No. of Printed Pages : 5 **MPH–007**

MASTER OF SCIENCE IN PHYSICS

(MSCPH)

Term-End Examination

June, 2026

MPH-007 : CLASSICAL ELECTRODYNAMICS

Time : 2 Hours *Maximum Marks : 50*

Note : *(i) Answer any* ***five*** *questions.*

(ii) Marks for each question are indicated against it.

(iii) Symbols have their usual meaning.

(iv) You can use calculator.

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1. (a) What are electromagnetic potentials ? Discuss their non-uniqueness and hence explain the significance of gauge transformation. 2+3

   (b) Given scalar potential $\phi_0 = \frac{a}{x}$ and vector potential :

$$\vec{A}_0 = \frac{at}{x^2}\,\hat{x} + A_0 \sin(kx - wt)\,\hat{y}$$

   compute the gauge trans-formation for which the transformed potentials will satisfy the Coulomb's gauge conditions. 5

2. Write down Maxwell's equations in a good conductor and hence, find electromagnetic wave equations. Explain skin depth of a conductor. 8+2

3. Derive the Fresnel's equations for reflection and transmission of plane electromagnetic waves at an interface between two dielectric media when an electric field of the incident wave lies in the plane of incidence. 10

4. (a) What are retarded time and retarded potentials ? Explain. 5

(b) Calculate the radiation resistance of the wire joining the two ends of the dipole. Show that $R = 790\left(\frac{a}{\lambda}\right)^2 \Omega$ where λ is the wave-length of the radiation. 5

5. (a) Show that if a surface is described by $\psi(x, y, z)$ = constant, then $\vec{\nabla}\psi(x, y, z)$ is normal to the surface at the point (x, y, z). 5

(b) Show that if $\vec{\nabla}\,\psi(x, y, z) = \vec{k}$ (a constant vector) for all points on a surface, then the surface is described by $\psi(x, y, z) = \vec{k}\,.\,\vec{r} =$ constant. Explain why this surface is a plane. 5

6. (a) Evaluate the first relativistic correction to the Non-Relativistic (NR) kinetic energy. 5

(b) At what speed does the correction become 1% of the Non-Relativistic (NR) term ? 5

7. (a) An electron is released from rest and falls under the force of gravity. In the first centimeter, what fraction of the potential energy lost is radiated away ? 5

(b) Suppose an electron is decelerated at a constant rate and its velocity reduces from V_0 to zero. What fraction of kinetic energy is lost to retardation ? 5

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

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

retains its form under a Lorentz transformation. 10

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