QP Code : 76963

(2½ Hours) [Total Marks : 75

N.B. : (1) **All** questions are **compulsory**.
(2) **Figures** to the **right** indicate **full** marks.
(3) **Symbols** have usual meaning unless stated otherwise
(4) **Use** of logtable/non programmable **calculator** is **allowed.**

1. (a) Attempt any **one** of the following:-
(i) Explain the term electric potential. Using fundamental theorem for gradient obtain the relation $\overline{E} = -\overline{\nabla} V$, hence write comments on the potential. Check if the following equation can represent electrostatic field **10**

$\overline{E} = K\left[y^2\hat{i} + \left(2xy + z^2\right)\hat{j} + 2yz\hat{k} \right]$, K is constants.

(ii) A point charge q is held at a distance 'd' above an infinite grounded conducting plane. Using method of image obtain the expression for induced charge on the plane, the force acting on charge 'q' and the energy of the system. **10**

(b) Attempt any **one** of the following:-
(i) Find electric field outside a uniformly charged solid sphere of radius R and having total charge 'q'. **5**
(ii) Find the potential inside and outside a spherical shell of radius R which carries a uniform surface charge. Set the reference point at ∞. **5**

2. (a) Attempt any **one** of the following:-
(i) Obtain an expression for potential due to polarized object in terms of surface bound charge density $\left(\sigma_b\right)$ and volume bound charge density $\left(\rho_b\right)$. **10**
(ii) Using Ampere's circuital law for an infinite solenoid carrying a steady current I, show that the magnetic field is parallel to the axis of the solenoid. Obtain the expression for magnetic field inside and outside the solenoid. Express the field in vector form. **10**

(b) Attempt any **one** of the following:-
(i) Obtain Gauss law in polarized dielectric. **5**
(ii) Define energy density for dielectric system. A uniform electric field 5V/m exist in a linear homogeneous dielectric (dielectric constant 5) Find the energy density stored in the dielectric system $\left(\varepsilon_0 = 8.85\times10^{-12} C^2/Nm^2\right)$. **5**

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3. (a) Attempt any **one** of the following:-
   (i) Obtain Maxwell's equations inside matter. **10**
   (ii) What is meant by magnetization? Show, using an expression for magnetostatic vector potential, that the magnetization of a medium gives rise to a volume current density $\vec{J}_b = \vec{\nabla} \times \vec{M}$ and a surface current density $\vec{K}_b = \vec{M} \times \hat{n}$. **10**

   (b) Attempt any **one** of the following:-
   (i) Obtain an expression for Ampere's law in presence of magnetic materials. **5**
   (ii) A long copper rod of radius R carries a uniformly distributed free current **5**

   I. Find $\vec{H}$ inside the rod.

4. (a) Attempt any **one** of the following:-
   (i) A plane electromagnetic wave is incident normally on the interface of two non-conducting media. Write expressions for the incident, reflected and transmitted fields. Apply suitable boundary conditions and obtain reflection coefficient (R) and transmission coefficient (T). **10**
   (ii) State and prove Poynting theorem. Compare its differential version with continuity equation. **10**

   (b) Attempt any **one** of the following:-
   (i) Obtain electromagnetic wave equations in free space from maxwell's equations and show that the velocity of electromagnetic waves in free space is equal to velocity of light. **5**

   Given : $\varepsilon_0 = 8.85 \times 10^{-12} C^2 / Nm^2$

   $\mu_0 = 4\pi \times 10^{-7} N/A^2$.

   (ii) Write down the Maxwell's equations for free space. Show that Maxwell's equations already include the principle of conservation of charge. **5**

5. (a) Attempt any **one** of the following:-
   (i) Show that for electrostatic field curl E = 0. **4**
   (ii) An infinite plane carries a uniform surface charge 'σ' find the electric field just above the plane. **4**

(b) Attempt any **one** of the following:-

(i) Using Biot-savarts law show that $\overline{\nabla}.\overline{B} = 0$. 4

(ii) Find the electric susceptibility and permittivity of diamond (Given: dielectric constant of dimond = 5.7 and, $\varepsilon_0 = 8.85\times10^{-12} C^2/Nm^2$). 4

(c) Attempt any **one** of the following:-

(i) Magnetic susceptibility of a linear medium is 2.5×10^{-5}. If auxiliary field $\vec{H} = 10^5 A/m$ is applied along the z-axis, find the magnetization $\vec{M}$ and magnetic field $\vec{B}$. 4

(ii) Find the total energy required to set up a uniform magnetic field of 2.0 Tesla in a cube of 20cm sides. 4

(d) Attempt any **one** of the following:-

(i) The maximum value of magnetic field in a plane electromagnetic wave is 0.003T, find the maximum value of electric field associated with this wave. Also find the magnitude of Poynting vector for the same wave. 3

Given: $c = 3\times10^8 m/s, \varepsilon_0 = 8.85\times10^{-12} C^2/N.m^2$

(ii) Obtain an equation of continuity for electrodynamics. 3
