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## Fifth Semester B.E. Degree Examination, Dec.2023/Jan.2024

### 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 of force between two point charges in vector form. (06 Marks)
  - b. Convert point P(1, 3, 5) to cylindrical and spherical co-ordinates. Also write the equations for differential surface, differential volume for rectangular, cylindrical and spherical systems. (06 Marks)
  - c. Find electric field intensity at P(1, 1, 1) caused by 4 identical 3nc charges are 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)

**OR**

- 2
  - a. Define electric field intensity. Derive an expression for electric field intensity due to infinite line charge. (08 Marks)
  - b. A point charge of 50nc 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. Also find  $\vec{E}$  at A. (06 Marks)
  - c. A uniform line charge  $\rho_L = 25nc/m$  lies on the line  $x = -3m$ ,  $y = 4m$  in freespace. Find electric field intensity at a point (2, 3, 15)m. (06 Marks)

#### Module-2

- 3
  - a. State and prove Gauss's law. (06 Marks)
  - b. Evaluate both sides of the divergence theorem for the defined plane in which  $1 \leq x \leq 2$ ,  $2 \leq y \leq 3$ ,  $3 \leq z \leq 4$ , if  $\vec{D} = 4x\hat{a}_x + 3y^2\hat{a}_y + 2z^3\hat{a}_z$  c/m<sup>2</sup>. (10 Marks)
  - c. Derive the point form of continuity of current equation. (04 Marks)

**OR**

- 4
  - a. Obtain the expression for the work done in moving a point charge in an electric field. (06 Marks)
  - b. Given that the field  $\vec{D} = \frac{5\sin\theta \cos\phi}{r}\hat{a}_r$  c/m<sup>2</sup>. Find : i) Volume charge density ii) The total electric flux leaving the surface of the spherical volume of radius 2m. (08 Marks)
  - c. Define potential difference. Derive the expression for potential field of a point charge. (06 Marks)

#### Module-3

- 5
  - a. State and prove uniqueness theorem. (08 Marks)
  - b. Define Stoke's theorem. Use this theorem to evaluate both sides of the theorem for the field  $\vec{H} = 6xy\hat{a}_x - 3y^2\hat{a}_y$  A/m and the rectangular path around the region,  $2 \leq x \leq 5$ ,  $-1 \leq y \leq 1$  and  $z = 0$ . Let the positive direction of ds be  $\hat{a}_z$ . (12 Marks)

OR

- 6 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 concentric spheres. (08 Marks)
- b. Derive the expression for magnetic field intensity due to infinite long straight conductor using Biot-Savart's law. (06 Marks)
- c. Determine whether or not the following potential fields satisfy the Laplace's equation:
- i)  $V = 2x^2 - 3y^2 + z^2$  ii)  $V = r \cos\theta + \phi$  (06 Marks)

**Module-4**

- 7 a. Derive an expression for Lorentz Force equation. (06 Marks)
- b. If  $\vec{B} = 0.05x \hat{a}_y$  Tesla in a material for which  $\mu_m = 2.5$ , Find: i)  $\mu_r$  ii)  $\mu$  iii)  $\vec{H}$  iv)  $\vec{M}$  v)  $\vec{J}$  vi)  $\vec{J}_b$ . (08 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. (10 Marks)
- b. Calculate the magnetization in magnetic material where:
- i)  $\mu = 1.8 \times 10^5$  H/m and  $M = 120$  A/m
- ii)  $\mu_r = 22$ , there are  $8.3 \times 10^{28}$  Atoms/m<sup>3</sup> and each atom has a dipole moment of  $4.5 \times 10^{-27}$  A/m<sup>2</sup>
- iii)  $B = 300 \mu\text{T}$  and  $\chi_m = 15$ . (06 Marks)
- c. Briefly explain the forces on magnetic materials. (04 Marks)

**Module-5**

- 9 a. List and explain Maxwell's equations in point form and integral form. (08 Marks)
- b. Given  $\vec{E} = E_m \sin(\omega t - \beta z) \hat{a}_y$  v/m. Find: i)  $\vec{D}$  ii)  $\vec{B}$  iii)  $\vec{H}$ . Sketch  $\vec{E}$  and  $\vec{H}$  at  $t = 0$ . (08 Marks)
- c. Find the frequency at which conduction current density and displacement current density are equal in a medium with  $\sigma = 2 \times 10^{-4}$  mho/m and  $\epsilon_r = 81$ . (04 Marks)

OR

- 10 a. State and prove Poynting theorem. (08 Marks)
- b. For the given medium  $\epsilon = 4 \times 10^{-9}$  F/m and  $\sigma = 0$ , find 'K' so that  $\vec{E} = (20y - kt) \hat{a}_x$  v/m and  $\vec{H} = (y + 2 \times 10^6 t) \hat{a}_z$  A/m. (06 Marks)
- c. A uniform plane wave of frequency 10MHz travels in positive direction in a lossy medium with  $\epsilon_r = 2.5$ ,  $\mu_r = 4$  and  $\sigma = 10^{-3}$  S/m. Calculate  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\eta$ ,  $\lambda$ . (06 Marks)

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