CBCS SCHEME

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21EC54

Fifth Semester B.E./B.Tech. Degree Examination, Dec.2025/Jan.2026
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. State vector form of coloumb's law of force between two point charges and indicate the units of the quantities in the equation. **(06 Marks)**

b. A charge of $Q_1 = 3 \times 10^{-4}$C at M(1, 2, 3) and a charge of $Q_2 = -10^{-4}$C at N(2, 0, 5) in a vacuum. Find the force exerted on Q_2 by Q_1. **(06 Marks)**

c. Derive an expression for the electric field intensity due to infinite line charge. **(08 Marks)**

OR

2 a. Explain the following terms with mathematical expressions with respect to electrostatics:
i) Volume charge density
ii) Line charge density
iii) Surface charge density
iv) Electric flux density **(10 Marks)**

b. Find electric flux density $\vec{D}$ in Cartesian co-ordinate system at a point P(6, 8, -10) due to
i) A point charge of 40 mc at the origin and
ii) A uniform line charge of $\rho_L = 40$ μc/m on the z-axis.
iii) A uniform surface charge of density $\rho_S = 57.2$ μc/m^2 on the plane x = 12 m. **(10 Marks)**

Module-2

3 a. State and prove Gauss divergence theorem. **(06 Marks)**

b. In a certain region of space $\vec{D} = 2xy\ \vec{a}_x + 3yz\ \vec{a}_y + 4zx\ \vec{a}_z$. Evaluate the amount of electric flux that passes through the portion bounded by $-1 \le y \le z$ and $0 \le z \le 4$ in the x = 3 plane. **(08 Marks)**

c. Prove that $\rho_V = \nabla.D$ **(06 Marks)**

OR

4 a. Establish relation $E = -\nabla V$ **(06 Marks)**

b. If three charges 3 μc, 4 μc and 5μc are located at (0, 0, 0), (2, -1, 3) and (0, 4, -2) respectively. Find the potential at (1, 0, 1) assuming zero potential at infinity. **(08 Marks)**

c. Let $\vec{D} = 5r^2\ \vec{a}_r$ mc/m^2 for r < 0.08 m and $\vec{D} = \frac{0.1}{r^2}\ \vec{a}_r$ mc/m^2 for r > 0.08 m

i) Find charge density for r = 0.06 m
ii) Find charge density for r = 0.1 m **(06 Marks)**

Module-3

5 a. Derive an expression for Poisson's and Laplace's equation. **(05 Marks)**

b. State and prove uniqueness theorem. **(08 Marks)**

c. Determine whether or not the following potential fields satisfy the Laplace's equation.
i) $v = x^2 - y^2 + z^2$
ii) $v = r\cos\phi + z$ **(07 Marks)**

OR

6 a. State and explain Ampere circuital law. **(06 Marks)**

b. Given the general vector $\vec{A} = (\sin 2\phi)\vec{a}_\phi$ in cylindrical co-ordinates. Find the curl of $\vec{A}$ at $(2, \pi/4, 0)$ **(08 Marks)**

c. Explain the concept of scalar and vector magnetic potential. **(06 Marks)**

Module-4

7 a. Derive an expression for force on a differential current element. **(08 Marks)**

b. A conductor 6 m long lies along z-direction with a current of 2A in $\vec{a}_z$ direction. Find the force experienced by conductor if $\vec{B} = 0.08\vec{a}_x$ T **(04 Marks)**

c. A current element $I_1 \overrightarrow{\Delta L_1} = 10^{-5}\vec{a}_z$ A – m is located at P_1 (1, 0, 0) while a second element. $I_2 \overrightarrow{\Delta L_2} = 10^{-5}(0.6\vec{a}_x - z\vec{a}_y + 3\vec{a}_z)$ A – m is at P_2 (-1, 0, 0) both in free space. Find the vector force exerted on $I_2 \overrightarrow{\Delta L_2}$ by $I_1 \overrightarrow{\Delta L_1}$. **(08 Marks)**

OR

8 a. If $\vec{B} = 0.05x\ \vec{a}_y$ T in a material for which $X_m = 2.5$. Find :

i) μr ii) μ iii) $\vec{H}$ iv) $\vec{M}$ v) $\vec{J}$ **(10 Marks)**

b. Write a note on forces on magnetic material and magnetic circuits. **(10 Marks)**

Module-5

9 a. Derive Maxwell's equations in point form and integral form for time varying fields. **(08 Marks)**

b. State and explain Faraday's law of electromagnetic induction. **(08 Marks)**

c. The depth of penetration in a region of certain conducting medium is 0.1 m. The frequency of the electromagnetic wave is one Mega Hertz. Find the conductivity of the conducting medium. **(04 Marks)**

OR

10 a. Obtain solution of the wave equation for a uniform plane wave in free space. **(06 Marks)**

b. State and prove Poynting theorem. **(08 Marks)**

c. A plane wave of 16 GHz frequency and E = 10V/m propagates through the body of salt water having constants $\epsilon_r = 100$, $\mu_r = 1$ and $\sigma = 100$ mho/m. Determine attenuation constant, phase shift constant, phase velocity and intrinsic impedance of the medium and depth of penetration. **(06 Marks)**

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