CBCS SCHEME

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18EE45

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. Define the following:
(i) Scalar and Vector (ii) Dot product and cross product
(iii) Divergence (iv) Curl **(08 Marks)**

b. State and explain Coulomb's law of force between two point charges in vector form. **(06 Marks)**

c. Explain electric field intensity at a point due to a point charge. **(06 Marks)**

OR

2 a. The flux density $\vec{D} = \frac{r}{3}\vec{a}_r$ nc/m^2 is in free space. Find:

(i) $\vec{E}$ at r = 0.2 m
(ii) Find the total electric flux leaving sphere of r = 0.2 m.
(iii) Find the total charge within the sphere of r = 0.3 m **(10 Marks)**

b. Given $\vec{D} = 5r\,\vec{a}_r$ c/m^2, prove divergence theorem for a shell region enclosed by spherical surfaces at r = a and r = b (b > a) and centred at the origin. **(10 Marks)**

Module-2

3 a. Obtain an expression for the workdone in moving a point charge 'Q' in an electric field $\vec{E}$. **(08 Marks)**

b. Show that $\vec{E} = -\nabla V$ i.e. electric field intensity is negative gradient of potential. **(06 Marks)**

c. Obtain the equation of continuity in both integral and differential form. **(06 Marks)**

OR

4 a. Explain and derive the boundary conditions for a conductor dielectric interface. **(10 Marks)**

b. The capacitance of the condenser formed by the two parallel metal sheets, each 100 cm^2 in area separated by a dielectric 2 mm thick is 2×10^{-4} μF. A potential of 20 KV is applied to it. Find:
(i) Electric flux
(ii) Potential gradient in KV/m
(iii) The relative permittivity of the material
(iv) Electric flux density **(10 Marks)**

Module-3

5 a. From the Gauss's law, derive Poisson's and Laplace's equation and write Laplace's equation in Cartesian, cylindrical and spherical coordinate systems. **(10 Marks)**

b. State and prove Uniqueness theorem. **(05 Marks)**

c. There exists a potential of V = –2.5 Volts on a conductor at 0.02 m and V = 15 Volts at r = 0.35 m. Determine E and D by solving the Laplace's equation in spherical coordinates representing the potential system. **(05 Marks)**

OR

6 a. State and explain Biot-Savart's law. **(08 Marks)**

b. State and prove Ampere's circuital law. **(08 Marks)**

c. Define magnetic field and state its properties. **(04 Marks)**

Module-4

7 a. Derive Lorent'z Force Equation. **(08 Marks)**

b. A point charge of Q = –40 μC is moving with a velocity of $\vec{V} = (-3\vec{a}_x - 4\vec{a}_y + 4.5\vec{a}_z) \times 10^6$ m/sec. Find the magnitude of the vector force exerted on the moving particle by the field:

(i) $\vec{B} = 2\vec{a}_x - 3\vec{a}_y + 5\vec{a}_z$ mT

(ii) $\vec{E} = (2\vec{a}_x + 3\vec{a}_y - 4\vec{a}_z$ KV/m

(iii) Both $\vec{B}$ and $\vec{E}$ active together. **(06 Marks)**

c. Derive an expression for magnetic force due to magnetic field $\vec{B}$ on a conductor of length 'L' metre. **(06 Marks)**

OR

8 a. Find the force per meter length between two long parallel wires separated by 10 cm in air and carrying a current of 10 A in same direction. **(06 Marks)**

b. Derive an equation for the magnetic force between two differential current elements. **(08 Marks)**

c. A loop has a dimension of 1m × 2m and lies in the uniform magnetic field, $\vec{B}_0 = -0.6\vec{a}_y + 0.8\vec{a}_z$ T. The loop current is 4 mA. Calculate the torque on the loop. **(06 Marks)**

Module-5

9 a. List Maxwell's equations for steady and time varying fields in point form and integral form. Also mention the relevant laws. **(10 Marks)**

b. Show that the ratio of the amplitudes of conduction current density and displacement current density is $\frac{\sigma}{\omega\varepsilon}$. **(10 Marks)**

OR

10 a. Starting from Maxwell's equations, obtain the general wave equations in electric and magnetic fields. **(10 Marks)**

b. The magnetic field intensity of uniform plane wave in air is 20 A/m in $\vec{a}_y$ direction. The wave is propagating in $\vec{a}_z$ direction at an angular frequency of 2×10^9 rad/sec. Find:

(i) Phase shift constant

(ii) Wavelength

(iii) Frequency

(iv) Amplitude of electric field intensity **(10 Marks)**

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