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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.

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

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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 :

$$\phi\left(\vec{r}, t\right)=\frac{1}{4 \pi \epsilon_0} \int \frac{1}{\left|\vec{r}-\vec{r}'\right|} e\left(\vec{r}'\right) d V'$$

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

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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