(3 hrs) Total Marks: 100

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. Attempt any two:---

(a) Derive an expression for the Gauss Law in differential and integral forms. Suppose the electric field is given by $\bar{E} = kr^3\hat{r}$. Find the charge density ρ and the total charge contained in a sphere of radius R centred at the origin. **10**

(b) Find the electrostatic field in free space due to a cylindrical charge distribution at a point within the charge distribution i) when the charge density 'ρ' is uniform and ii) when the charge density varies as $\rho = ks$, where 'k' is a constant and 's' is the distance from the axis. **10**

(c) Consider a charge 'q' placed at a distance 'd' above an infinite earthed and conducting plane. Find the electrostatic potential near the plane. Also, find the surface charge density induced on the plane and show that the total induced charge is $-q$. **10**

2 Attempt any two:---

(a) A dipole $\bar{p}$ is placed in an uniform electric field $\bar{E}$, show that the net torque acting on the dipole is $\bar{N} = \bar{p} \, X \, \bar{E}$. Derive an expression for the net torque acting on the dipole placed in a non-uniform electric field $\bar{E}$. **10**

(b) Derive an expression for the electrostatic energy stored in a linear homogeneous isotropic dielectric material. **10**

(c) Using Ampere's circuital law, derive an expression for the circumferential, radial and axial component of the magnetic field inside and outside a long current carrying solenoid. Also derive an expression for the magnetic vector potential of an infinite current carrying solenoid. **10**

3. Attempt any two:---

(a) Explain the term magnetization and obtain the expression for vector potential due to magnetized object in terms of bound currents. **10**

(b) Why was it necessary to modify Ampere's law in its original form? Explain how Maxwell modified it. Write Maxwell's corrected equation in integral form. **10**

(c) Determine the boundary conditions for the fields $\vec{E}$, $\vec{B}$, $\vec{D}$ and $\vec{H}$ across the boundary between the two media. **10**

4. Attempt any two:---

(a) Derive Poynting's work energy theorem in electrodynamics. Define Poynting vector **S**. Obtain continuity equation for **S**. **10**

(b) Write Maxwell's equations in vacuum and in medium with no free charge and free current densities. Obtain the wave equations of electromagnetic waves in vacuum and in medium. Show that electromagnetic waves travels with less speed in medium than in vacuum. Derive formula for refractive index of medium. **10**

(c) A plane monochromatic electromagnetic wave is obliquely incident on the boundary separating two dielectric media at an angle of incidence θ_i. Write the expressions for complex electric and magnetic fields vectors for incident, reflected and transmitted wave. Show that the incident, reflected and transmitted the wave vectors form a plane of incidence. Derive the law of reflection and law of refraction. **10**

5. Attempt any **Four:---**

(i) An infinite plane carries a uniform surface charge 'σ'. Find the electric field due to it. **05**

(ii) State and prove First Uniqueness Theorem. **05**

(iii) Calculate the polarization of Helium at STP in an external electric field of 6000 V/m, given that its atomic polarizability is 2.278×10^{-41} C^2m/N. Avagadro's number is 6.023×10^{26} /k-mole. Volume of one kilo mole of a gas at STP is 22.4 m^3 **05**

(iv) A long solenoid consists of 5000 turns per meter of its length. What must be the steady current flowing through the windings of the solenoid to produce a magnetic field of 5×10^{-3} wb/m^2? Given $\mu_o = 4\pi \times 10^{-7}$ N/A^2 **05**

(v) Show that the divergence of volume bound current density $\vec{J}_b$ is zero. **05**

(vi) A long copper rod of radius R carries a uniformly distributed free current I. Find $\vec{H}$ inside and outside the rod. **05**

(vii) Light passing through air is normally incident on a glass. Calculate reflection coefficient R and transmission coefficient T. Given: $n_{air} = 1$, $n_{glass} = 1.5$. **05**

(viii) The average value of intensity of sunlight reaching the earth's surface is 1300 W/m^2. Assuming sunlight reaching the earth's surface to be plane and monochromatic, calculate the amplitude of electric and magnetic field vectors associated with it. Given: $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N.m^2$; $c = 3 \times 10^8$ m/s. **05**

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