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18EC55

Fifth Semester B.E. Degree Examination, July/August 2022
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. Convert point P(1, 3, 5) from Cartesian to cylindrical and spherical coordinates. Also write the equation for differential surface and differential volume for cylindrical and spherical system. **(08 Marks)**

b. A line charge of 2 nc/m lies along y-axis while surface charge densities of 0.1 and -0.1 nc/m^2 exist on the plane z = 3 and z = -4 respectively. Find the electric field intensity at a point (1, -7, 2). **(06 Marks)**

c. A point charge of 50 nc each are located at A(1, 0, 0), B(-1, 0, 0), C(0, 1, 0) and D(0, -1, 0) in free space. Find the total force on the charge at A. **(06 Marks)**

OR

2 a. Compute the value of $\overline{E}$ at P(1, 1, 1) caused by four identical 3nc charges located at $P_1(1, 1, 0)$, $P_2(-1, 1, 0)$, $P_3(-1, -1, 0)$ and $P_4(1, -1, 0)$. **(08 Marks)**

b. Define electric field intensity and flux density. Derive the expression for electric field intensity due to several point charges. **(06 Marks)**

c. Calculate the total charge for the defined volume. Given that $0.1 \le |x|, |y|, |z| \le 0.2$

$$\rho_v = \frac{1}{x^3y^3z^3}$$ **(06 Marks)**

Module-2

3 a. Evaluate both sides of divergence theorem for the defined plane in which $1 \le x \le 2$, $2 \le y \le 3$, $3 \le z \le 4$. $\overline{D} = 4x\bar{a}_x + 3y^2\bar{a}_y + 2z^3\bar{a}_z$ c/m^2. **(10 Marks)**

b. Determine workdone in carrying a charge of -2c from (2, 1, -1) to (8, 2, -1) in the electric field $\overline{E} = y\bar{a}_x + x\bar{a}_y$ V/m, (in Cartesian system). **(05 Marks)**

c. Considering the path along the parabola $x = 2y^2$, obtain the equation of continuity in integral and differential form. **(05 Marks)**

OR

4 a. Let $V = \frac{\cos 2\phi}{r}$ in the free space in cylindrical system:

(i) Find $\overline{E}$ at B(2, 30°, 1)

(ii) Find the volume charge density at point A(0.5, 60°, 1) **(08 Marks)**

b. Calculate the numerical value for div $\overline{D}$ at the point P(2, 3, -1) for $\overline{D} = (2xyz - y^2)\bar{a}_x + (x^2z - 2xy)\bar{a}_y + x^2y\bar{a}_z$ c/m^2 **(06 Marks)**

c. Define potential difference. Derive the expression for potential due to several point charges. **(06 Marks)**

Module-3

5 a. Solve the Laplace's equation for the potential field in the homogeneous region between the two concentric conducting spheres with radii a and b, such that b > a if potential V = 0 at r = b and V = V_0 at r = a. Also find the capacitance between the two concentric spheres. **(09 Marks)**

b. State and explain Biot-Savart law. **(05 Marks)**

c. If the magnetic field intensity in a region is $\overline{H} = (3y - 2)\bar{a}_z + 2x\bar{a}_y$. Find the current density at the origin. **(06 Marks)**

OR

6 a. State and prove uniqueness theorem. **(07 Marks)**

b. Find $\overline{E}$ at P(3, 1, 2) for the field of two coaxial conducting cylinders V = 50 V at ρ = 2m and V = 20 V at ρ = 3m. **(06 Marks)**

c. Evaluate both side of the Stoke's theorem for the filed $\overline{H} = 6xy\bar{a}_x - 3y^2\bar{a}_y$ A/m and the rectangular path around the region $2 \le x \le 5$, $-1 \le y \le 1$, z = 0. Let the direction of $\overline{d}_s$ to be $\bar{a}_z$. **(07 Marks)**

Module-4

7 a. Obtain the expression for magnetic force between differential current elements. **(06 Marks)**

b. Calculate the normal components of the magnetic field which traversal from medium 1 to medium 2 having $\mu_{r_1} = 2.5$ and $\mu_{r_2} = 4$. Given that $\overline{H}_1 = -30\bar{a}_x + 50\bar{a}_y + 70\bar{a}_z$ V/m. **(06 Marks)**

c. Derive the integral and differential form of Faraday's law. **(08 Marks)**

OR

8 a. A current element $I_1 dL_1 = 10^{-4}\bar{a}_z$ Am is located at $P_1(2, 0, 0)$ and another current element $I_2 dL_2 = 10^{-6}[\bar{a}_x - 2\bar{a}_y + 3\bar{a}_z]$ Am is located at $P_2(-2, 0, 0)$. Both are in free space. Find:

(i) Force exerted on $I_2 dL_2$ by $I_1 dL_1$

(ii) Force exerted on $I_1 dL_1$ by $I_2 dL_2$ **(06 Marks)**

b. Calculate the magnetization in magnetic material where:

(i) $\mu = 1.8 \times 10^5$ (H/m) and M = 120 (A/m)

(ii) μ_r = 22, there are 8.3×10^{28} atoms/m^3 and each atom has a dipole moment of 4.5×10^{-27} (A/m^2)

(iii) B = 300 (μT) and χ_m = 15. **(06 Marks)**

c. Obtain the magnetic boundary conditions at interface between two different magnetic material. **(08 Marks)**

Module-5

9 a. List and explain Maxwell's equation in point form and integral form. **(06 Marks)**

b. Calculate intrinsic impedance η_1 the propagation constant γ and wave velocity υ for a conducting medium in which σ = 58 Ms/m, μ_r = 1, ε_r = 1 at a frequency of 100 MHz. **(06 Marks)**

c. The $\overline{H}$ field in free space is given by $\overline{H}(x,t) = 10\cos(10^8 t - \beta x)\bar{a}_y$ A/m. Find β, λ and E(x, t) at P(0.1, 0.2, 0.3) and t = 1 ns. **(08 Marks)**

OR

10 a. State and prove Poynthing theorem. **(08 Marks)**

b. A metal sheet of aluminium has σ = 38.2 M $\mho$/m and μ_r = 1. Calculate the skin depth δ, propagation constant γ and velocity of propagation v at the frequency of 1.6 MHz. **(06 Marks)**

c. Do the field $\overline{E} = E_m \sin x \sin t\, \bar{a}_y$ and $\overline{H} = \frac{E_m}{\mu_0}\cos x \cos t\, \bar{a}_z$. Satisfy Maxwell's equation. **(06 Marks)**