Q.P. Code:-20135

2:30 Hours **[Total Marks : 75]**

N.B. : (1) **All** questions are **compulsory**.

(2) **Figures** to the **right** indicate **full** marks.

(3) Draw **neat** diagrams wherever **necessary**.

(5) Symbols have usual meaning unless otherwise stated.

(5) Use of **non-programmable** calculator is allowed.

1. (a) Attempt any **one:---**

(i) Find the potential inside and outside a uniformly charged solid sphere whose radius is R and total charge is **q**, use infinity as your reference point. Compute the gradient of **V** in each region and check that it yields the correct field. Sketch **V**(r). **10**

(ii) A grounded conducting plane of infinite extent is kept coinciding with X-Y plane, a point charge **q** is placed at a distance '**d**' above the plane along Z axis using method of images obtain: **10**
1) The position and the magnitude of image charge.
2) Electrostatic potential at any point above the conducting plane and electrostatic field at any point on the conducting plane.

(b) Attempt any **one:---**

(i) Define Electric flux. State Gauss law in electrostatics. What are the merits and demerits of Gauss law? **5**

(ii) The electric field in some region is found to be $\bar{E} = kr^3\hat{r}$ where k is a constant, find the charge density ρ **5**

2. (a) Attempt any **one:---**

(i) Explain the term 'Polarization'; obtain the expression for potential due to polarized object in terms of bound charge densities. **10**

(ii) Starting from Biot-Savart's law obtain the expression for $\bar{\nabla} \times \bar{B}$ and $\bar{\nabla} \cdot \bar{B}$ **10**

(b) Attempt any **one:---**

(i) Explain what is meant by linear homogeneous and isotropic dielectric. Obtain the expression $k = 1 + \chi_e$ **5**

(ii) A vector field in vacuum is given by; $2y\hat{i} + 3z\hat{j} + 4x\hat{k}$; check if it can represent magnetic field, if yes then find the associated current density **5**

3. (a) Attempt any **one:---**

(i) Explain the terms – Magnetic susceptibility and permeability. Describe in brief the deceptive parallel between the equations i) $\bar{\nabla} \times \bar{H} = \bar{J}_f$ and ii) $\bar{\nabla} \times \bar{B} = \mu_0 \bar{J}$ **10**

(ii) Obtain the expression for energy stored in magnetic field. What is energy density? **10**

(b) Attempt any **one:---**

(i) Express $\overline{J_b}$ and $\overline{K_b}$ in terms of $\overline{M}$ .Show that $\overline{\nabla} \cdot \overline{J}_B = 0$ **5**

(ii) The magnetic susceptibility of a linear sample of Aluminum is 2.1×10^{-5} if an auxiliary field of 2000 A-turns/m is applied along Z axis find the Magnetization and the Magnetic field in the medium. ($\mu_0 = 4\pi \times 10^{-7} N/A^2$) **5**

4. (a) Attempt any **one:---**

(i) Starting from Maxwell's equation obtain the wave equation. For plane wave solution show that the electric field magnetic field and the direction of propagation are mutually perpendicular. **10**

(ii) Explain the term Poynting vector; hence obtain the expression for Poynting Theorem. **10**

(b) Attempt any **one:---**

(i) Show that conservation of charge leads to the continuity equation. **5**

(ii) In case of monochromatic plane waves show that the contributions from electric field and magnetic field towards total energy density are same. **5**

5. (a) Attempt any **one:---**

(i) Determine the electric field due to potential $V = x^2 + 2y^2 + 4z^2$ **4**

(ii) An alpha particle with a kinetic energy of 1.7×10^{-12} J is shot directly towards a platinum nucleus from a very large distance. What will be the distance of closest approach? The electric charge of the alpha particle is +2e and that of the platinum nucleus is +78e. Treat the alpha particle and the nucleus as spherical charge distributions and disregard the motion of the nucleus.($e = 1.6 \times 10^{-19}$ Coul, $\varepsilon_0 = 8.85 \times 10^{-12} Coul^2/Nm^2$) **4**

(b) Attempt any **one:---**

(i) Show that for linear isotropic homogeneous dielectrics, volume bound charge (ρ_b) is proportional to volume charge density of free charge(ρ_f) **4**

(ii) A very long closely wound solenoid has 3000 turns per metre; it carries a current of 2 amperes. Find the magnetic field inside the solenoid ($\mu_0 = 4\pi \times 10^{-7} N/A^2$) **4**

(c) Attempt any **one:---**

(i) An infinite solenoid with 'n' turns per unit length carrying a current 'I' and filled with linear material of susceptibility χ_m find the Magnetic field B inside the solenoid. **4**

(ii) A long copper rod of radius 'R' carries a uniformly distributed free current 'I' find $\overline{H}$ inside and outside the rod. **4**

(d) Attempt any **one:**---

(i) Dielectric constant of diamond is 5.5, if the permeability of diamond (μ_d) is same as the permeability of free space (μ_0) i.e. $\mu_0 = \mu_d$. Find the refractive index of diamond. **3**

(ii) If R is the reflection coefficient and T is the transmission coefficient then show that R+T=1 **3**

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