Roll No. .....

(05/25)

15412

M. Sc. EXAMINATION

(For Batch 2021 & Onwards)

(Second Semester)

PHYSICS

MSc/Phy/2/CC7

Classical Electrodynamics

Time : Three Hours *Maximum Marks : 70*

Note : Attempt *Five* questions in all, selecting *one* question from each Unit. Q. No. **1** is compulsory.

1. (i) Prove that the curl of an electrostatic field is always zero.

   (ii) Derive the relation between electric displacement vector $\vec{D}$. Electric field $\vec{E}$ and Polarization $\vec{P}$.

(iii) Write the statements of first and second uniqueness theorem.

(iv) Using Maxwell's equations prove that an electromagnetic wave travels with the speed of light in free space.

(v) What is Poynting theorem ? How does it prove the conservation of energy ?

$2 \times 5 = 10$

Unit I

2. Prove that electric potential can be written as the negative gradient of electric potential Write the expressions of electric potential for a continuous charge distribution. Find the electric potential of a uniformly charged spherical shell of radius R. 15

3. Derive the expression for the magnetic vector potential of a magnetized object in terms of surface bound current density and volume bound

current density. Find the magnetic field produced by a uniformly magnetized sphere of radius R. Derive the expression for Ampere's law in magnetized materials. 15

Unit II

4. Derive the expression for the electric potential of a polarized object in terms of surface bound charge density and volume bound charge density. Find the electric field produced by a uniformly polarized sphere of radius R. Derive the expression for Gauss's law in the presence of dielectrics. 15

5. A point charge q is situated a distance a from the centre of grounded conducting sphere of radius R. Find the potential outside the sphere. Derive the expression for the charge induced on the sphere. What is the force between the point charge and the sphere ? 15

Unit III

6. Derive an expression for the displacement current. What is the significance of the displacement current ? Write Maxwell's equations in terms of electric and magnetic potentials. 15

7. Show that the skin depth in a good conductor ($\sigma >> \omega\varepsilon$) is $\lambda / 2\pi$ (where λ is the wavelength in the conductor). Find the skin depth (in nanometres) for a typical metal ($\sigma = 10^7$ $(\Omega m)^{-1}$) in the visible range ($\omega = 10^{15}/s$) assuming $\varepsilon = \varepsilon_0$ and $\mu = \mu_0$. Why are metals opaque ? Show that in a good conductor the magnetic field lags the electric field by 45° and find the ratio of their amplitudes. 15

Unit IV

8. Derive the expressions (using suitable approximations) for the electric potential, magnetic potential, electric field and magnetic

field, intensity and the total power radiated by an oscillating magnetic dipole. Prove that for configurations with comparable dimensions, the power radiated electrically is enormously greater than the magnetic power. 15

9. Derive the Fresnel's equations for an electromagnetic wave at an oblique incidence with polarization in the plane of incidence at the interface between two media. Discuss the concept of "Brewster's angle". Find the expressions of reflection and transmission coefficients. 15

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