CBCS SCHEME

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17EE45

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

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. For a vector field defined by the equations, $\vec{F} = x^2 y \hat{a}_x + 2z \hat{a}_y + xy2 \hat{a}_z$. Find the curve of $\vec{F}$. **(08 Marks)**

b. Transform the vector 10_{ax} at P(x = –3, y = 2 and z = 4) to spherical coordinates. **(06 Marks)**

c. A charge $Q_2 = 121 \times 10^{-9}$C is located in vacuum at P_2(–0.03, 0.01, 0.04)m. Find the force on Q_2 due to Q_1 = 110 μc at P_1(0.03, 0.08, –0.02)m. **(06 Marks)**

OR

2 a. Two points A(2, 2, 1) and B(3, –4, 2) are given in the Cartesian system. Obtain the vector from A to B and a unit vector directed from A to B. **(06 Marks)**

b. Two small identical conducting spheres have charges of 2nc and –1nc respectively. When they are separated by 4 cm apart, find the magnitude of the force between them. If they are brought into contact and then again separated by 4cm, find the force between them. **(06 Marks)**

c. If $\vec{D} = xy^2z^2 \hat{a}_x + x^2yz^2 \hat{a}_y + x^2y^2z \hat{a}_z \, c/m^2$,
Find :
i) An expression for ρ_v
ii) The total charge will in the cube
where cube is defined by $0 \le x \le 2$, $0 \le y \le 2$, $0 \le z \le 2$. **(08 Marks)**

Module-2

3 a. Given that the potential field is $V = 2x^2y - 5z$, find the potential, electric field intensity and volume charge density at point P(–4, 3, 6). **(08 Marks)**

b. At the boundary between glass ($\epsilon_r = 4$) and air, the lines of electric field make an angle of 40° with normal to the boundary. If electric flux density in the air is 0.25μc/m^3, determine the orientation and magnitude of electric flux density in the glass. **(06 Marks)**

c. Derive the continuity equation in point and integral forms. **(06 Marks)**

OR

4 a. Find the total current in outward direction form a cube of 1m, with one corner at the origin and edges parallel to the coordinate axes, if $\bar{J} = 2x^2 \bar{a}_x + 2xy^3 \bar{a}_y + 2xy \bar{a}_z \, A/m^2$. **(08 Marks)**

b. Determine the capacitance of a capacitor consisting of two parallel plates 30cm × 30cm surface area, separated by 5mm in air. What is the total energy stored by the capacitor is charged to a potential difference of 500V? What is the energy density? **(07 Marks)**

c. An electric potential is given by $V = \frac{60 \sin\theta}{r^2} V$. Find V and $\vec{E}$ at P(3, 60°, 25°). **(05 Marks)**

Module-3

5 a. State and prove Uniqueness Theorem. **(10 Marks)**

b. Determine whether or not the potential equations :
i) $V = 2x^2 - 4y^2 + z^2$
ii) $V = r^2 \cos \phi + \theta$
Satisfy the Laplace's equation. **(05 Marks)**

c. List the Maxwell's equation is point and integral forms. **(05 Marks)**

OR

6 a. State and prove Biot Savart law. **(06 Marks)**

b. Find the magnetic flux density at the centre '0' of a square of sides equal to 5m and carrying 10 amperes of current. **(10 Marks)**

c. Define scalar and vector magnetic potentials. **(04 Marks)**

Module-4

7 a. A point charge, Q = –60nc is moving with a velocity of 6×10^6 m/s in the direction specified by unit vector $-0.48\hat{a}_x - 0.6\hat{a}_y + 0.64\hat{a}_z$. Find the magnitude of the force on a moving charge in the magnetic field. $B = 2\hat{a}_x - 6\hat{a}_y + 5\hat{a}_z$ mT. **(06 Marks)**

b. Find the magnitude of magnetic flux density in a material for which
i) The magnetization is 2.8 A/m, the magnetic susceptibility is 0.0025
ii) The magnetic field intensity is 1300 A/m and the relative permeability is 1.006. **(06 Marks)**

c. Find the normal component of the magnetic field which traverses form medium –1 to medium –2 havign $\mu_{r_1} = 2.5$ and $\mu_{r_2} = 4$. Given that $\vec{H} = -30\hat{a}_x + 50\hat{a}_y + 70\hat{a}_z$ V/m in medium –1 and the interface of the two media is x – y plane. **(08 Marks)**

OR

8 a. Find the magnetic field intensity inside a magnetic material, for the following conditions.
M = 100 A/m and $\mu = 1.5 \times 10^{-5}$ H/m
B = 200 μT, $\chi_m = 15$. **(06 Marks)**

b. A air core toroid has a mean radius of 40mm and is wound with 4000 turns of wire. The circular cross-section of the toriod has a radius of 4mm. A current of 10A is passed in the wire. Find the inductance and the energy stored. **(06 Marks)**

c. A rectangular coil as shown below is in the magnetic field given by $\overline{B} = 0.05\frac{\hat{a}_x + \hat{a}_y}{\sqrt{2}}$ T. Find the torque about Z –axis when the coil is in position shown in Fig.Q8(c) and carries a current of 5A.

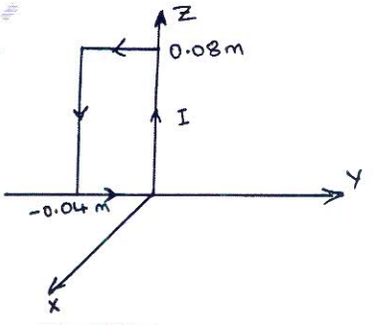

Fig.Q8(c) **(08 Marks)**

Module-5

9 a. For a lossy electric, $\sigma = 5$ S/m and $\varepsilon_r = 1$. The electric field intensity is $E = 100 \sin 10^{10}t$. Find J_C, J_D and frequency at which both have equal magnitudes. **(08 Marks)**

b. Determine :
i) Attenuation constant
ii) Phase constant
iii) Propagation constant
iv) Wave length
v) Phase velocity
vi) Intrinsic impedance
For damp soil of frequency of 1 MHz given that $\varepsilon_r = 12$, $\mu_r = 1$ and conductivity $\sigma = 20 \times 10^{-3}$ S/m. **(06 Marks)**

c. The depth of penetration in a certain conducting medium is 0.1m and the frequency of electromagnetic wave is 1.0 MHz. Find the conductivity of the conducting medium. **(06 Marks)**

OR

10 a. Find the displacement current density within a parallel plate capacitor having a dielectric with $\varepsilon_r = 10$, are of plates $A = 0.01m^2$, distance of separation d = 0.05mm. Applied voltage is $V = 200 \sin 200t$. **(08 Marks)**

b. A 800 MHz plane wave travelling has an average pointing vector of $8MW/m^2$. If the medium is losses with $\mu_r = 1.5$ and $\epsilon_r = 6$.
Find :
i) Velocity of wave
ii) Wave length
iii) Impedance of the medium
iv) rms electric field E
v) rms magnetic field H. **(12 Marks)**

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