Exam. Code : 209003
Subject Code : 3764

M.Sc. Physics 3rd Semester
ELECTRODYNAMICS—II
Paper : PHY-502

Time Allowed—3 Hours] [Maximum Marks—100

Note :— Attempt **ALL** the questions from Section-A and attempt **ONE** question each from the Sections B, C, D and E.

SECTION—A

1. (a) What do you mean by "Transverse Magnetic" modes in a waveguide ? 2

   (b) Differentiate between a cavity and a waveguide. 2

   (c) What are the postulates of special relativity ? 2

   (d) What do you understand by proper and improper time ? 2

   (e) What do you mean by "Poynting vector" ? Explain. 2

   (f) In case of electric dipole radiation, if just the input current is doubled, by how much amount the radiated power will increase. 2

   (g) Draw the polar intensity diagrams for (a) $l = 2$, $m = 0$ and (b) $l = 2$, $m = \pm 2$. 2

(h) What is the difference between Coulomb and Lorentz gauge ? 2

(i) What do you mean by the "Q" of a cavity ? 2

(j) A particle with a proper life time of 4 μs, moves through a laboratory frame at a speed of 0.96 c. Calculate its life as measured by an observer in laboratory. 2

SECTION—B

2. (a) Suppose we have a rectangular waveguide with height 'a' and width 'b'. Assume TM mode is propagating along the z-direction. Obtain an expression for :

(i) Variation of "E_z" as a function of 'x' and 'y', and 8

(ii) Allowed wave vector of the TM waves in terms of relevant parameters. 4

(b) What is the advantage of perturbing the boundary conditions ? Explain. 8

3. (a) Consider a resonant cavity with close faces at "z = 0" and "z = d". If $\psi(x, y) = \psi_0 \cos\left(\frac{m\pi x}{a}\right) \cos\left(\frac{n\pi y}{a}\right)$, determine $\vec{E}_t$ and $\vec{H}_t$ for TM waves using suitable boundary conditions. 12

(b) Consider a rectangular waveguide with dimensions 2.38 cm × 1.11 cm. Find the cut off frequency. What TE modes will propagate in this waveguide, if the driving frequency is 1.70×10^{10} Hz ? 8

SECTION—C

4. (a) Obtain the transformation relations between u_x', u_y', u_z' and u_x, u_y, u_z and other relevant parameters where the primed frame of reference is moving at a speed "v" with respect to the unprimed frame. 10

(b) Find the speed of a particle if its kinetic energy is n-times its rest energy. 10

5. (a) How are Maxwell's equations recast under special relativity ? 8

(b) A straight wire placed along z-axis carries a charge density "λ", travelling along +ve z-direction at a speed "v_0". Construct (a) the field tensor and (b) the dual tensor at a point on x-axis. 12

SECTION—D

6. Derive expressions for radiation field "E" and "B" produced by an oscillating electric dipole oriented along z-axis. 20

7. Show that

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

and $\vec{A}(\vec{r}, t) = -\frac{\mu_0 p_0 \omega}{4\pi r}\sin\left[\omega\left(t-\frac{r}{c}\right)\right]\hat{z}$, satisfy the Lorentz gauge condition. 20

SECTION—E

8. (a) Obtain a mathematical expression for angular distribution of radiation emitted by an accelerated charge particle. 10

   (b) Obtain a mathematical expression for Larmour' formula and give its relativistic generalisation. 10

9. (a) Derive an expression for the power radiated by a point charge and discuss its relativistic generalisation ? 14

   (b) Discuss briefly about relativistic (a) energy and (b) momentum. 6