GUJARAT TECHNOLOGICAL UNIVERSITY
BE - SEMESTER–V • EXAMINATION – WINTER 2013

Subject Code: 151002 Date: 04-12-2013

Subject Name: Engineering Electromagnetics

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.

Q.1 (a) (i) Transform the vector \(\mathbf{B} = y\mathbf{a}_x - x\mathbf{a}_y + z\mathbf{a}_z\) into cylindrical coordinates.
(ii) Transform vector field \(\mathbf{G} = (xz/y)\mathbf{a}_x\) into spherical components and variables.
(b) Derive the expression for the electric field \(\mathbf{E}\) due to infinite sheet of charge having a uniform density of \(\rho_S \text{ C/m}^2\).

Q.2 (a) State and derive following:
(1) Maxwell’s first equation for electrostatics, (2) Divergence theorem.
(b) Write a detailed note on potential gradient. OR
(b) Derive the expression of curl. Also mention its physical interpretation.

Q.3 (a) What are the characteristics of a good conductor? Determine boundary conditions at a boundary between a conductor and free space.
(b) A slab of dielectric material has a relative dielectric constant of 3.8 and contains a uniform electric flux density of 8 nC/m². If the material is lossless, find: (a) \(E\); (b) \(P\); (c) the average number of dipoles per cubic meter if the average dipole moment is \(10^{-29} \text{ C•m}\).

OR
Q.3 (a) Derive the expression of following capacitors: (a) coaxial capacitor, (b) spherical capacitor, (c) isolated spherical capacitor, (d) parallel-plate capacitor having two dielectrics parallel to the plates.
(b) Given the electric flux density, \(\mathbf{D} = 0.3r^2\mathbf{a}_r\) nC/m² in free space: (a) find \(\mathbf{E}\) at point \(P(r = 2, \theta = 25^\circ, \phi = 90^\circ)\); (b) find the total charge within the sphere \(r = 3\); (c) find the total electric flux leaving the sphere \(r = 4\).

Q.4 (a) State and Explain Biot-Savart law. Derive an expression of magnetic field intensity for an infinitely long straight filament carrying a direct current \(I\) on the \(z\) axis from \(-\infty < z < \infty\).
(b) Write a detailed note on Magnetization and permeability.

OR
Q.4 (a) A current filament carrying 15 A in the \(\mathbf{a}_z\) direction lies along the entire \(z\) axis.
Find \(\mathbf{H}\) in rectangular coordinates at \(P_1(20^{\frac{1}{2}}, 0, 4)\).
(b) Explain Hall voltage and Hall effect and mention its uses. Also derive the equation for the force on a differential current element.

Q.5 (a) Mention all four Maxwell’s equations for steady fields. Using the concept of Faraday’s law and displacement current modify them for time varying fields.
(b) The electric field amplitude of a uniform plane wave propagating in the \(\mathbf{a}_z\) direction is 250 V/m. If \(\mathbf{E} = E_0\mathbf{a}_z\) and \(w = 1.00 \text{ Mrad/s}\), find: (a) the frequency; (b) the wavelength; (c) the period; (d) the amplitude of \(\mathbf{H}\).

OR
Q.5 (a) Given the potential field, \(V = 2x^2y - 5z\), and a point \(P(-4, 3, 6)\), find following values at point \(P\): the potential \(V\), the electric field intensity \(\mathbf{E}\), the direction of \(\mathbf{E}\), the electric flux density \(\mathbf{D}\), and the volume charge density \(\rho_v\).
(b) Write a detailed note on skin effect and skin depth.