CBCS SCHEME

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17EE45

Fourth Semester B.E. Degree Examination, June/July 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. Show that the vectors $\vec{A} = 4\hat{a}x + 2\hat{a}y - \hat{a}z$ and $\vec{B} = 2\hat{a}x - 2\hat{a}y + 4\hat{a}z$ are mutually perpendicular to each other. Also find cross product $\vec{A}$ and $\vec{B}$. **(04 Marks)**

b. Consider a cylinder of length 'L' m and radius 'R' m, obtain its volume by integration and also surface area by integrator. **(08 Marks)**

c. Given a vector function

$$\vec{F} = 2\sqrt{x}\ y\hat{a}x + xy^2\hat{a}y + \frac{1}{z}\hat{a}z$$

Find the divergence and curl of vector $\vec{F}$ at P(0.5, 0.8, 0.2). **(08 Marks)**

OR

2 a. State and explain Coulomb's law in vector form. **(06 Marks)**

b. A uniform line charge $P_L = 25\eta$ c/m lies on the line x = -3m and y = 4m. Find $\vec{E}$ at the point M(2, 3, 15)m. **(06 Marks)**

c. A point charge of 6μc is located at the origin, an uniform line charge density $180\eta cm^{-1}$ lies along the x-axis and an uniform sheet and charge $25\eta cm^{-2}$ lies on the line z = 0 plane.

Find: i) $\vec{D}$ at A(0, 0, 4) ii) Total flux leaving the surface of a sphere of 4m radius centered at the origin. **(08 Marks)**

Module-2

3 a. Derive an expression for potential difference between points A and B due to a charge of 'Q'c placed at origin and hence derive an expression for absolute potential. **(08 Marks)**

b. Find the work done in moving a charge of +2C from (2, 0, 0)m to (0, 2, 0)m along the straight line path joining two points, if $\vec{E} = 12x\,\hat{a}x - 4y\hat{a}y$ v/m. **(06 Marks)**

c. Find the energy stored in the system of three equal point charges of 2ηc arranged in a line with 0.5m separation between them. **(06 Marks)**

OR

4 a. Show that $\nabla.\vec{J} = -\frac{\partial \rho_v}{\partial t}$ as per continuity of current equation. **(06 Marks)**

b. Derive the relationship between tangential and normal components of electric field intensity and electric flux density in case of dielectric-dielectric interface. **(08 Marks)**

c. Find the capacitance of a parallel plate capacitor

Case i) : when the plate area is $1m^2$, distance between the plates is 1mm, voltage gradient is $10^5\ Vm^{-1}$, and charge density on the plates is $2\mu\ cm^{-2}$

Case ii) : when the stored energy is 5μJ and the voltage across the plates is 5V. **(06 Marks)**

Module-3

5 a. Derive an expression for Poisson's and Laplace equivalent and hence express them in all three coordinate system. **(08 Marks)**

b. Solve Laplace's equation in cylindrical c-ordinates for the potential in the region between two infinite concentric conducting cylinders of radii R_1 and R_2 respectively ($R_2 > R_1$). Hence obtain an expression for electric field intensity (E), electric flux density (D) and capacitance between them. **(12 Marks)**

OR

6 a. Derive an expression for magnetic field intensity at a point using Biot Savart's law. **(06 Marks)**

b. Find the value of magnetic flux density (B) at point 'P' for the current circuit carrying a current of 10A shown in Fig.Q.6(b). **(08 Marks)**

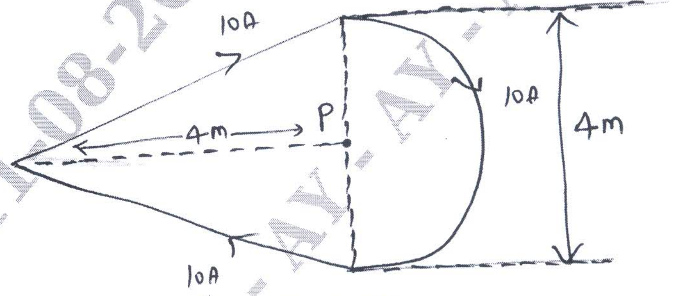

Fig.Q.6(b)

c. The magnetic field intensity in a certain region of space is given at $\vec{H} = \frac{(x+2y)}{z^2}\hat{a}y + \frac{2}{z}\hat{a}z$ A/m. Find: i) $\nabla \times \vec{H}$ ii) $\vec{J}$ iii) use $\vec{J}$ to find total current polling through the surface $z = 4, 1 < x < 2, 3 < y < 5$ in $\hat{a}z$ direction. **(06 Marks)**

Module-4

7 a. Derive an expression for Lorentz force equation, and hence derive an expression for force acting on a differential current element kept in magnetic field of B Tesla from Lorentz force equation. **(08 Marks)**

b. Two parallel conductors are separated by 2cm in air carrying a current of 100A flowing in the opposite direction. Find the force per meter length of the conductor. **(04 Marks)**

c. A rectangular loop in the XY plane with the sides b_1 and b_2 carry a current of IA lies in a uniform magnetic field $\vec{B} = Bx\,\hat{a}x + By\,\hat{a}y + Bz\,\hat{a}z$. Determine the force and torque of the loop. **(08 Marks)**

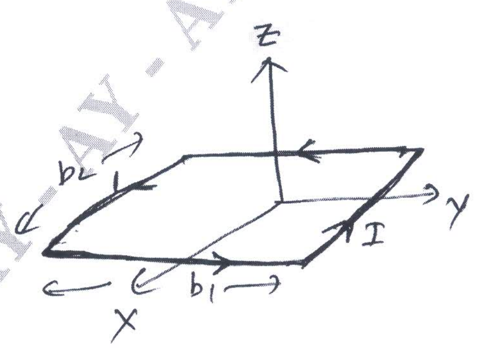

Fig.Q.7(c)

OR

8 a. Derive an expression for the relationship between tangential and normal components of $\vec{H}$ and $\vec{B}$ applied to magnetic boundary condition. **(10 Marks)**

b. Derive an expression for inductance of solenoid and toroidal magnetic circuits. **(10 Marks)**

Module-5

9 a. A 3 turn loop with $0.5m^2$ area situated in air has a uniform magnetic field normal to the plane of the loop. If the flux density changes 5MT/s, what is the emf appearing at the terminals of the loop? If the emf at the loop terminals is 100mV, what is the rate of change of magnetic field? **(06 Marks)**

b. A conductor of length 1cm is parallel to z-axis and rotates at a radius of 25cm at 1200rpm. Find the induced voltage if the radial field is $\vec{B} = 0.5\hat{a}r$ T. **(06 Marks)**

c. List the Maxwell's equations both in integral form and differential form applied to both electric and magnetic fields. **(08 Marks)**

OR

10 a. Derive an expression for wave equation in terms of $\vec{E}$ and $\vec{D}$ and hence realize for free space and perfect dielectrics. **(06 Marks)**

b. A wave is propagating in a lossless dielectric has a component $\vec{E} = 500 \cos(10^7 t - \beta z)\ \hat{a}x$ v/m and $\vec{H} = 1.1 \cos(10^7 t - \beta z)\ \hat{a}y$ A/m. If the wave is travelling at velocity V = 0.5C. Find: i) μ_Ω ii) ε_Ω iii) β iv) λ v) impedance z or η **(08 Marks)**

c. Derive an expression for skin depth or depth of penetration. **(06 Marks)**

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