B.Tech.
(SEM. IV) THEORY EXAMINATION 2013-14
ELECTROMAGNETIC FIELD THEORY

Time : 3 Hours  Total Marks : 100

Note :- Attempt all Sections.

SECTION–A

1. Attempt all parts : $(10 \times 2 = 20)$

(a) What do you mean by gradient of a scalar? Write its expression in all co-ordinate systems.

(b) Prove that the divergence of the curl of a vector field vanishes.

(c) Define Gauss's law. What do you mean by Gaussian surface?

(d) What do you mean by conservative fields?

(e) Define Polarization in dielectric materials.

(f) Write the Maxwell's equations in integral & differential form.

(g) What do you mean by Mutual & Self inductances?

(h) A plane wave in a nonmagnetic medium has $\overline{E} = 50 \sin(0^8 t+2z)\hat{a}y$ V/m. Find $d$, $f$, $e$.

(i) Differentiate between lumped and distributed components.

(j) Write the condition for distortionless transmission line.
2. Attempt any three parts: \((10 \times 3 = 30)\)

(a) Determine the flux of \(\mathbf{D} = \rho^2 \cos 2\phi \hat{\mathbf{a}}_\rho + 2 \sin \phi \hat{\mathbf{a}}_\rho\) over the closed surface of the cylinder \(0 \leq z \leq 1, \rho = 4\). Verify the divergence theorem for this case.

(b) Given that \(\mathbf{E} = (3x^2 + y) \hat{\mathbf{a}}_x + x \hat{\mathbf{a}}_y\) kV/m. Find the work done in moving a -2\(\mu\)C charge from \((0,5,0)\) to \((2,-1,0)\) by taking the straight line path as:

(i) \((0,5,0) \rightarrow (2,5,0) \rightarrow (2,-1,0)\)

(ii) \(y = 5 - 3x\).

(c) Determine the self-inductance of coaxial cable of inner radius \(a\) and outer radius \(b\).

(d) What do you mean by intrinsic impedance of a medium? Derive intrinsic impedance for plane waves in lossless dielectrics.

(e) Derive the equation for a two conductor transmission line in terms of \(V\) and \(I\).

SECTION-B

3. Attempt any two parts: \((5 \times 10 = 50)\)

(a) Write the statement of divergence theorem. Prove the divergence theorem and also write the physical significance of divergence.
(b) Let \( \mathbf{A} = \rho \sin \phi \mathbf{\hat{a}}_\rho + \rho^2 \mathbf{\hat{a}}_\phi \) Verify the Stokes theorem for the given contour.

(c) Express the vector \( \mathbf{B} = \frac{10}{r} \mathbf{\hat{a}}_r + r \cos \theta \mathbf{\hat{a}}_\phi + \mathbf{\hat{a}}_\phi \) in Cartesian coordinate system.

4. Attempt any two parts:

(a) Point charges \( Q_1 = 1\text{nc}, \ Q_2 = -2\text{nc}, \ Q_3 = 3\text{nc} \) and \( Q_4 = -4\text{nc} \) are positioned one at a time in that order at \((0,0,0), (1,0,0), (0,0,-1) \) and \((0,0,1) \) respectively. Calculate the energy in the system after each charge is positioned.

(b) Three identical small spheres of mass \( m \) are suspended from a common point by threads of negligible masses and equal lengths \( l \). A charge \( Q \) is divided equally among the spheres, and they come to equilibrium at the corners of a horizontal equilateral triangle whose sides are \( d \). Show that

\[
Q^2 = 12 \pi \varepsilon_0 mgd^3 \left[ l^2 - \frac{d^2}{3} \right]^{\frac{1}{2}}
\]

Where \( g = \text{acceleration due to gravity} \).

(c) Derive the electric field for each possible case due to an uniformly charged sphere of radius \( R \) and volume charge density \( \rho \).
5. Attempt any two parts:
   (a) Derive the magnetic field intensity due to a finite length conductor at a point, when current I is flowing in it. Assume the necessary parameters yourself. Therefore determine the magnetic field intensity at a point due to an infinite length conductor.
   (b) Show mathematically that $\nabla \cdot \vec{B} = 0$
   (c) A charged particle of mass 1 kg. and charge 2 c. starts at origin with zero initial velocity in a region where $\vec{E} = 3\hat{z} \text{ V/m}$
       Find the following:
       (i) The force on the particle.
       (ii) The time it takes to reach point P (0,0,12)
       (iii) Its velocity and acceleration at P.
       (iv) Its K.E. (kinetic energy) at P.

6. Attempt any two parts:
   (a) At 50 MHz, a lossy dielectric material is characterized by, $\varepsilon = 3.6 \varepsilon_0$, $\mu = 2.1 \mu_0$, and $\sigma = 0.08 \text{ s/m}$. If $E_z = 6e^{-rx} \hat{z} \text{ V/m}$. Compute (a) $\gamma$ (b) $\lambda$ (c) $\eta$ (d) $H_z$
   (b) Define and derive skin depth for conductors.
   (c) State and derive Poynting's theorem.

7. Attempt any two parts:
   (a) A transmission line operating at 500 MHz has $z_0 = 80 \Omega$, $\alpha = 0.04 \text{ NP/m}$, $\beta = 1.5 \text{ rad/m}$.
       Find the line parameters $R$, $L$, $G$, $C$.
   (b) Derive the input impedance, standing wave ratio and voltage reflection coefficient of a two conductor transmission line.
   (c) Why do we need impedance matching in transmission line? Also discuss the various methods of impedance matching.