



CBCS SCHEME

USN

--	--	--	--	--	--	--	--	--	--

18EE45

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. Derive the relationship between rectangular and cylindrical coordinate system. (05 Marks)
- b. Define the terms gradient and divergence. Give equations for them in rectangular coordinates. Mention their physical significance. (09 Marks)
- c. Define scalar and vector. For a vectors $\vec{A} = 6\vec{a}_x + 2\vec{a}_y + 6\vec{a}_z$ and $\vec{B} = -2\vec{a}_x + 9\vec{a}_y - \vec{a}_z$
 - (i) Show that vectors \vec{A} and \vec{B} are perpendicular to each other.
 - (ii) Find $\vec{A} \times \vec{B}$ and show that $\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$ (06 Marks)

OR

- 2 a. State and prove the Gauss law. (08 Marks)
- b. Three point charges $Q_1 = -1\mu\text{c}$, $Q_2 = -2\mu\text{c}$ and $Q_3 = -3\mu\text{c}$ are paced at the corners of an equilateral triangle of side 1m. Find the magnitude of electric field intensity at the point bisecting the line joining Q_1 and Q_2 . (06 Marks)
- c. Starting from Gauss theorem obtain Maxwell's equation in terms of flux density or point form of Gauss law. (06 Marks)

Module-2

- 3 a. Define the term electric potential. Obtain the expression for Absolute electric potential at a point due to point charge obtained from potential difference equation. (12 Marks)
- b. Find the potential and volume charge density at point P(0.5, 1.5, 1) in the free space. Given the potential field $V = 2x^2 - y^2 - z^2$. (08 Marks)

OR

- 4 a. Explain the concept of "continuity equation" and hence show that
$$\nabla \cdot \vec{J} = -\frac{\partial \rho_v}{\partial t}$$
(08 Marks)
- b. Derive an expression for capacitance of a parallel plate capacitor with dielectric interface (ϵ_{r1} and ϵ_{r2}) parallel to the conducting plates. (06 Marks)
- c. Let $A = 120 \text{ cm}^2$, $d = 5\text{mm}$ and $\epsilon_R = 12$ for the parallel plate capacitor. Calculate the capacitance after connecting a 40 V battery across the capacitor, calculate E and total stored energy. (06 Marks)

Module-3

- 5 a. Starting from Gauss's law in integral form, derive Poisson's and Laplace equation. Write Laplace equation in all coordinate systems. (09 Marks)
- b. Using Poisson's equation, obtain the expression for capacitance of a parallel plate capacitor. (06 Marks)

- c. Derive an expression for capacitance between two concentric spherical shell having radius R_1 and R_2 . ($R_2 > R_1$) (05 Marks)

OR

- 6 a. Derive an expression for Ampere's law. (05 Marks)
 b. Evaluate both sides of Stoke's theorem for the field $\vec{H} = 10\sin\theta d\phi$ Ampere's/meter and the surface $r = 3\text{m}$, $0 \leq \theta \leq 90^\circ$, $0^\circ \leq \phi \leq 90^\circ$. Let the surface has the \hat{a}_r direction. What each side of Stoke's theorem represents? (10 Marks)
 c. Find the magnetic field at point P(0.01, 0, 0) if current through a coaxial cable is 6A, which is along the z-axis and $a = 3\text{mm}$, $b = 9\text{mm}$, $c = 11\text{mm}$. (05 Marks)

Module-4

- 7 a. Derive an expression for the force acting between two conductors carrying current in opposite directions. (08 Marks)
 b. A point charge of $Q = -40\mu\text{C}$ is moving with a velocity of $\vec{V} = (-3\hat{a}_x - 4\hat{a}_y + 4.5\hat{a}_z) \times 10^6$ m/s. Find the magnitude of the vector force exerted on moving particle by the field:
 i) $\vec{B} = 2\hat{a}_x - 3\hat{a}_y + 5\hat{a}_z$ mT
 ii) $\vec{E} = 2\hat{a}_x + 3\hat{a}_y - 4\hat{a}_z$ kV/m
 iii) Both B and E active together. (08 Marks)
 c. Derive an expression for inductance of a solenoid. (04 Marks)

OR

- 8 a. Define magnetization, relative permeability and susceptibility. Derive the relation $\mu_r = (1 + \chi)$ (09 Marks)
 b. Find the magnetization in a magnetic material of (i) permeability 1.8×10^{-5} H/m and $H = 120$ A/m and (ii) $B = 300 \mu\text{T}$ and $\chi_m = 15$ (iii) $\mu_r = 22$, if there are 8.3×10^{28} atom/m³ and each atom contribute a dipole moment of 4.5×10^{-27} Am². (06 Marks)
 c. An air cored toroid has a cross sectional area of 6 cm^2 , a mean radius of 15 cm and is with 500 turns and carries a current of 4 A. Find magnetic field intensity at the mean radius. (05 Marks)

Module-5

- 9 a. Derive the integral and differential form of Faraday's law. (08 Marks)
 b. List Maxwell's equations in point form and in integral form. (06 Marks)
 c. The circular loop conductor at $z = 0$ plane has a radius of 0.1 m and resistance of 5Ω . Given $\vec{B} = 0.2 \sin 10^3 t \hat{a}_z$ Tesla. Find current in the coil. (06 Marks)

OR

- 10 a. Modify the Ampere's circuital law to suit the time varying condition and hence obtain an expression for displacement current density. (10 Marks)
 b. The magnetic field intensity of uniform plane wave in air is 20 A/m in \hat{a}_y direction. The wave is propagating in \hat{a}_z divides 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)
