2023

M.Sc.

Second Semester

CORE – 05

PHYSICS

Course Code: MPHC 2.11

(Electrodynamics)

Total Mark: 70 *Pass Mark: 28*

Time: 3 hours

Answer five questions, taking one from each unit.

UNIT–I

1. (a) Write down the Laplace equation in cylindrical co-ordinates and obtain its solution. 10

   (b) For a vector potential $\vec{A}$, the divergence of $\vec{A}$ is $\vec{\nabla}.\vec{A} = -\frac{\mu_0}{4\pi}.\frac{Q}{r^2}$, where Q is a constant of appropriate dimension. Find the corresponding scalar potential $\phi(r,t)$ that makes $\vec{A}$ and ϕ, Lorentz gauge invariant. 4

2. (a) Write the Maxwell's equations in free space, linear isotropic media and for harmonically varying fields. 5

   (b) A long cylindrical conductor kept along z-axis carries a current density $\vec{J} = J_0 r\hat{k}$, where J_0 is a constant and *r* is the radial distance from the axis of the cylinder. Calculate the magnetic induction $\vec{B}$ inside the conductor at a distance *d* from the axis of the cylinder. 6

   (c) In the region $0 < r < 0.5$ m, in cylindrical co-ordinates, the current density is $\vec{J} = 4.5e^{-2r}\vec{a}_z$ A/m^2 and $\vec{J} = 0$ elsewhere. Use Amperes circuital law to find $\vec{H}$. 3

UNIT–II

3. (a) Derive the propagation of plane electromagnetic waves in an isotropic dielectric medium. 10

(b) Find the reflection coefficient for light at an air to silver interface $\mu_1 = \mu_2 = \mu_0$, $\varepsilon_1 = \varepsilon_0$, $\sigma = 6\times10^7 (\Omega.\text{m})^{-1}$, at optical frequencies $\omega = 4\times10^{15}/s$. 4

4. (a) Derive the reflection and transmission of electromagnetic waves at oblique incidence. 10

(b) Consider two concentric spherical conducting shells centred at the origin. The outer radius of the inner shell is r_a and the inner radius of the outer shell is r_b. The charge density $\rho = 0$ in the origin $r_a < r < r_b$. If $V = 0$ at $r = r_0$ and $V = V_0$ at $r = r_0$, then find V in the region $r_a < r < r_b$. 4

UNIT–III

5. (a) What do you mean by resonant cavity? Discuss it for a cylindrical cavity. Show that the resonant frequency depends on the height of the cylinder and dimension of the cavity. 1+8=9

(b) A rectangular wave guide with inner dimension 6 cm × 6 cm is designed for a single mode operation. Find the frequency range of operation such that the lowest frequency is 5% above the cut-off and the highest frequency is 5% below the cut-off of the next higher mode. 5

6. (a) What is a rectangular waveguide? Discuss TE mode for rectangular wave guide. 1+ 8=9

(b) A rectangular waveguide has dimensions 2.5 cm and 5 cm. Determine guide wavelength λ_g, phase velocity and phase constant at a wavelength of 4.5 cm for dominant mode. 5

UNIT–IV

7. (a) What is Lienard-Weichert potentials? Obtain the acceleration fields or radiation fields for a relativistic moving point charge in space trajectory. 1+13=14

8. (a) Write a short note on radiation reaction. 7

(b) Discuss the radiative reaction force for Abraham-Lorentz formula. 7

UNIT–V

9. (a) Two Lorentz transformations with relative velocities u_1 and u_2 are carried out one after another. Prove that these two transformations are equivalent to a single Lorentz transformation for which the relative velocity is $u = \dfrac{u_1 + u_2}{1 + (u_1 u_2 / c^2)}$. Hence show that it is impossible to combine a sequence of Lorentz transformation into one having a relative velocity greater than c. 7

   (b) Establish the equation of continuity and express it in covariant form. 7

10. (a) What is an electromagnetic field tensor? Express the EM field tensor in matrix form and show that it is anti-symmetric. 1+8=9

    (b) Show that the square of a four wave vector K_μ is zero. 5
