T.Y. Phy
Electrodynamics
(Rev) (3)

($2\frac{1}{2}$ 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) Obtain an expressions for the divergence and curl of the electrostatic field **E** in free space. **10**
   (ii) A grounded conducting plane of infinite extent is kept coinciding with x-y plane. A point charge q is placed at distances d above the plane along z-axis, using method of images, obtain the expression for the potential of the configuration and induced surface charge on the plane. **10**

   (b) Attempt any **one:---**
   (i) An infinite plane carries a uniform surface charge density σ on both sides of the surface. Find the electric field in free space at a point close to surface. **5**
   (ii) Write down Poisson's equation and obtain Laplace's equation from it. Discuss the properties of the solution of Laplace's equation in two dimension. **5**

2. (a) Attempt any **one:---**
   (i) Obtain the expression for potential due to polarized object in terms of bound charge densities. **10**
   (ii) Obtain an expression for energy stored in dielectric system. **10**

   (b) Attempt any **one:---**
   (i) Using Biot-Savart's law show that $\nabla . \boldsymbol{B} = 0$ **5**
   (ii) Obtain the expression $\nabla . \boldsymbol{D} = \rho_f$ for dielectrics. **5**

3. (a) Attempt any **one:---**
   (i) What is magnetization? Show that magnetization of material gives rise to surface and volume bound currents with current densities $\mathbf{K_b} = \mathbf{M} \times \hat{\mathbf{n}}$ and $\mathbf{J_b} = \nabla \times \mathbf{M}$ **10**
   (ii) Derive the set of Maxwell's equations in matter in differential and integral form. **10**

   (b) Attempt any **one:---**
   (i) Show that Maxwell's equations strongly support for the existence of magnetic charge. **5**
   (ii) A long copper rod of radius R carries a uniformly distributed free current I. Find **H** inside and outside the rod. Calculate **B** outside the rod. **5**

37357C23A926A0EA397F573075B4EBA9

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

(i) Obtain work energy theorem in electrodynamics (Poynting theorem). What is Poynting vector **S?** Write continuity equation for S. **10**

(ii) Derive electromagnetic wave equation in vacuum and in material. Show that electromagnetic waves travels with less speed in material than in vacuum. Obtain formula for refractive index of material. **10**

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

(i) For plane monochromatic electromagnetic waves obtain the expression for average value of energy density <u>, and Poynting vector <**S**>. **5**

(ii) Show that electromagnetic waves are transverse in nature and real amplitudes, E_0 and B_0 are related by the equation $B_0 = E_0 / C$. **5**

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

(i) The electric field in some region is found to be $\vec{E} = kr^3\hat{r}$ (k is constant). Find the charge density. **4**

(ii) Find the electrostatic potential in vacuum due to an infinite charged plane with charge density σ, at a point at distance d from the surface. **4**

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

(i) Find the magnitude of magnetic field due to an infinite straight conductor at a point 2.5 m away, when current of 2.0 A is flowing through it ($\mu_0 = 4\pi \times 10^{-7}$ N/A^2). **4**

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

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

(i) Show that for volume bound current density J_b; $\nabla \cdot J_b = 0$ **4**

(ii) The magnetic susceptibility of platinum is 2.8×10^{-4}. Find the permeability of platinum. Given: $\mu_0 = 4\pi \times 10^{-7}$ **4**

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

(i) Calculate the speed C of light in free space. The permittivity and permeability of free space respectively given by, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 / Nm^2 and $\mu_0 = 4\pi \times 10^{-7}$ N / A^2 **3**

(ii) A plane monochromatic electromagnetic waves passes from air ($n_1 = 1$) into glass ($n_2 = 1.5$) at normal incidence. Calculate coefficient of reflection R and coefficient of transmission T. **3**

37357C23A926A0EA397F573075B4EBA9