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# MPH–007

## M. SC. (PHYSICS) (MSCPH)

## Term-End Examination

## June, 2024

### MPH-007 : CLASSICAL ELECTRODYNAMICS

*Time : 2 Hours* *Maximum Marks : 50*

***Note :*** *Attempt any **five** questions. Marks for each question are indicated against it. Symbol have their usual meanings. You can use a calculator.*

1. Write Gauss' laws for electric field and magnetic field, Faraday's law and Ampere's law is differential form. Discuss the asymmetry in the mathematical expressions for these laws which prompted Maxwell to introduce modification in Ampere's law. Obtain generalised Ampere's law. 2+4+4

**P. T. O.**

2. (a) Show that for a plane polarised, plane electromagnetic wave travelling in the positive $x$-direction, we can write the electric field in $y$-direction as : 4

$$\vec{E} = (x, t) = E_y \left( t - \frac{x}{c} \right) \hat{y}$$

(b) For the plane polarised, plane electromagnetic wave described by : 2+4

$$\vec{E}(x, t) = E_0 \sin(\omega t - kx + \delta)\, \hat{y}$$

$$\vec{B}(x, t) = B_0 \sin(\omega t - kx + \delta)\, \hat{z}$$

Calculate :

(i) Electromagnetic energy density; and

(ii) Poynting vector.

3. (a) State Lorentz's force law for the motion of a charged particle in electromagnetic field. Using this law, show that in a uniform static magnetic field, a charged particle having velocity perpendicular to the magnetic field moves along a circular path. 2+3

(b) A primitive model of an atom consists of a negative charge $-q$ distributed uniformly in a sphere of radius R and a positive point charge $q$ placed at its centre. If the proton is at a distance $x$ ($x < R$) from the centre of the spherical cloud of negative charge, calculate the electrostatic force on it due to the negative charge. 5

4. Write Maxwell's equations in a dielectric material medium. Show that for an isotopic, dielectric homogeneous dielectric placed in a charge free and current free region : 3+3+4

$$\vec{\nabla}.\vec{E} = 0 \text{ and } \vec{\nabla} \times \vec{B} = \mu\varepsilon\frac{\partial \vec{E}}{\partial t}$$

Hence, deduce the electromagnetic wave equation for electric field in a dielectric.

5. Show that for normal incidence of a plane polarised electromagnetic wave at the boundary of two different dielectric media, the amplitude of the electric field associated with the reflected and transmitted waves are given by : 10

$$E_{or} = \frac{n_1 - n_2}{n_1 + n_2} E_{oi}$$

$$E_{ot} = \frac{2n_1}{n_1 + n_2} E_{oi}$$

6. Show that Maxwell's equations imply the existence of vector potential and scalar potential. Obtain inhomogeneous wave equations for the scalar and vector potentials. 10

7. (a) (i) What are the advantages of writing Maxwell's equations in terms of scalar potential and vector potential ? 3

   (ii) What do you understand by retarded time and retarded potentials ? 2

   (b) State and explain Einstein's postulates of special theory of relativity. What is relativity of simultaneity ? 2+3

8. Show that the wave equation for a scalar function $\phi(\vec{r}, t)$ : 10

$$\nabla^2\phi(\vec{r}, t) - \frac{1}{c^2}\frac{\partial^2\phi(\vec{r}, t)}{\partial t^2} = 0$$

retains its form under a Lorentz transformation.