

GUJARAT TECHNOLOGICAL UNIVERSITY**B. E. Sem. - V - Examination – June- 2011****Subject code: 151002****Subject Name: Engineering Electromagnetics****Date: 22/06/2011****Time: 10:30 am – 01:00 pm****Total Marks: 70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
4. The symbols have the usual meaning.

- Q.1** (a) Define electric field intensity. Derive the expression for the intensity of electric field due a line charge along the Z direction with uniform charge density ρ_L C/m using Coulomb's law and verify the same using Gauss's law. **07**
- (b) Prove the following relations from the fundamental principle of electromagnetic theory : **07**

(i) $R = \frac{\rho l}{a}$ ohms

(ii) $F = Q(E + v \times B)$

- Q.2** (a) What is an electric dipole? Derive the expression for the potential and electric field intensity due to a dipole at distances very large from the origin compared to the spacing d between the charges $+Q$ and $-Q$. **07**
- (b) Given the Potential field in cylindrical coordinates $V = 1000 \Phi + 50$ Volts. Calculate the value at $P(0.4, 30^\circ, 1)$ in air of (i) E (ii) D (iii) ρ_v (iv) Energy density **07**

OR

- (b) Given that $D = \frac{10\rho^3}{4} a_\rho$ C/m² in cylindrical coordinates. Evaluate both sides of the divergence theorem for the volume enclosed by $\rho = 1$ m, $\rho = 2$ m, $z = 0$ and $z = 10$ m **07**

- Q.3** (a) Assuming the potential function V varies as a function of ρ in cylindrical coordinates systems, obtain the solution of Laplace equation and deduce the value of capacitance of a coaxial capacitor **07**
- (b) Curl free vector is an irrotational field, which is a conservative field also. Justify **03**
- (c) E and F are vector fields given by $E = 2x a_x + a_y + yz a_z$ and $F = xy a_x - y^2 a_y + xyz a_z$. Determine **04**
- (a) $|E|$ at $(1, 2, 3)$
- (b) The component of E along F at $(1, 2, 3)$
- (c) A vector perpendicular to both E and F at $(0, 1, -3)$ whose magnitude is unity

OR

- Q.3** (a) An infinitely long coaxial cable is carrying current I by the inner conductor of radius ' a ' and $-I$ by the outer conductor of radii ' b ' and ' c '. where $c > b$. **07**
- (i) Deduce the expressions for H at
- (i) $\rho < a$ (ii) $a < \rho < b$ (iii) $b < \rho < c$ (iv) $\rho > c$. Sketch the plot of H as a function of radius. (ii) Find the inductance of the coaxial cable

- (b) Do as directed 07
- (i) $\mathbf{D} = 8\rho \sin \phi \mathbf{a}_\rho + 4\rho \cos \phi \mathbf{a}_\phi \text{ C/m}^2$. Find $\text{div } \mathbf{D}$
- (ii) Find the laplacian of the scalar $V = e^{-z} \sin 2x \cosh y$.

- Q.4** (a) Using Gauss's law explain the concept of divergence. Prove Divergence theorem. Obtain Maxwell's first equation 07
- (b) (i) Express the vector field $\mathbf{D} = (x^2 + y^2)^{-1}(x\mathbf{a}_x + y\mathbf{a}_y)$ in cylindrical components. Evaluate $\mathbf{D}$ at the point $P(\rho = 2, \phi = 60^\circ, z = 5)$. Express the result in cylindrical and Cartesian components. 07
- (ii) Find $\nabla \times \mathbf{A}$ for the vector field $\mathbf{A} = 10 \sin \theta \mathbf{a}_\theta$ in spherical coordinates at $P(2, \Pi/2, 0)$.

OR

- Q.4** (a) Deduce the boundary conditions with necessary derivations (i) at the interface between two dielectric materials with permittivities ϵ_1 and ϵ_2 and (ii) at the interface between two magnetic materials with permeabilities μ_1 and μ_2 07
- (b) A circuit has 2000 turns enclosing a magnetic circuit of 30 sq cm in section. A current of 5A in the circuit produces a field of flux density 1 wb/cm² and when the current is doubled, the flux density increases by 50%. Determine the value of the inductance of the circuit for the current varying between 5A and 10A. Also find the induced emf when the current increases from 5A to 10A in 0.1 sec.
- Q.5** (a) Using Faraday's law and the concept of displacement current density, Ampere's circuital law, divergence theorem, obtain all Maxwell's equations for time varying fields in point and integral forms. Derive the necessary equations. 07
- (b) A wave propagating in a lossless dielectric has the components $\mathbf{E} = 500 \cos(10^7 t - \beta z) \mathbf{a}_x \text{ V/m}$ and $\mathbf{H} = 1.1 \cos(10^7 t - \beta z) \mathbf{a}_y \text{ A/m}$. 07
- If the wave is travelling with the velocity of $v = 0.5c$, find (i) μ_r (ii) ϵ_r (iii) β (iv) λ (v) η

OR

- Q.5** (a) State and prove Poynting theorem relating to the flow of energy at a point in space in an electromagnetic field. 07
- (b) A certain signal generator produces a uniform plane wave in free space having a wavelength of 12 cm. When it propagates through a lossless material of unknown wavelength, its wavelength reduces to 8 cm. The E field amplitude is 50V/m and H field is 0.1 A/m. Find the generator frequency, μ_r , ϵ_r of unknown material. 07
