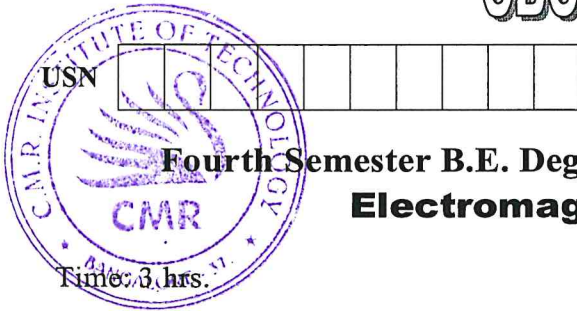


CBCS SCHEME



15EE45

Fourth Semester B.E. Degree Examination, July/August 2022

Electromagnetic Field Theory

Time: 3 hrs.

Max. Marks: 80

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

Module-1

- 1 a. State and explain the Coulomb's law of electrostatic force between two point charges. (05 Marks)
- b. Two uniform line charges of density 4 nc/m and 6 nc/m lie in $x = 0$ plane at $y = +5$ and -6 m respectively. Find \vec{E} at (4, 0.5)m. (05 Marks)
- c. Given the electric flux density $\vec{D} = \frac{r}{3} \vec{a}_r$ nc/m² in free space.
 - (i) Find \vec{E} at $r = 0.2$ m
 - (ii) Find the total charge within the sphere $r = 0.2$ m
 - (iii) Find the electric flux leaving the sphere $r = 0.3$ m (06 Marks)

OR

- 2 a. State and prove Gauss's law. (05 Marks)
- b. What is the divergence of a vector field? Obtain the point form of Gauss's law. (05 Marks)
- c. Evaluate both side of divergence theorem for the region $r \leq a$ (spherical coordinates) having flux density $\vec{D} = \frac{5r}{3} \vec{a}_r$ c/m². (06 Marks)

Module-2

- 3 a. Obtain an expression for the energy expanded in moving a point charge in an electric field. (05 Marks)
- b. Potential is given by $V = 2(x+1)^2(y+2)^2(z+3)^2$ Volts in free space. At a point P(2, -1, 4) calculate (i) Potential (ii) Electric field intensity (iii) Flux density. (05 Marks)
- c. Obtain boundary conditions for dielectric-dielectric boundary. (06 Marks)

OR

- 4 a. Derive an expression for the equation of continuity of current. (05 Marks)
- b. Show that the electric field intensity \vec{E} can be expressed as a negative gradient of scalar potential. (05 Marks)
- c. Find the stored energy in a system of four identical charges of 4nc at the corners of a square of side 1m. What is the stored energy? (06 Marks)

Module-3

- 5 a. Explain Poisson's equation and Laplace equation. (05 Marks)
- b. Using Biot Savart's law, obtain magnetic field intensity expression due to an infinite length conductor carrying current I. (05 Marks)
- c. Determine the expression for \vec{E} in cylindrical coordinates between two planes insulated along z-axis, assuming a potential of 100V for $\phi = \alpha$ and zero reference at $\phi = 0^\circ$. (06 Marks)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and/or equations written eg, 42+8 = 50, will be treated as malpractice.

OR

- 6 a. State and prove Uniqueness theorem. (05 Marks)
 b. Derive the Gauss's law for the magnetic field in point form. Hence show that scalar magnetic potential follows Laplace's equation. (05 Marks)
 c. Given the field $\vec{H} = 20r^2 \vec{a}_\phi$ A/m
 (i) Determine the current density \vec{J}
 (ii) Integrate J over the circular surface $r = 1\text{m}$, $0 < \phi < 2\pi$ and $z = 0$ to determine the total current passing through that surface in the \vec{a}_z direction. (06 Marks)

Module-4

- 7 a. Derive Lorentz force equation and mention the application of the solution. (05 Marks)
 b. Derive the expression for self inductance of a co-axial cable. (05 Marks)
 c. Two infinitely long straight conductors are located at $x = 0$; $y = 0$ and $x = 0$; $y = 10\text{m}$. Both carry current of 10 A in positive a_z direction. Determine force experienced (per meter) between them. (06 Marks)

OR

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- 8 a. Explain the terms magnetization and permeability. (05 Marks)
 b. Calculate the inductance of a solenoid of 200 turns wound tightly on a cylindrical tube of length 60 cm and of diameter 6cm, given that medium is air. Derive the expression used. (05 Marks)
 c. A point charge $Q = 18\text{ nc}$ has a velocity of $5 \times 10^6\text{ m/s}$ in the direction $\vec{a}_v = 0.6\vec{a}_x + 0.75\vec{a}_y + 0.3\vec{a}_z$. Calculate the magnitude of the force exerted on the charge by the field (i) $\vec{E} = -3\vec{a}_x + 4\vec{a}_y + 6\vec{a}_z\text{ KV/m}$ (ii) $\vec{B} = -3\vec{a}_x + 4\vec{a}_y + 6\vec{a}_z\text{ mT}$
 (iii) \vec{B} & \vec{E} acting together. (06 Marks)

Module-5

- 9 a. Write the Maxwell's equation in point form for static fields and in integral form for time varying fields. (05 Marks)
 b. Define wave equation. Derive the wave equation for \vec{E} in a general medium. (05 Marks)
 c. Find the displacement current density with in a parallel plate capacitor having a dielectric with $\epsilon_r = 10$, area of plates = 0.01 m^2 , distance of separation = 0.05mm and the capacitor voltage is $200 \sin 200t$. (06 Marks)

OR

- 10 a. Define depth of penetration. Show that depth of penetration of a wave in a conductor decreases with an increase in frequency. (05 Marks)
 b. Explain the interpretation of Faraday's law applicable to time-varying field and derive the expression for transformer emf and motional emf. (05 Marks)
 c. A radio station transmits power radially around the spherical region. The desired electric field intensity at a distance of 10 km from the station is 1 mV/m. Calculate the corresponding H, P and station power. (06 Marks)
