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21EC54

Fifth Semester B.E. Degree Examination, June/July 2024
Electromagnetic Waves

Time: 3 hrs. Max. Marks: 100

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

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.

Module-1

1 a. State and explain Coulomb's law of force between two point charges in vector form and mention the units of quantities in the force equation. **(06 Marks)**

b. Two point charge Q_1 and Q_2 are located at (1, 2, 0)m and (2, 0, 0)m respectively. Find the relation between the charges Q_1 and Q_2 such that the total force on a unit positive charge at (–1, 1, 0) have : i) No x-component ii) No y-component. **(08 Marks)**

c. List the expressions of electrified intensity $\vec{E}$ due to various charge distributions. **(06 Marks)**

OR

2 a. Derive the expression for eclectic field intensity $(\vec{E})$ due to infinite line charge of uniform charge distribution and lies along the Z-axis. **(12 Marks)**

b. Evaluate $\vec{D}$ (Electric flux density) at a point (6, 8,–10) due to :
i) A point charge of 40mC at the origin
ii) A uniform line charge of $\rho_L = 40\mu C/m^2$ on the z-axis
iii) A uniform surface charge density of $\rho_s = 57.2\mu C/m^2$ on the plane x = 12m. **(08 Marks)**

Module-2

3 a. State and prove Gauss's law for a point charge. **(06 Marks)**

b. The flux density within the cylindrical volume bounded by r = 5m, z = 0 to z = 2m is given by $\vec{D} = 30e^{-r}a_r - 2ZQ_z c/m^2$. Estimate the total outward flux crossing the surface of cylinder. **(08 Marks)**

c. Define and derive the mathematical expression for divergence of a vector $\vec{D}$. **(06 Marks)**

OR

4 a. Given $\vec{D} = 5ra_r c/m^2$, prove divergence theorem for a shell region enclosed by spherical surfaces @r = a and r = b (b > a) and centred @ the origin. **(08 Marks)**

b. Define electric potential. Obtain an expression for the potential difference between two points in an electric field. **(06 Marks)**

c. Drive current continuity equation. **(06 Marks)**

Module-3

5 a. Find V at P(2, 1, 3) for the field of two co-axial conducting cones with V = 50V @ θ = 30° and V = 20V @ @ θ = 50°. **(06 Marks)**

b. Derive Laplace and Poisson's equation from Gauss's law. **(06 Marks)**

c. Use Laplace equation to find the capacitance per unit length of a co-axial cable of inner radius 'a'm and outer radius 'b'm. Assume $V = V_0$ @ r = a and V = 0 @ r = b. **(08 Marks)**

OR

6 a. State and explain Biot-Savart's law. **(06 Marks)**

b. Give $H = 20r^2 a\phi A/m$

i) Determine the current density (J). **(08 Marks)**

ii) Also determine the total current that crosses the surface $r = 1m$, $0 < \phi < 2\pi$ and $z = 0$,

c. Explain the concept of magnetic flux and magnetic flux density. **(06 Marks)**

Module-4

7 a. A point charge of $Q = -1.2C$ has velocity $\vec{V} = [5a_x + 2ay - 3a_z]m/s$. Find the magnitude of the force exerted on the charge, if

i) $\vec{E} = -18a_x + 5a_y - 10a_z v/m$

ii) $\vec{B} = -4a_x + 4a_y + 3a_z T$

iii) Both the field are present. **(08 Marks)**

b. Derive an expression for the force on a differential current element placed in a magnetic field. **(07 Marks)**

c. State and explain Faraday's law of electromagnetic induction. **(05 Marks)**

OR

8 a. Discuss the magnetic boundary conditions to apply to $\vec{B}$ and $\vec{H}$ at the interface between two different magnetic materials. **(12 Marks)**

b. If $B = 0.05xayT$ in a material for which $x_m = 2.5$, find μr, μ, H, M, J, J_b. **(08 Marks)**

Module-5

9 a. Derive Maxwell's equation in integral and point form for time varying fields. **(12 Marks)**

b. Verify the field $\vec{E} = E_m \sin x \sin t\, a_y$ and $\vec{H} = \frac{E_m}{\mu_0} \cos x \cos t\, a_z$ satisfy Maxwell's equations. **(08 Marks)**

OR

10 a. Determine the relation between $\vec{E}$ and $\vec{H}$ of an electromagnetic wave travelling in free space along z-direction. **(10 Marks)**

b. Discuss uniform plane wave propagating in a good conducting media and also explain the term skin depth. **(10 Marks)**

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