

# CBCS SCHEME

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15EE45

## Fourth Semester B.E. Degree Examination, Jan./Feb. 2023 Electromagnetic Field Theory

Time: 3 hrs.

Max. Marks: 80

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

### Module-1

- 1 a. Define Divergence and Curl in Cartesian coordinate system with mathematical expressions. (10 Marks)
- b. Define:
- i) Electric Field intensity
- ii) Gauss Law. (06 Marks)

OR

- 2 a. Find Curl  $\vec{H}$  if  $\vec{H} = (2\rho \cos\phi \vec{a}_\rho - 4\rho \sin\phi \vec{a}_\phi + 3\vec{a}_z)$ . (04 Marks)
- b. Identical point charges of  $3\mu\text{C}$  are located at the four corners of the square of 5cm side, find the magnitude of force on any one charge. (06 Marks)
- c. Derive an expression for field due to an infinite line charge using Gauss law. (06 Marks)

### Module-2

- 3 a. Obtain the boundary condition between conductor and free space in an electric field. (08 Marks)
- b. The potential field in free space is given by  $V = 50/r$ ,  $a \leq r \leq b$  (spherical).
- i) Show that  $\rho_v = 0$  for  $a < r < b$
- ii) Find the energy stored in the region  $a < r < b$ . (08 Marks)

OR

- 4 a. Potential is given by  $V = 2(x+1)^2 (y+2)^2 (z+3)^2$  volts in free space. At a point  $P(2, -1, 4)$ . Calculate: i) Potential ii) Electric Field Intensity. (04 Marks)
- b. Show that the potential at the origin due to the uniform surface charge density  $\rho_s$  over a ring  $z = 0$  and radius between  $R < r < R + 1$ , is independent of  $R$ . (06 Marks)
- c. Obtain an expression for the energy stored in a capacitor. (06 Marks)

### Module-3

- 5 a. From the Gauss's law derive Poisson's and Laplace's equation. (08 Marks)
- b. Evaluate both sides of the Stoke's theorem for the field  $\vec{H} = 6xy\vec{a}_x - 3y^2\vec{a}_y$  A/m and the rectangular path around the region,  $2 \leq x \leq 5$ ,  $-1 \leq y \leq 1$ ,  $z = 0$ . Let the positive direction of  $d\vec{s}$  be  $\vec{a}_z$ . (08 Marks)

OR

- 6 a. State and explain Ampere's circuital law. (04 Marks)
- b. Given the potential field  $V = 3x^2yz + ky^3z$  volts:
- i) Find  $K$  if potential field satisfies Laplace's equation.
- ii) Find  $\bar{E}$  at (1, 2, 3). (06 Marks)
- c. Find the incremental field strength at  $P_2$  due to the current element of  $2\pi \bar{a}_z \pi Am$  at  $P_1$ . The co-ordinates of  $P_1$  and  $P_2$  are (4, 0, 0) and (0, 3, 0) respectively. (06 Marks)

Module-4

- 7 a. Define:
- i) Magnetization
- ii) Permeability. (04 Marks)
- b. A current element 4cm long is along y-axis with a current of 10mA flowing in y-direction. Determine the force on the current element due to the magnetic field, if the magnetic field  $H = [5\bar{a}_x / \mu] A / m$ . (06 Marks)
- c. Derive an expression for the force on differential current carrying element. (06 Marks)

OR

- 8 a. Discuss the magnetic boundary conditions at the interface between two media of different permeabilities. (08 Marks)
- b. Calculate the inductance of a solenoid of 200 turns wound tightly on a cylindrical tube of 6cm diameter. The length of the tube is 60cm and the solenoid is in air. (04 Marks)
- c. State Lorentz force equation. (04 Marks)

Module-5

- 9 a. Derive the wave equation for uniform plane wave propagation in perfect dielectric. (08 Marks)
- b. A conductor 1cm in length is parallel to z-axis and rotates at radius of 25cm at 1200rpm. Find the induced voltage, if the radial field is given by  $\bar{B} = 0.5\bar{a}_r$  T. (08 Marks)

OR

- 10 a. Obtain the solution of wave equation for uniform plane wave in free space. (08 Marks)
- b. Calculate the induced e.m.f at  $t = 10$ sec. When the flux through each turn of a 200 turn coil is  $t(t-1)m$  wb. (04 Marks)
- c. The magnetic field intensity of uniform plane wave in air is  $20(A/m)$  in  $\bar{a}_y$  direction. The wave is propagating in the  $\bar{a}_z$  direction at an angular frequency of  $2 \times 10^9$  (rad/sec). Find: i) Phase shift constant ii) Wave length. (04 Marks)

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