No. of Printed Pages : 5 **MPH–007**

M. SC. (PHYSICS) (MSCPH)

Term-End Examination

June, 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 meaning.

(iv) You can use calculator.

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1. Write Maxwell's equations in differential and integral forms. How are these equations

modified in vacuum (charge and current free region) ? Explain the reasons which prompted Maxwell to modify Ampere's law. Explain the concept of displacement current. 2+2+3+3

2. Derive expressions for electric and magnetic fields in terms of scalar and vector potentials, using the homogeneous Maxwell's equations. Show that the potentials associated with a given magnetic field are not unique. Express the inhomogeneous Maxwell's equations in terms of scalar and vector potentials. 4+3+3

3. (a) A particle of mass m and charge q having position $\vec{r}_0$ and velocity $\vec{v}_0$ at $t = 0$ is in an electric field $\vec{E}(t) = \vec{E}_0 \sin \omega t$. Determine its position at time t. 5

(b) Using Fresnel's equation :

$$E_{or} = \frac{\alpha - \beta}{\alpha + \beta} E_{oi}$$

where $\alpha = \frac{\cos\theta_t}{\cos\theta_i}$ and $\beta = \frac{\mu_1 n_2}{\mu_2 n_1}$, derive Brewster's law. 5

4. Derive the expression for AC dielectric susceptibility for a dielectric made of non-polar atoms/molecules. 10

5. What is Lorentz oscillator model of dielectric ? Using this model, write the equation of motion of electron in a dielectric in the presence of an electromagnetic wave explaining all terms. Also, obtain an expression for the dipole moment of the electrons in the dielectric. 2+2+6

6. Obtain expressions for scalar and vector potentials due to an oscillating electric dipole at a point far away from it. 10

7. (a) The retarded scalar and vector potentials are given by :

$$\phi\left(\vec{r},t\right)=\frac{1}{4\pi\in_0}\int\frac{1}{\left|\vec{r}-\vec{r'}\right|}e\left(\vec{r'}\right)d\mathrm{V}'$$

$$\vec{\mathrm{A}}\left(\vec{r},t\right)=\frac{\mu_0}{4\pi}\int\frac{1}{\left|\vec{r}-\vec{r'}\right|}\vec{j}\left(\vec{r'}\right)d\mathrm{V}'$$

Calculate the retarded electric field. 5

(b) A particle of mass M decays at rest into two particles of masses m_1 and m_2. Calculate the energies of the two decay products in terms of the masses, m_1, m_2, and M. 5

8. What is Minkowski space ? Express Lorentz transformations in matrix form. Consider two reference frames S and S′, with the coordinate axes aligned and the origins coinciding at $t = t' = 0$. Frame S′ moves with uniform velocity v along the positive z-direction. Write down Lorentz transformations for this case. Also write it in matrix form. 2+3+3+2

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