JADAVPUR UNIVERSITY
MASTER OF SCIENCE EXAMINATION, 2018.
(1st Year,-1st Semester)

Subject: PHYSICS
Paper: ELECTRODYNAMICS - I
PHY / TG / 105
(Ref. No. *EX/M.SC./P/I/105/17/2018*)

Time: Two Hours
Full Marks: 40

Answer any TWO questions

1. (a) One hemisphere of a hollow metallic sphere of radius R is maintained at a constant potential V_0 while the other hemisphere is maintained at zero potential, there being an insulation along the equator. Find the potential inside and outside the sphere.

   [Given $(2n+1)\int_0^1 P_n(x)dx = P_{n-1}(0) - P_{n+1}(0)$]

   (b) A dielectric sphere of radius R and of permittivity ϵ_1 is placed in a medium of permittivity ϵ_2, through which passes an electric field $\vec{E} = E\hat{z}$. Show that (by putting appropriate limiting values of ϵ_1 and ϵ_2 in the expressions for potential and intensity) if the sphere is metallic and the outside medium is vacuum, then the electric field lines are perpendicular to the surface of the sphere.

   Marks: 10 + 10 = 20

2. (a) Half of the space sandwiched between two concentric metallic spheres of radii R_1 and R_2 (with $R_1 < R_2$) is filled with a dielectric of permitivity ϵ_1 and the rest half-space is filled with a dielectric of permitivity ϵ_2. A charge $+q$ is smeared on the inner sphere and a charge $-q$ is smeared on the outer sphere.

   i. Find the surface bound charge densities on the inner and outer spheres.

   ii. Infer in *two different ways* that the volume bound charge density in the space occupied by the dielectrics is zero.

   (b) A surface charge of density $\sigma = \sigma_0(\sin\theta + \cos\theta)$ is smeared on the surface of a non-conducting hollow sphere of radius R. Find the potential at $r > R$, upto the quadrupole term, and express all the terms in the form $\frac{P_n(\cos\theta)}{r^{n+1}}$. [Hint: You may save time by resorting to the principle of superposition.]

   Marks: (6 + 4) + 10 = 20

3. (a) Along the z-axis charges q, $-2q$ and q are placed at $z = a$, the origin and $z = -a$ respectively. Find the quadrupole potential in two different ways:

   i. By calculating the quadrupole tensor first and then evaluating the potential.

   ii. By directly evaluating the potential in terms of derivatives of the monopole potential.

   (b) A uniform surface charge density σ is given on a spherical shell of radius R and thshell is being rotated about one of its diameter at an angular velocity ω.

   i. Find the vector potential inside and outside the sphere.

   ii. Verify that the boundary discontinuities are obeyed.

   Marks: (6 + 4) + (8 + 2) = 20