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18EC55

Fifth Semester B.E. Degree Examination, Feb./Mar. 2022 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 and explain Coulomb's Law. Also express in Vector form. (06 Marks)
b. Derive the expression for electric field intensity due to infinite line charges. (08 Marks)
c. Find the electric field at a point P(2, 15, 13)m due to the uniform line charge density $\rho_L = 25\text{nc}$. Given that a perpendicular to drawn from A meets the line charge at a point B(3, 0, 4)m. (06 Marks)

OR

- 2 a. A charge $Q_2 = 121 \times 10^{-9} \text{ C}$ is located in free space at $P_2(-0.03, 0.01, 0.04)\text{m}$. Find the force on Q_2 due to Q_1 where $Q_1 = 110 \times 10^{-6} \text{ C}$ at $P_1(0.03, 0.08, -0.02)\text{m}$. (06 Marks)
b. Define Electric Field Intensity. Derive the expression for Electric field at a point due to may charges. (08 Marks)
c. Derive the expression for field due to continuous volume charge distribution. (06 Marks)

Module-2

- 3 a. State and explain Gauss Law. (06 Marks)
b. Evaluate both sides of divergence theorem for the field $D = 2xy\bar{a}_x + x^2\bar{a}_y \text{ c/m}^2$ and the rectangular parallel piped formed by the planes $x = 0$ and $y = 1$, $y = 0$ and $y = 2$, $z = 0$ and $z = 3$. (10 Marks)
c. Show that electric field intensity is negative potential gradient. (04 Marks)

OR

- 4 a. Obtain the expression for the work done in moving a point charge in an electric field. (06 Marks)
b. Derive the expression for equation of continuity. (08 Marks)
c. Give $V = 2x^2y - 5z$ at point P(-4, 3, 6). Find the potential, electric field intensity and volume charge density. (06 Marks)

Module-3

- 5 a. Solve the Laplace's equation to find the potential field in the homogeneous region between the two concentric conducting sphere with radii a and b such that $b > a$. If potential $V = 0$ at $r = b$ and $V = V_0$ at $r = a$. Also find Electric field intensity. (10 Marks)
b. If the magnetic field intensity in a region is $H = (3y - 2)az + 2 \times ay$. Find the current density at the origin. (04 Marks)
c. State and explain Biot - Savart's law. (06 Marks)

OR

- 6 a. State and prove Uniqueness theory. (08 Marks)
b. Determine whether or not the following potential fields satisfy the Laplace's equation.
i) $V = x^2 - y^2 + z^2$ ii) $V = r \cos \phi + z$. (08 Marks)
c. Explain the concepts of Scalar Potential. (04 Marks)

Module-4

- 7 a. Derive an expression for force between differential current elements. (06 Marks)
 b. Obtain the boundary conditions at the interface between two magnetic materials. (10 Marks)
 c. Find the magnetization in a magnetic material, where
 i) $\mu = 1.8 \times 10^{-5}$ H/m and $H = 120$ A/m ii) $B = 300\mu\text{T}$ and susceptibility = 15. (04 Marks)

OR

- 8 a. State and explain Faraday's law of Electromagnetic Induction. Show its equation in differential form and integral form. (10 Marks)
 b. A point charge $Q = 18\text{nc}$ has a velocity of 5×10^6 m/s in the direction $\vec{a}_v = 0.6\vec{a}_x + 0.75\vec{a}_y + 0.3\vec{a}_z$. Calculate the magnitude of force exerted on the charge by the field i) $\vec{E} = -3\vec{a}_x + 4\vec{a}_y + 6\vec{a}_z$ Kv/m ii) $\vec{B} = -3\vec{a}_x + 4\vec{a}_y + 6\vec{a}_z$ MT
 iii) \vec{B} and \vec{E} acting together. (06 Marks)
 c. A conductor of length 4m long lies along the Y – axis with a current of 10 Amp in the \vec{a}_y direction. Find the force on the conductor if the field in the region is $B = 0.005\vec{a}_x$ tesla. (04 Marks)

Module-5

- 9 a. What is meant by Uniform Plane Wave? Derive the expression for Uniform Plane Wave in the free space. (10 Marks)
 b. Let $\mu = 10^{-5}\text{H/m}$, $\epsilon = 4 \times 10^{-9}\text{F/m}$, $\sigma = 0$ and $\rho_v = 0$. Determine 'K' so that each of the following pair of fields satisfies Maxwell's equation :
 i) $\vec{D} = 2x\hat{a}_x - 3y\hat{a}_y + 4z\hat{a}_z$ nC/m², $\vec{H} = Kx\hat{a}_x + 10y\hat{a}_y - 25z\hat{a}_z$ A/m
 ii) $\vec{E} = (20y - kt)\hat{a}_x$ V/m, $\vec{H} = (y + 2 \times 10^6 t)\hat{a}_z$ A/m. (10 Marks)

OR

- 10 a. State and explain Poynting's theorem. (10 Marks)
 b. Discuss Wave propagation in good conducting medium. (06 Marks)
 c. Find the frequency at which conduction current density and displacement current density are equal in a medium with $\sigma = 2 \times 10^{-4}$ S/m and $\epsilon_r = 81$. (04 Marks)
