

CBCS SCHEME

21EC54



Fifth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025 Electromagnetic Waves

Time: 3 hrs.

Max. Marks: 100

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

Module-1

- 1 a. If two position vectors $\vec{A} = -2\vec{a}_x - 5\vec{a}_y - 4\vec{a}_z$ and $\vec{B} = 2\vec{a}_x + 3\vec{a}_y + 5\vec{a}_z$ then find,
 - i) \vec{AB}
 - ii) \vec{a}_A, \vec{a}_B
 - iii) \vec{a}_{AB}
 - iv) Unit vector from C to A where C is (3, 5, 8) (06 Marks)
- b. Ten identical charges each of $500 \mu\text{C}$ are spaced equally around a circle of radius 2 m. Find the force on a charge of $-20 \mu\text{C}$ located on the axis, 2m from the plane of the circle. (07 Marks)
- c. Define Electric Field Intensity. Derive expression for electric field intensity due to 'n' number of charges. (06 Marks)

OR

- 2 a. Given the two points A(2, 3, -1) and B(4, 25, 120). Find spherical coordinates of A and Cartesian coordinates of B. (06 Marks)
- b. Derive an expression for electric field intensity due to infinite line charge. (07 Marks)
- c. Find electric field \vec{E} at origin, if the following charge distribution are present in free space :
 - i) Point charge of 21nC at P(2, 0, 6)
 - ii) Uniform line charge of infinite length with charge density $\rho_l = 3 \text{ nC/m}$ at $x = 2, y = 3$.
 - iii) Uniform surface charge of density 0.2 nC/m^2 at $x = 2$. (07 Marks)

Module-2

- 3 a. A charge is uniformly distributed over a spherical surface of radius 'a'. Determine electric field intensity at all the places, use Gauss law. (07 Marks)
- b. Evaluate both sides of divergence theorem for the field $\vec{D} = 2xy\vec{a}_x + x^2\vec{a}_y \text{ C/m}^2$, for a rectangular parallel piped formed by the planes $x = 0$ and $x = 1$; $y = 0$ and $y = 2$; $z = 0$ and $z = 3$. (08 Marks)
- c. Show that electric field intensity is negative potential gradient. (05 Marks)

OR

- 4 a. The flux density $\vec{D} = \frac{r}{3}\vec{a}_r \text{ nC/m}^2$ in free space :
 - i) Find \vec{E} at $r = 0.2 \text{ m}$
 - ii) Find the total electric flux leaving the sphere of $r = 0.2 \text{ m}$.
 - iii) Find the total charge within the sphere of $r = 0.3 \text{ m}$ (07 Marks)
- b. State and prove Gauss divergence theorem. (07 Marks)
- c. Derive an expression for continuously equation. (06 Marks)

Module-3

- 5 a. Determine whether or not the following potential fields satisfy the Laplace's equation:
 i) $V = x^2 - y^2 + z^2$ ii) $V = r \cos\phi + z$ iii) $V = r \cos\theta + \phi$ (06 Marks)
- b. Evaluate both sides of Stoke's theorem for the field $\vec{H} = 6xy\vec{a}_x - 3y^2\vec{a}_y$ A/m, for rectangular path around the region, $2 \leq x \leq 5$, $-1 \leq y \leq 1$, $z = 0$. (08 Marks)
- c. Explain the concept of magnetic potential. (06 Marks)

OR

- 6 a. State and prove uniqueness theorem. (06 Marks)
- b. Two plates of parallel plate capacitor are separated by distance 'd' and maintained at potential zero and V_0 respectively. Determine,
 i) Potential at any position between the plates
 ii) Surface charge density on the plates
 iii) Capacitance between the plates. (08 Marks)
- c. Find the magnetic flux density at the centre 'O' of a square of sides equal to 5 m and carrying 10 A of current. (06 Marks)

Module-4

- 7 a. Derive an expression for force on a differential current element and find force experienced by conductor of 6 m long, lies along z-direction with a current of 2A in \vec{a}_z direction, if $\vec{B} = 0.08\vec{a}_x$ T. (07 Marks)
- b. Explain magnetization and permeability. (07 Marks)
- c. Derive boundary conditions at the interface of two magnetic materials. (06 Marks)

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OR

- 8 a. A point charge of $Q = -1.2C$ has velocity $\vec{v} = (5\vec{a}_x + 2\vec{a}_y - 3\vec{a}_z)$ m/s. Find the magnitude of force exerted on the charge if,
 i) $\vec{E} = -18\vec{a}_x + 5\vec{a}_y - 10\vec{a}_z$ V/m
 ii) $\vec{B} = -4\vec{a}_x + 4\vec{a}_y + 3\vec{a}_z$ T
 iii) Both are present simultaneously. (07 Marks)
- b. Find the magnetization in a magnetic material where:
 i) $\mu = 1.8 \times 10^5$ H/m and $M = 120$ A/m
 ii) $\mu = 22$, there are 8.3×10^{28} atoms/m³ each atom has a dipole moment of 4.5×10^{-27} A/m² and
 iii) $B = 300$ μ T and $X_m = 15$ (07 Marks)
- c. State and explain Faraday's law of electromagnetic induction. Hence obtain Maxwell's equation in point form and integral form. (06 Marks)

Module-5

- 9 a. Derive Maxwell's equations for time varying fields, represent them in point form and integral form. (08 Marks)
- b. Obtain relationship between \vec{E} and \vec{H} in free space. (06 Marks)

- c. In free space $\vec{E} = 50 \cos(\omega t - \beta z) \vec{a}_x$ V/m. Find the average power crossing a circular area of radius 2.5m in the plane $z = 0$. (06 Marks)

OR

- 10 a. Given $\vec{E} = E_m \sin(\omega t - \beta z) \vec{a}_y$ in free space, find \vec{D} , \vec{B} and \vec{H} . Sketch \vec{E} and \vec{H} at $t = 0$. (08 Marks)
- b. Explain wave propagation in good conductor with relevant equations. (08 Marks)
- c. Wet marshy soil is characterized by $\sigma = 10^{-2}$ S/m, $\epsilon_r = 15$ and $\mu_r = 1$. At 1 MHz whether soil be considered as conductor or dielectric. (04 Marks)
