CBCS SCHEME

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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

1 a. Derive the expression for electric field intensity due to finite line charge. **(08 Marks)**

b. Derive the relation between $\vec{D}$ and $\vec{E}$. **(04 Marks)**

c. 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 vaccum. **(08 Marks)**

OR

2 a. State Coulomb's law and prove the expression for electric field intensity due to several charge. **(08 Marks)**

b. Derive the expression for the force due to several charges. **(04 Marks)**

c. 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

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

b. Determine the volume charge density, if the field $\vec{D} = \frac{10\cos\theta\sin\phi}{r}\hat{ar}$ c/m^2. **(07 Marks)**

c. Calculate the divergence of $\vec{D}$ at specified points if $\vec{D} = \frac{1}{Z^2}[10xyz]\hat{ax} + 5x^2z\hat{ay} + (2z^3 - 5x^2y)\hat{az}$ at P(–2, 3, 5). **(07 Marks)**

OR

4 a. Derive the expression for equation of continuity. **(05 Marks)**

b. Give the relation between $\vec{E}$ and V. **(05 Marks)**

c. 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

5 a. Derive the expression for Poisson's equation. **(05 Marks)**

b. Determine whether the pontifical field $V = x^2 - y^2 + z^2$ satisfy the laplace equation. **(05 Marks)**

c. Given vector $\vec{E} = (12yx^2 - 6z^2x)\hat{ax} + (4x^3 + 18zy^2)\hat{ay} + (6y^3 - 6zx^2)\hat{az}$ check whether it represents a possible electric field. **(10 Marks)**

OR

6 a. State and prove Ampers circuit low. **(08 Marks)**

b. Explain the concepts of scalar and vector magnetic potential. **(06 Marks)**

c. Given : $\overline{H} = [y\cos(\alpha x)\hat{a}x + (y + e^{x})\hat{a}z]$. 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,

$I_1 dL_1 = 3\times10^{-6} a\hat{y}$ Am at $P_1(1, 0, 0)$ and

$I_2 dL_2 = 3\times10^{-6}(-0.5a\hat{x} + 0.4\hat{y} + 0.3a\hat{z})$Am at $P_2(2, 2, 2)$ are located in a free space. Find the vector force exerted on $I_2 dL_2$ by $I_1 dL_1$. **(08 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 = 18nC has a velocity of 5×10^{6}m/s in the direction :

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

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

ii) $\vec{E} = -3a\hat{x} + 4a\hat{y} + 6a\hat{z}$ 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 $\sigma = 2 \times 10^{4}$℧/m and $\varepsilon_r = 81$. **(06 Marks)**

c. A circular cross section conductor of radius 1.5mm carries a current $i = 5.5\sin(4 \times 10^{10t})\mu A$. Find the magnitude of displacement current density if $\sigma = 35$℧/m and $\varepsilon_r = 10$. **(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/m in $\overline{ay}$ direction. The wave is propagating in $\overline{az}$ direction at an angular frequency of 2×10^{9}rad/s. Find

i) Phase shift constant

ii) Frequency

iii) Wave length

iv) Amplitude of electric field intensity. **(06 Marks)**

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