JADAVPUR UNIVERSITY

MASTER OF SCIENCE EXAMINATION, 2017.

(1st Year, 1st Semester)

Subject: PHYSICS

Paper: ELECTRODYNAMICS - I

PHY / TG / 105

(Ref. No. *EX/M.SC./P/I/105/17/2017*)

Time: Two Hours

Full Marks: 40

Answer any TWO questions

1. (a) A conducting sphere of radius R carries a charge Q on its surface. A point charge q is placed at a distance $d > R$, from its centre.

   i. Calculate the force f the charge q feels.

   ii. Plot $\frac{f}{q^2}$ against $\frac{d}{R}$ to show that even if Q and q are of same sign, they attract each other in a region close to the surface of the sphere.

   (b) A point charge Q is placed at a distance r from the centre of two grounded concentric metallic spheres of radii R_1 and R_2 such that $R_1 < r < R_2$. Find the charges induced on the spheres.

   Marks: (10 + 4) + 6 = 20

2. (a) Two semi-infinite dielectric media of permitivities ϵ_1 and ϵ_2 are separated by the xy-plane, the former occupying the region $z > 0$. A point charge q is placed at $z = h > 0$. Find the potential everywhere and draw the electric field lines for $\epsilon_1 > \epsilon_2$ and $\epsilon_1 < \epsilon_2$ separately, with "one-line" explanations for each case.

   (b) A solid ellipsoid of revolution with the lengths of the three semi-axes given by (a, a, c) is charged uniformly with volume charge density ρ. Find the quadrupole moment with respect to the centre of the ellipsoid.

   Marks: 12 + 8 = 20

3. (a) Find the boundary conditions obeyed by a magnetic field $\vec{B}$, the vector potential $\vec{A}$, and the spatial derivative of $\vec{A}$ across a surface through which flows a current of surface density $\vec{K}$.

   (b) A circular ring of radius r_0 is given a charge Q uniformly distributed along its circumference. Find the magnetic scalar potential at a distance d from the centre of the loop, along the axis, if the loop is rotated about its axis with an angular velocity ω.

   (c) Find out general expressions for the magnetic scalar potential at an arbitrary off-axis point (r, θ) for the regions $r < r_0$ and $r > r_0$ separately and show that the scalar potential is not continuous at $r = r_0$.

   (d) Why is it not continuous at $r = r_0$?

   Marks: 6 + 4 + 8 + 2 = 20