

CBCS SCHEME

15EC36

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Third Semester B.E. Degree Examination, Aug./Sept.2020 Engineering Electromagnetics

Time: 3 hrs.

Max. Marks: 80

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

Module-1

- 1 a. Define Electric Field Intensity, \vec{E} . Find \vec{E} at $(2, \frac{\pi}{2}, \frac{\pi}{6})$ due to a point charge located at origin. Let $Q = 40\text{nC}$. (04 Marks)
- b. Point charges of 120nC are located at A $(0, 0, 1)$ and B $(0, 0, -1)$ in free space. Find \vec{E} at $P(x, 0, 0)$. Also find the maximum value of \vec{E} . (06 Marks)
- c. Uniform line charges of 120 nC/m each lie along the entire extent of the three co-ordinate axes. Assuming free space conditions, find \vec{E} at $P(-3, 2, -1)\text{m}$. (06 Marks)

OR

- 2 a. Derive an expression for electric field intensity at a point in cylindrical coordinate system due to an infinite line charge distribution on Z - axis. (06 Marks)
- b. A point charge $Q_1 = 10\ \mu\text{C}$ is located at $P_1(1, 2, 3)\text{m}$ in free space while $Q_2 = -5\ \mu\text{C}$ is at $P_2(1, 2, 10)\text{m}$. i) Find vector force exerted on Q_2 by Q_1 ii) Also, find the co-ordinates of P_3 at which a point charge Q_3 experiences no force. (07 Marks)
- c. Find the total electric flux crossing an infinite plane at $y = 0$ due to the following charge distributions :
• a point charge, 30nC located at $(1, 2, 3)$.
• Two line charge distributions of 10nC/m each located in $x = 0$ plane at $y = \pm 2\text{m}$ extending over a length of 4m . (03 Marks)

Module-2

- 3 a. Define 'Divergence of a Vector' and 'Gradient of a Scalar'. (04 Marks)
- b. Derive the point form of Gauss's law. (06 Marks)
- c. Give the flux density, $\vec{D} = \frac{5 \sin \theta \cos \phi}{r} \hat{a}_r$, C/m^2 . Find
• Volume charge density
• Total charge contained in the region, $r < 2\text{m}$.
• Total electric flux leaving the surface, $r = 2\text{m}$. (06 Marks)

OR

- 4 a. The value of \vec{E} at $P(\rho = 2, \phi = 40^\circ, Z = 3)$ is given by $\vec{E} = 100 \hat{a}_\rho - 200 \hat{a}_\phi + 300 \hat{a}_z$, V/m . Determine the incremental work required to move a $20\ \mu\text{C}$ charge a distance of $6\ \mu\text{m}$ in the direction of : i) \hat{a}_ρ ii) \vec{E} iii) $\vec{G} = \hat{a}_\rho + 3 \hat{a}_\phi - 2 \hat{a}_z$. (06 Marks)
- b. State and explain continuity equation of current. (05 Marks)
- c. Given the potential field $V = 2x^2y - 80$, and a point, $P(2, 3, -4)$ in free space, find at 'P'.
i) V ii) \vec{E} iii) $\frac{dV}{dN}$ iv) \hat{a}_N .

Where \hat{a}_N is the unit vector normal to equipotential surface?

(05 Marks)

Module-3

- 5 a. Conducting plates at $Z = 2\text{cm}$ and $Z = 8\text{cm}$ are held at potentials of -3V and 9V respectively. The region between the plates is filled with a perfect dielectric of $\epsilon = 5\epsilon_0$. Find V , \vec{E} and \vec{D} in the region between the plates. (06 Marks)

- b. Let $V = \frac{\cos 2\phi}{\rho}$ volts in free space. Find volume charge density at $P(5, 60^\circ, 1)$ using Poisson's equation. (05 Marks)
- c. State the following : i) Uniqueness theorem ii) Ampere's law iii) Stoke's theorem. (05 Marks)

OR

- 6 a. Explain Scalar and Vector magnetic potentials. (05 Marks)
- b. Verify Stoke's theorem for $\vec{H} = 2r \cos \theta \hat{a}_r + r \hat{a}_\phi$ for the path defined by $0 \leq r \leq 1$ and $0 \leq \theta \leq 90^\circ$. (06 Marks)
- c. The magnetic field intensity is given by $\vec{H} = 0.1 y^3 \hat{a}_x + 0.4 x \hat{a}_z$, A/m. Determine the current flow through the path $P_1(5, 4, 1)$ to $P_2(5, 6, 1)$ to $P_3(0, 6, 1)$ to $(0, 4, 1)$. Also find current density, \vec{J} . (05 Marks)

Module-4

- 7 a. Obtain an expression for magnetic force between differential current elements. (05 Marks)
- b. A point charge, $Q = 18\text{nC}$ has a velocity of 5×10^6 m/s in the direction $\hat{a} = 0.6 \hat{a}_x + 0.75 \hat{a}_y + 0.3 \hat{a}_z$. Calculate the magnitude of the force exerted on the charge by the field $\vec{B} = -3 \hat{a}_x + 4 \hat{a}_y + 6 \hat{a}_z$, mT. (05 Marks)
- c. Three infinitely long parallel filaments each carry 50A in the \hat{a}_z direction. If the filament lie in the plane, $x = 0$ with a 2cm spacing between wires, find the vector fore per meter on each filament. (06 Marks)

OR

- 8 a. Obtain the boundary conditions at the interface between two magnetic materials. (05 Marks)
- b. Find Magnetization in magnetic material where
i) $\mu = 1.8 \times 10^{-5}$ H/m and $H = 120$ A/m ii) $B = 300\mu\text{T}$ and $X_m = 15$. (05 Marks)
- c. Explain briefly the following as applicable to magnetic materials :
i) Magnetization ii) Permeability iii) Potential energy. (06 Marks)

Module-5

- 9 a. Write Maxwell's equations in integral form and word statement form for free space. (06 Marks)
- b. In a certain dielectric medium, $\epsilon_r = 5$, $\sigma = 0$ and displacement current density $\vec{J}_d = 20 \cos(1.5 \times 10^8 t - bx) \hat{a}_y$, $\mu\text{A/m}^2$. Determine electric flux density and electric field intensity. (06 Marks)
- c. A radial magnetic field $\vec{H} = \frac{2.239 \times 10^6}{r} \cos \phi \hat{a}_r$, a/m exists in free space. Find the magnetic flux, ϕ crossing the surface defined by $-\frac{\pi}{4} \leq \phi \leq \frac{\pi}{4}$, $0 \leq z \leq 1$, m. (04 Marks)

OR

- 10 a. Discuss the wave propagation of a uniform plane wave in a good conducting medium. (06 Marks)
- b. Derive the relation between \vec{E} and \vec{H} for a perfect dielectric medium. (05 Marks)
- c. Determine the skin depth for copper with conductivity of 58×10^6 , S/m at a frequency, 10 MHz. Also find α , β and V_p . (05 Marks)
