2022

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) Discuss the potential formulation in electrodynamics. Show that the four Maxwell's equations reduce to two inhomogeneous wave equations in terms of the vector and scalar potentials. 6

   (b) What is gauge invariance? Derive the four-dimensional poison's equation by using the concept of Coulomb's and Lorentz gauges and show that the D'Alembertian plays the same role in four dimension as Laplacian plays in classical mechanics. 1+7=8

2. (a) A current flowing in long solenoid with a radius (r) is varied so that the magnetic field is increased with $B = \alpha t^2$, such that α signifies a constant. Calculate the displacement current density at some arbitrary distance (x) from the axis of the solenoid. 3

   (b) A parallel plate capacitor with circular plates of radius (a) is charged. Compute the electromagnetic energy flux through the lateral surface of the capacitor after neglecting the fringing effect. 6

   (c) Prove the Green's reciprocity theorem. 5

UNIT–II

3. (a) Calculate the reflection and transmission coefficient at normal incidence for an electromagnetic wave propagating between two nonconducting media and show that the electromagnetic wave obeys the law of conservation of energy during its propagation. 7

(b) Derive the Fresnel's equation of reflection and refraction of electromagnetic waves at a plane boundary separating two media when the incident wave is polarized parallel to the plane of incidence and show that there is an angle of incidence for which there is no reflective wave. 7

4. (a) The electric field of an electromagnetic wave propagating through free space is represented as

$E(r,t) = E_0 \cos\left(100\sqrt{3}\pi x - 100y - \omega t\right)\hat{z}$. Calculate the propagating vector along z–axis and compute the value of ω 3

(b) An electromagnetic source incident on the surface of the earth has an intensity of 1300 watt/m^2. Calculate the magnitude of the magnetic field vector of the source at normal incidence. 4

(c) Discuss the propagation of electromagnetic wave in conductors and show how the Maxwell's equations are modified in a homogenous isotropic conducting media. 7

UNIT–III

5. (a) What is wave guide? Describe the propagation of transverse electromagnetic wave in a rectangular wave guide and determine its wave number, and wave velocity. 1+6=7

(b) Describe the modes of the guide for an electromagnetic wave in a rectangular wave guide and establish the waves of mode that can propagate in the guide. Determine the cut off frequency. 5+2=7

6. (a) How many TE and TM modes can the wave guide transmit, if the wave guide is filled with a medium characterized by $\varepsilon = 4\varepsilon_0$, $\sigma = 0$ and with a relative permeability of unity for a rectangular waveguide with dimensions $a = 2.5$ cm. $b = 1$ cm operating below 15.1 GHz. Calculate the cut off frequencies of the modes. 7

(b) What must be the width of a rectangular guide such that the energy of electromagnetic radiation, whose free space wavelength is 3 cm. travels down the guide at 95% of the speed of light? 7

UNIT–IV

7. (a) Discuss retardation in terms of retarded potential. 4
   (b) Develop the concept of Green's function and obtain the retarded potential solution of inhomogeneous wave equation. 5+5=10

8. What do you mean by retarded potential? Derive an expression for Lienard–Wiechert retarded potential and show that it is velocity dependent. 4+10=14

UNIT–V

9. (a) Derive the Lorentz transformation of space and time in four vector form. 7
   (b) Obtain the Lorentz transformation of the components of charge and current densities and show that they form a four vector. 7

10. (a) Establish the components of electric and magnetic field vectors in terms of electromagnetic field tensor. 6
    (b) Write a short note on time like, space like and light like interval and explain them with the help of a Null cone. 8
