

CBCS SCHEME

18EC55



Fifth Semester B.E. Degree Examination, Dec.2023/Jan.2024 Electromagnetic Waves

Time: 3 hrs.

Max. Marks: 100

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

Module-1

- Derive the expression for electric field intensity due to finite line charge. (08 Marks)
 - Derive the relation between \vec{D} and \vec{E} . (04 Marks)
 - Determine the force exerted on Q_2 by Q_1 , if the charges are located :
 $Q_1 = 3 \times 10^{-4}C$ at $M(1, 2, 3)$ and $Q_2 = -10 \times 10^{-4}$ at $N(2, 0, 5)$ in a vacuum. (08 Marks)

OR

- State Coulomb's law and prove the expression for electric field intensity due to several charge. (08 Marks)
 - Derive the expression for the force due to several charges. (04 Marks)
 - A charge $Q_1 = 25nC$ is located at $A(4, -2, 7)$ and a charge $Q_2 = 60nC$ is located at $B(-3, 4, -2)$. Find \vec{E} at $C(1, 2, 3)$. Also find the direction of electric field. Given $\epsilon_0 = 8.854 \times 10^{-12}F/m$. (08 Marks)

Module-2

- State and prove divergence theorem. (06 Marks)
 - Determine the volume charge density, if the field $\vec{D} = \frac{10 \cos \theta \sin \phi}{r} a_r \text{ c/m}^2$. (07 Marks)
 - Calculate the divergence of \vec{D} at specified points if
 $\vec{D} = \frac{1}{z^2} [10xyz] a_x + 5x^2z a_y + (2z^3 - 5x^2y) a_z$ at $P(-2, 3, 5)$. (07 Marks)

OR

- Derive the expression for equation of continuity. (05 Marks)
 - Give the relation between \vec{E} and V . (05 Marks)
 - Given potential field, $V = 2x^2y - 5z$ and a point $(-4, 3, 6)$ find several numerical values at P
i) Potential V ii) \vec{E} and the direction iii) \vec{D} iv) ρ_v . (10 Marks)

Module-3

- Derive the expression for Poisson's equation. (05 Marks)
 - Determine whether the potential field $V = x^2 - y^2 + z^2$ satisfy the laplace equation. (05 Marks)
 - Given vector $\vec{E} = (12yx^2 - 6z^2x) a_x + (4x^3 + 18zy^2) a_y + (6y^3 - 6zx^2) a_z$ check whether it represents a possible electric field. (10 Marks)

OR

- 6 a. State and prove Ampers circuit law. (08 Marks)
 b. Explain the concepts of scalar and vector magnetic potential. (06 Marks)
 c. Given : $\vec{H} = [y \cos(\alpha x) \hat{a}_x + (y + e^x) \hat{a}_z]$. Find current density vector over the yz plane. (06 Marks)

Module-4

- 7 a. Derive the expression for force on differential current element. (08 Marks)
 b. Define magnetization and Magnetic moment. (04 Marks)
 c. Two differential current elements,

$$I_1 dL_1 = 3 \times 10^{-6} a \hat{y} \text{ Am at } P_1(1, 0, 0) \text{ and}$$

$$I_2 dL_2 = 3 \times 10^{-6} (-0.5a \hat{x} + 0.4 \hat{y} + 0.3 \hat{a}_z) \text{ Am at } P_2(2, 2, 2) \text{ are located in a free space. Find the vector force exerted on } I_2 dL_2 \text{ by } I_1 dL_1. \quad (08 \text{ Marks})$$

OR

- 8 a. State and explain Lorentz force equation. (08 Marks)
 b. Define Magnetic pole strength and Magnetic field intensity. (04 Marks)
 c. A point charge $Q = 18 \text{ nC}$ has a velocity of $5 \times 10^6 \text{ m/s}$ in the direction :

$\vec{a} = 0.6 a \hat{x} + 0.75 a \hat{y} + 0.3 a \hat{z}$. Calculate the magnitude of the force exerted on the charge by the field :

i) $\vec{B} = -3 a \hat{x} + 4 a \hat{y} + 6 a \hat{z} \text{ MT}$

ii) $\vec{E} = -3 a \hat{x} + 4 a \hat{y} + 6 a \hat{z} \text{ KV/m}$

ii) \vec{B} and \vec{E} acting together. (08 Marks)

Module-5

- 9 a. Write a Maxwell's equations in point form and integral form. (06 Marks)
 b. Find the frequency at which conduction current density and displacement current density are equal in a medium with $\sigma = 2 \times 10^4 \text{ } \Omega/\text{m}$ and $\epsilon_r = 81$. (06 Marks)
 c. A circular cross section conductor of radius 1.5mm carries a current $i = 5.5 \sin(4 \times 10^{10} t) \mu\text{A}$. Find the magnitude of displacement current density if $\sigma = 35 \text{ } \Omega/\text{m}$ and $\epsilon_r = 10$. (08 Marks)

OR

- 10 a. Derive the expression for uniform plane wave for a free space. (08 Marks)
 b. State and prove Poynting theorem. (06 Marks)
 c. The magnetic field intensity of a uniform plane wave in air is $20/\text{m}$ in \vec{a}_y direction. The wave is propagating in \vec{a}_z direction at an angular frequency of $2 \times 10^9 \text{ rad/s}$. Find
 i) Phase shift constant
 ii) Frequency
 iii) Wave length
 iv) Amplitude of electric field intensity. (06 Marks)

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