Phy - IV
Elec.

8/10

QP Code : 12772

(2½ Hours) **[Total Marks : 75**

N.B. : (1) **All questions are compulsory with internal options.**
(2) Figures to the right indicate full marks.
(3) Symbols have the usual meaning unless stated otherwise.
(4) Use of non-programmable calculators and log tables is allowed.

1. (a) Attempt **any one** of the following:
   i) Show that for an electrostatic field, div $\overline{E} = \rho/\varepsilon_0$ and curl $\overline{E} = 0$. Examine whether the following is a possible electrostatic field: $\overline{E} = k[xy\hat{x} + 2yz\hat{y} + 3zx\hat{z}]$ here k is a constant with appropriate units. **10**
   ii) Use Gauss' Law to find the electrostatic field outside and inside a uniformly charged sphere of charge density ρ and radius R. Hence calcuate the electric potential in both the regions, taking the reference point at infinity. **10**

   (b) Attempt **any one** of the following:
   i) An infinite plane carries a uniform surface charge density σ. Find $\overline{E}$. Hence find the $\overline{E}$ for points inside and outside a charged parallel plate capacitor, making the appropriate assumptions. **5**
   ii) Find the electric field at a distance 's' from an infinitely long, straight wire carrying a uniform linear charge density 'λ'. Hence calculate the electric potental assuming $P(s_0, \theta_0, z_0)$ as the reference point. **5**

2. (a) Attempt **any one** of the following:
   i) Obtain an expression for potential due to bound charges, for a polarized dielectric in terms of σ_b and ρ_b. **10**
   ii) Using Biot-Savart's law, show that $\overline{\nabla} \cdot \overline{B} = 0$. Also explain the physical significane of the result. **10**

   (b) Attempt **any one** of the following.
   i) Obtain Gauss's law for a polaized dielectric in both differential and integral form. **5**
   ii) For a very long solenoid consisting of 'n' closely wound turns per unit length on a cylinder of radius 'R' and carrying a steady current

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T, assume that $B_s=0$ and $B_\phi=0$. Calculate $\overline{B}$ both inside and outside the solenoid. 5

3. (a) Attempt **any one** of the following:

(i) Explain why it was necessary to modify Ampere's law in its original form. Explain how Maxwell modified it. 10

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

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

(i) Show that in a linear medium $\vec{B} = \mu\vec{H} = \mu_0(1+\chi_m)\vec{H}$. 5

(ii) Give the physical interpretation of surface current density $\overline{K}_b$. 5

4 (a) Attempt **any one** of the following:

(i) Derive the electromagnetic wave equation in vacuum, where there are no free charges or currents. For a plane wave, show that the electric field, magnetic field and the direction of propagation are mutually perpendicular. 10

(ii) State and prove Poynting's theorem and obtain its differential version. 10

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

(i) For a certain medium $\varepsilon = 17.7 \times 10^{-12}\ C^2/Nm^2$ and $\mu = 4\pi \times 10^{-7}\ N/A^2$ Find the velocity of plane electromagnetic wave in the medium. Also find the refractive index of the medium.($c=3 \times 10^8$ m/s) 5

(ii) Show that in case of plane monochromatic waves the contributions from electric and magnetic fields towards the electromagnetic energy density are equal.

5. (a) Attempt **any one** of the following: 5

(i) Consider the xy plane to be a grounded, conducting plane. Charges q_1, and q_2 are held fixed at (x_1,y_1,z_1) and (x_2,y_2,z_2) respectively where both z_1 and $z_2 > 0$. Locate the image charges and hence find V(x,y,z) for points above the plane. 4

(ii) A hollow spherical shell carries charge density $\rho = k/r^2$ for $a \le r \le b$. Find $\overline{E}$ in the regions $r < a$ & $a < r < b$ 4

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