CBCS SCHEME

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15EE45

Fourth Semester B.E. Degree Examination, July/August 2022
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. State and explain the Coulomb's law of electrostatic force between two point charges. **(05 Marks)**

b. Two uniform line charges of density 4 nc/m and 6 nc/m lie in x = 0 plane at y = +5 and – 6m respectively. Find $\bar{E}$ at (4, 0.5)m. **(05 Marks)**

c. Given the electric flux density $\bar{D} = \frac{r}{3}\bar{a}_r \ nc/m^2$ in free space.

(i) Find $\bar{E}$ at r = 0.2m
(ii) Find the total charge within the sphere r = 0.2m
(iii) Find the electric flux leaving the sphere r = 0.3m **(06 Marks)**

OR

2 a. State and prove Gauss's law. **(05 Marks)**

b. What is the divergence of a vector field? Obtain the point form of Gauss's law. **(05 Marks)**

c. Evaluate both side of divergence theorem for the region r ≤ a (spherical coordinates) having flux density $\bar{D} = \frac{5r}{3}\bar{a}_r \ c/m^2$. **(06 Marks)**

Module-2

3 a. Obtain an expression for the energy expanded in moving a point charge in an electric field. **(05 Marks)**

b. 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 (iii) Flux density. **(05 Marks)**

c. Obtain boundary conditions for dielectric-dielectric boundary. **(06 Marks)**

OR

4 a. Derive an expression for the equation of continuity of current. **(05 Marks)**

b. Show that the electric field intensity $\bar{E}$ can be expressed as a negative gradient of scalar potential. **(05 Marks)**

c. Find the stored energy in a system of four identical charges of 4nc at the corners of a square of side 1m. What is the stored energy? **(06 Marks)**

Module-3

5 a. Explain Poisson's equation and Laplace equation. **(05 Marks)**

b. Using Biot Savart's law, obtain magnetic field intensity expression due to an infinite length conductor carrying current I. **(05 Marks)**

c. Determine the expression for $\bar{E}$ in cylindrical coordinates between two planes insulated along z-axis, assuming a potential of 100V for $\phi = \alpha$ and zero reference at $\phi = 0°$. **(06 Marks)**

OR

6 a. State and prove Uniqueness theorem. **(05 Marks)**

b. Derive the Gauss's law for the magnetic field in point form. Hence show that scalar magnetic potential follows Laplace's equation. **(05 Marks)**

c. Given the field $\overline{H} = 20r^2\,\bar{a}_\phi\ A/m$

(i) Determine the current density $\vec{J}$

(ii) Integrate J over the circular surface $r = 1m$, $0 < \phi < 2\pi$ and $z = 0$ to determine the total current passing through that surface in the $\bar{a}_z$ direction. **(06 Marks)**

Module-4

7 a. Derive Lorentz force equation and mention the application of the solution. **(05 Marks)**

b. Derive the expression for self inductance of a co-axial cable. **(05 Marks)**

c. Two infinitely long straight conductors are located at $x = 0$; $y = 0$ and $x = 0$; $y = 10m$. Both carry current of 10 A in positive a_z direction. Determine force experienced (per meter) between them. **(06 Marks)**

OR

8 a. Explain the terms magnetization and permeability. **(05 Marks)**

b. Calculate the inductance of a solenoid of 200 turns wound tightly on a cylindrical tube of length 60 cm and of diameter 6cm, given that medium is air. Derive the expression used. **(05 Marks)**

c. A point charge $Q = 18$ nc has a velocity of 5×10^6 m/s in the direction $\bar{a}_v = 0.6\,\bar{a}_x + 0.75\,\bar{a}_y + 0.3\,\bar{a}_z$. Calculate the magnitude of the force exerted on the charge by the field (i) $\overline{E} = -3\,\bar{a}_x + 4\,\bar{a}_y + 6\,\bar{a}_z$ KV/m (ii) $\overline{B} = -3\,\bar{a}_x + 4\,\bar{a}_y + 6\,\bar{a}_z$ mT

(iii) $\overline{B}$ & $\overline{E}$ acting together. **(06 Marks)**

Module-5

9 a. Write the Maxwell's equation in point form for static fields and in integral form for time varying fields. **(05 Marks)**

b. Define wave equation. Derive the wave equation for $\overline{E}$ in a general medium. **(05 Marks)**

c. Find the displacement current density with in a parallel plate capacitor having a dielectric with $\epsilon_r = 10$, area of plates $= 0.01\ m^2$, distance of separation $= 0.05$mm and the capacitor voltage is 200 sin200t. **(06 Marks)**

OR

10 a. Define depth of penetration. Show that depth of penetration of a wave in a conductor decreases with an increase in frequency. **(05 Marks)**

b. Explain the interpretation of Faraday's law applicable to time-varying field and derive the expression for transformer emf and motional emf. **(05 Marks)**

c. A radio station transmits power radially around the spherical region. The desired electric field intensity at a distance of 10 km from the station is 1 mV/m. Calculate the corresponding H, P and station power. **(06 Marks)**

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