Exam. Code : 209003
Subject Code : 4882

M.Sc. Physics 3[rd] Semester (Batch 2020-22)

ELECTRODYNAMICS—II

Paper—PHY-502

Time Allowed—3 Hours] [Maximum Marks—100

Note :—Attempt **FIVE** questions in all, selecting at least **ONE** question from each section. The **fifth** question may be attempted from any section. All questions carry equal marks.

SECTION—A

1. (a) What are TE and TM modes ? Why TEM modes cannot exist inside a hollow waveguide ? 4

   (b) Discuss the propagation of TE modes in a rectangular waveguide. The direction of propagation may be assumed z-axis and the dimensions of the waveguide to be a, b along x and y-axis respectively. 16

2. Starting from Maxwell's equations and boundary conditions for a perfectly conducting hollow waveguide, develop uncoupled wave equations for z- component of electric and magnetic field. "z" is the direction of propagation. 20

SECTION—B

3\. (a) What do you understand by covariance and manifest covariance ? 6

(b) Represent Maxwell's equations in the language of special theory of relativity. 14

4\. A parallel plate capacitor has surface charge densities $\pm\sigma_0$ respectively on its plates. Obtain transformation relation for electric and magnetic field components between two frames of reference moving at a speed "v" with respect to each other. 20

SECTION—C

5\. Verify whether potential

$$V(r,\theta,t)=\frac{p_0\cos\theta}{4\pi\epsilon_0 r}\left(-\frac{\omega}{c}\sin\left[\omega\left(t-\frac{r}{c}\right)\right]+\frac{1}{r}\cos\left[\omega\left(t-\frac{r}{c}\right)\right]\right)$$

and $\vec{A}(r,\theta,t)=-\frac{\mu_0 p_0\omega}{4\pi r}\sin\left[\omega\left(t-\frac{r}{c}\right)\right]\hat{z}$ satisfy

$\nabla.\vec{A}=-\mu_0\epsilon_0\frac{\partial V}{\partial t}$ (the Lorentz Gauge equation). The del operator may be taken as

$$\nabla.\vec{f}=\frac{1}{r^2}\frac{\partial}{\partial r}(r^2 f_r)+\frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\, f_\theta)+\frac{1}{r\sin\theta}\frac{\partial}{\partial\varphi}(f_\varphi).$$

20

6\. Consider an electric dipole oriented along z-axis, oscillating at frequency "ω". Derive expressions for (a) radiated electric field, (b) radiated magnetic field and (c) Poynting vector. Also determine the total power radiated. Use suitable approximations. 20

SECTION—D

7\. If $V(\vec{r},t)=\frac{qc}{4\pi\epsilon_0(\mathscr{r}c-\vec{\mathscr{r}}.\vec{v})}$ and $\vec{A}(\vec{r},t)=\frac{\vec{v}}{c^2}V(\vec{r},t)$.

Determine $\vec{E}(\vec{r},t)$ and $\vec{B}(\vec{r},t)$. Here $\vec{r}$ and $\vec{\mathscr{r}}$ represents the vector connecting origin and observation point and source point and observation point, respectively. 20

8\. (a) The Bohr radius of an electron travelling around hydrogen atom is 5×10^{-11} m. As per classical electrodynamics, this electron should radiate and hence spiral into the nucleus. Using Larmor formula, show that the electron velocity v is <<c (the speed of light) for most part of the trip. 5

(b) Calculate the life span of the Bohr atom in continuation of part (a). 10

(c) What are Lienard Wiechert potentials and why are they useful ? 5