Time: 3 Hours **Marks: 100**

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

Q1 Attempt any **two:---**

(i) Obtain the expression for the divergence and curl of electrostatic field in free space. **10**

(ii) Find the potential of a uniformly charged spherical shell of radius **R** for points outside the sphere. **10**

(iii) Explain First and second uniqueness theorem. **10**

(iv) Suppose a point charge **q** is held a distance **d** above an infinite grounded conducting plane. Find the potential in the region above the plane. **10**

Q2 Attempt any **two:---**

(i) For a linear, homogeneous, isotropic dielectric system, obtain expressions for energy stored and electrostatic energy density. **10**

(ii) For a polarized dielectric show that potential could be given as that due to bound surface charge density and bound volume charge density. **10**

(iii) 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. Also find the expression for magnetic field inside and outside the solenoid. **10**

(iv) Using Biot-Savart law show that $\vec{\nabla} \cdot \vec{B} = 0$. Also explain the physical significance of the result obtained. **10**

Q3 Attempt any **two:---**

(i) Show that magnetization of material give rise to surface and volume bound current densities $K_b = M \times \hat{n}$ and $J_b = \nabla \times M$ **10**

(ii) Give the physical interpretation of bound currents. **10**

(iii) 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**

(iv) Determine the boundary conditions for the fields **E, B, D** and **H** across boundary between two media **10**

Q4 Attempt any **two:---**

(i) Consider a wave travelling along z – axis in a medium with refractive index n_1. If it is incident on the medium with refractive index n_2 normally, calculate the reflection and transmission coefficients. **10**

(ii) State and derive Poynting's theorem. **10**

(iii) Derive expressions for time average of energy density $< u >$, Poynting vector $< \bar{S} >$ and momentum density $< \mathcal{P} >$ for plane electromagnetic wave travelling along z – axis. **10**

(iv) Consider a wave travelling in a medium with refractive index $\boldsymbol{n_1}$. If it is to be incident on the medium with refractive index $\boldsymbol{n_2}$ obliquely, show that $\boldsymbol{\theta_I = \theta_R}$ where $\boldsymbol{\theta_I}$ is an angle of incidence and $\boldsymbol{\theta_R}$ is the angle of reflection. **10**

Q5 Attempt any **four:---** **20**

(i) Find the charge density (ρ) of a sphere centered at the origin, if the electric field is found to be $\overline{\boldsymbol{E}} = \boldsymbol{kr^3\hat{r}}$,where $\boldsymbol{k}$ is some constant. **05**

(ii) Determine electric field due to potential $\mathbf{V= 2x^2 + 5y^3 + 6z^4}$. **05**

(iii) A uniform electric field **2 V/m** exists in a linear homogeneous dielectric of constant **3**. What is the energy density stored in the field? $\boldsymbol{\epsilon_0 = 8.85 \times 10^{-12}\ \frac{C^2}{Nm^2}}$. **05**

(iv) A vector field is given by $\vec{\boldsymbol{B}} = \boldsymbol{2yz\,\hat{x} + 4zx\,\hat{y} + 6\,xy\,\hat{z}}$ Find the current density in the field at point **(3, 4, -5)** $\boldsymbol{\mu_0 = 4\pi \times 10^{-7}}$ $SI\ units$. **05**

(v) Show that the divergence of volume bound current density $\overrightarrow{\boldsymbol{J_b}}$ is zero **05**

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

(vii) Derive the wave equation for the electric field in vacuum. **05**

(viii) Show using Maxwell's equations, **05**

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \bar{J} = 0$$

Symbols have their usual meanings.

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