No. of Printed Pages : 4 **MPH–007**

MASTER OF SCIENCE (PHYSICS)

(MSCPH)

Term-End Examination

December, 2025

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 meanings.

(iv) You can use a calculator.

1. State and establish Poynting theorem for electromagnetic fields. Compare it with the equation of continuity and give an interpretation of Poynting vector. 2+6+2

2. Show that Maxwell's equations can be written as two coupled second order differential equations in terms of scalar potential ϕ and vector potential $\vec{A}$. What are Coulomb gauge and Lorentz gauge conditions ? 8 + 2

3. If $\vec{E} = \vec{E}_0 e^{i(\omega t - ky + \delta)}$ and $\vec{B} = \vec{B}_0 e^{i(\omega t - ky + \delta)}$, then show that : 5 + 5

   (a) $\vec{\nabla} \times \vec{E} = -ik(\hat{y} \times \vec{E}_0) e^{i(\omega t - ky + \delta)}$.

   (b) $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ implies $\vec{B}_0 = \frac{k}{\omega}(\hat{y} \times \vec{E}_0)$

   $= \frac{1}{c}(\hat{y} \times \vec{E}_0)$

4. (a) At time $t = 0$, a charge q is at rest at the origin in a region of uniform static electric field $\vec{E} = E_0 \hat{x}$. Without assuming that $v < c$, derive expressions for the velocity and position of the charge at time t. 6

(b) Given $\vec{B} = B\hat{z}$, write down the x-component and y-component of the equation $m\frac{d\vec{V}}{dt} = q\vec{V} \times \vec{B}$. 4

5. Write Maxwell's equations in a linear, homogeneous and isotropic dielectric material. By using the equations, find wave equations in a charge free and current free region. 2+8

6. Obtain boundary conditions for electric field at the interface of two linear, homogeneous and isotropic dielectrics by considering there is no free charge or current densities at the interface. 10

7. In which context are Lienard-Wiechert (L-W) potential used in electrodynamics ? Determine the Leinard-Wiechert scalar potentials (ϕ) for a point charge moving with constant velocity $\vec{V}$. 2+8

8. Write down metric tensor in the form $\eta_{\mu\nu}$ in Minkowski space. Show that if A^{μ} (or A) is a timelike vector and B^{μ} (or B) is a nonzero vector orthogonal to A^{μ}, then B^{μ} is necessarily spacelike. 4+6

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