

# CBCS SCHEME

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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<sup>2</sup> 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  $\vec{E}$  at P(1, 1, 1) caused by four identical 3nc charges located at P<sub>1</sub>(1, 1, 0), P<sub>2</sub>(-1, 1, 0), P<sub>3</sub>(-1, -1, 0) and P<sub>4</sub>(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  $0.1 \leq |x|, |y|, |z| \leq 0.2$   

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

### Module-2

- 3 a. Evaluate both sides of divergence theorem for the defined plane in which  $1 \leq x \leq 2, 2 \leq y \leq 3, 3 \leq z \leq 4$ .  $\vec{D} = 4x\vec{a}_x + 3y^2\vec{a}_y + 2z^3\vec{a}_z$  c/m<sup>2</sup>. (10 Marks)
- b. Determine workdone in carrying a charge of -2c from (2, 1, -1) to (8, 2, -1) in the electric field  $\vec{E} = y\vec{a}_x + x\vec{a}_y$  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  $\vec{E}$  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  $\vec{D}$  at the point P(2, 3, -1) for  $\vec{D} = (2xyz - y^2)\vec{a}_x + (x^2z - 2xy)\vec{a}_y + x^2y\vec{a}_z$  c/m<sup>2</sup> (06 Marks)
- c. Define potential difference. Derive the expression for potential due to several point charges. (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. 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  $\vec{H} = (3y - 2)\vec{a}_z + 2x\vec{a}_y$ . Find the current density at the origin. (06 Marks)

## OR

- 6 a. State and prove uniqueness theorem. (07 Marks)
- b. Find  $\vec{E}$  at  $P(3, 1, 2)$  for the field of two coaxial conducting cylinders  $V = 50$  V at  $\rho = 2$  m and  $V = 20$  V at  $\rho = 3$  m. (06 Marks)
- c. Evaluate both side of the Stoke's theorem for the filed  $\vec{H} = 6xy\vec{a}_x - 3y^2\vec{a}_y$  A/m and the rectangular path around the region  $2 \leq x \leq 5$ ,  $-1 \leq y \leq 1$ ,  $z = 0$ . Let the direction of  $\vec{d}_s$  to be  $\vec{a}_z$ . (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  $\mu_{r1} = 2.5$  and  $\mu_{r2} = 4$ . Given that  $\vec{H}_1 = -30\vec{a}_x + 50\vec{a}_y + 70\vec{a}_z$  V/m. (06 Marks)
- c. Derive the integral and differential form of Faraday's law. (08 Marks)

## OR

- 8 a. A current element  $I_1 dL_1 = 10^{-4}\vec{a}_z$  Am is located at  $P_1(2, 0, 0)$  and another current element  $I_2 dL_2 = 10^{-6}[\vec{a}_x - 2\vec{a}_y + 3\vec{a}_z]$  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)  $\mu_r = 22$ , 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)  $B = 300$  ( $\mu$ T) and  $\chi_m = 15$ . (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  $\eta_1$  the propagation constant  $\gamma$  and wave velocity  $v$  for a conducting medium in which  $\sigma = 58$  Ms/m,  $\mu_r = 1$ ,  $\epsilon_r = 1$  at a frequency of 100 MHz. (06 Marks)
- c. The  $\vec{H}$  field in free space is given by  $\vec{H}(x, t) = 10 \cos(10^8 t - \beta x)\vec{a}_y$  A/m. Find  $\beta$ ,  $\lambda$  and  $E(x, t)$  at  $P(0.1, 0.2, 0.3)$  and  $t = 1$  ns. (08 Marks)

## OR

- 10 a. State and prove Poynting theorem. (08 Marks)
- b. A metal sheet of aluminium has  $\sigma = 38.2$  M  $\Omega$ /m and  $\mu_r = 1$ . Calculate the skin depth  $\delta$ , propagation constant  $\gamma$  and velocity of propagation  $v$  at the frequency of 1.6 MHz. (06 Marks)
- c. Do the field  $\vec{E} = E_m \sin x \sin t \vec{a}_y$  and  $\vec{H} = \frac{E_m}{\mu_0} \cos x \cos t \vec{a}_z$ . Satisfy Maxwell's equation. (06 Marks)