi a_\phi - \sin \phi a_\phi \text{ c/m}^2$ at $P_B\left(2, \frac{\pi}{3}, \frac{\pi}{6}\right)$ (07 Marks)
c. Evaluate both sides of Divergence Theorem if $D = \frac{5r^2}{4} a_r \text{ c/m}^2$ in spherical co-ordinate for the volume enclosed between $r = 1\text{m}$ and $r = 2\text{m}$. (08 Marks)

OR

- 4 a. Find the work done in moving a $5\mu\text{c}$ charge from origin to $P(2, -1, 4)$ through $E = 2xyza_x + x^22a_y + x^2y a_z \text{ V/m}$ 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 $P(3, 60^\circ, 25^\circ)$ in free space, given $V = \frac{60 \sin \theta}{r^2} \text{ V}$. (06 Marks)
c. Derive equation of continuity. Given $J = -10^6 z^{1.5} a_z \text{ A/m}^2$ in a region $0 \leq \rho \leq 20\mu\text{m}$, find the total current crossing a surface $z = 0.1\text{m}$. (06 Marks)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

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 $z = 4$, $1 \leq x \leq 2$, $3 \leq y \leq 5$. (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 5×10^6 m/s in the direction $a_v = 0.6 a_x + 0.75 a_y + 0.3 a_z$. 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 permittivity be 5μ H/m in region A where $x < 0$ and 20μ H/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 $\eta = \frac{|E|}{|H|} = \sqrt{\frac{\mu}{\epsilon}}$ 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)
