

Exam. Code : 209002

Subject Code : 4808

M.Sc. Physics 2<sup>nd</sup> Semester (Batch 2021-23)

**ELECTRODYNAMICS—I**

**Paper—Phy-452**

Time Allowed—3 Hours] [Maximum Marks—100

**Note** :—Attempt FIVE questions in all, selecting at least ONE question from each section. The fifth question may be attempted from any section. All questions carry equal marks.

**SECTION—A**

- (a) Consider a volume charge distribution such that " $\rho = kr$ ". Determine the electric field inside and outside the sphere. 12

(b) What is the utility of Gauss's law in electrostatics ? Determine an expression for Gauss's using the formula of electric field of a point charge 'q'. Also obtain its microscopic form. 8
- (a) Use multipole expansion to determine the potential at large distances due to an arbitrary localised charge distribution. 12

(b) Determine an expression for energy stored in a dielectric media. 8

## SECTION—B

3. (a) Use Biot-Savart's law to determine the magnetic field on the axis of an infinite straight wire carrying current "I". 10
- (b) Use the above result to find the force per unit length between two wires carrying current " $I_1$ " and " $I_2$ ", separated by a distance "d". 4
- (c) Consider a very long cylinder carrying current such that the current density at any distance "s" from the centre is given by " $J = ks$ ". Determine the total current flowing in the cylinder. 6
4. (a) Write SI units of  $\vec{B}$ ,  $\vec{H}$ ,  $\vec{M}$ ,  $\mu$ . 4
- (b) A phonograph record of radius "R", carrying a uniform surface charge density " $\sigma$ " is set rotating at constant angular velocity " $\omega$ ". Determine its magnetic moment. 6
- (c) Introduce the idea of magnetic vector potential " $\vec{A}$ ". How can " $\vec{A}$ " be made divergence less? Exploit the parallel between Poisson's equation and the corresponding equation of magnetostatics to write " $\vec{A}$ " for linear, surface and volume current distributions. 10

### SECTION—C

5. Starting from Maxwell's equations, obtain the two coupled equations involving "V" and " $\vec{A}$ " for position and time dependent charge ( $\rho(\vec{r}, t)$ ) and current ( $\vec{J}(\vec{r}, t)$ ) configurations. Hence discuss Coulomb and Lorentz gauge. 20
6. (a) Obtain an expression for continuity equation in electrodynamics. Discuss its significance. 6
- (b) Obtain an expression for Poynting's theorem in electrodynamics. 14

### SECTION—D

7. Consider a plane electromagnetic wave incident normally on the surface of a dielectric. Determine "R" and "T". Is  $R + T = 1$  ? 20
8. Write Maxwell's equations inside a good conductor. Considering that direction of propagation of electromagnetic waves to be along "z" direction, determine  $\vec{E}(z, t)$  and  $\vec{B}(z, t)$ . 20