Birla Institute of Technology and Science, Pilani, Rajasthan
First Semester 2015-16
MID-SEMESTER EXAMINATION (Closed Book)
Course Title: Electromagnetic Theory I, Dated: 10/10/2015

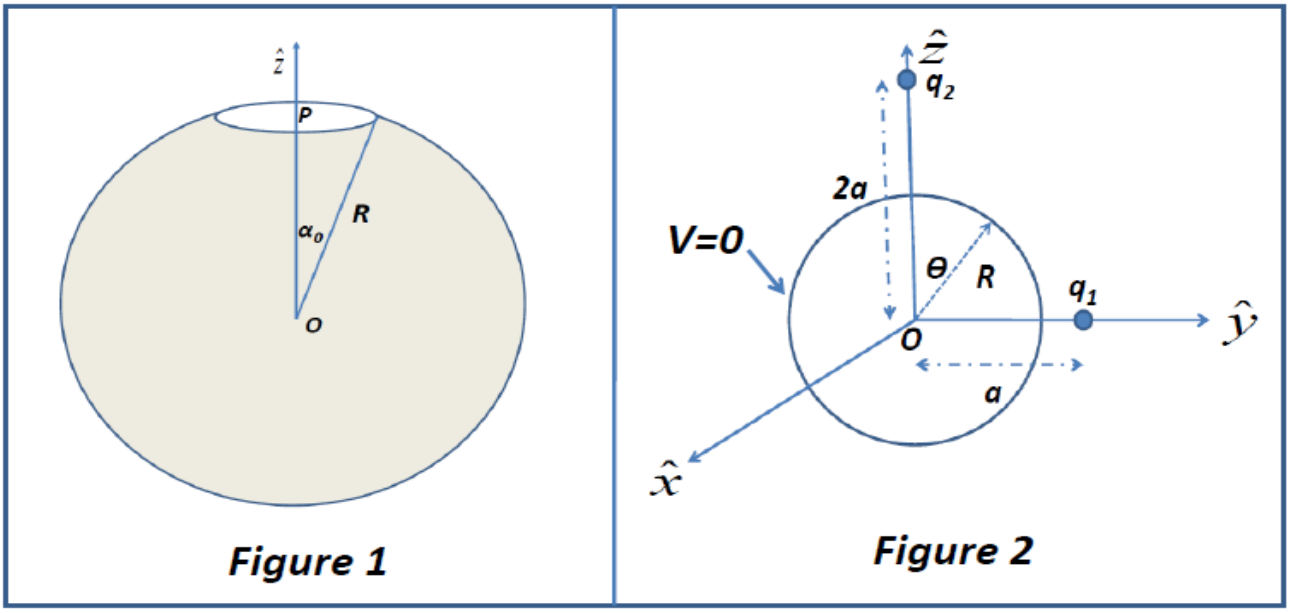
Course No. PHY F212 Maximum Marks: 90 Maximum Time: 90 Mins

1. A thin spherical shell radius of *R* (see Figure 1) with a small circular hole of radius *b* at its North Pole carries a uniform surface charge density σ. Calculate the expression for the electric field a point *P* which is on the z-axis at a distance *R* away from the origin of the sphere. (α_0 is the polar angle between the z-axis and the circumference of the circular hole) [10]

2. Two point charges q_1 and q_2 are place at a distance *a* and *2a* from the origin of a grounded conducting sphere of radius R as shown in the Figure 2.

(a) Calculate the induced surface charge density as a function of Θ.

(b) What is the total charge induced on the surface of the sphere. [10+5]



3. Consider three concentric spherical shells of radii *a*, *b*, and *c*, with charges Q_a, Q_b, and Q_c uniformly distributed on them. (a) Calculate the energy of this configuration. (b) Calculate the expression for the potential at the origin of the spherical shell. [8+7]

4. (a) Let Θ(x) be the step function:

Θ(x) = 1, if x>0,
Θ(x) = 0, if x≤0.

Show that $\frac{d\theta}{dx} = \delta(x)$

(b) Evaluate the integral, $J = \int_v e^{-r}\left(\nabla \bullet \frac{\hat{r}}{r^2}\right) d\tau$, where V is a sphere of radius R, centered at the origin. [5+5]

5. (a) Obtain the expression for the interaction energy U between two pure dipoles $\mathbf{p_1}$ and $\mathbf{p_2}$ if they are separated by a displacement **r**.

(b) Using the expression obtained for the interaction energy, calculate the interaction energy for the two dipole configuration shown in Figure 3.

(c) Obtain the expression for the torque on $\mathbf{p_1}$ due to $\mathbf{p_2}$ **(**about $\mathbf{p_1}$**)** and the torque on $\mathbf{p_2}$ due to $\mathbf{p_1}$ (about $\mathbf{p_2}$). [5+5+5]

6. A spherical conductor of radius *a*, carries a charge 'Q' as shown in Figure 4. It is surrounded by linear dielectric material of susceptibility χ_e , out to radius b.

(a) Find the energy of this configuration.

(b) Find the electrostatic energy of the free charges.

(c) Find the electrostatic energy of the bound charges. [5+5+5]

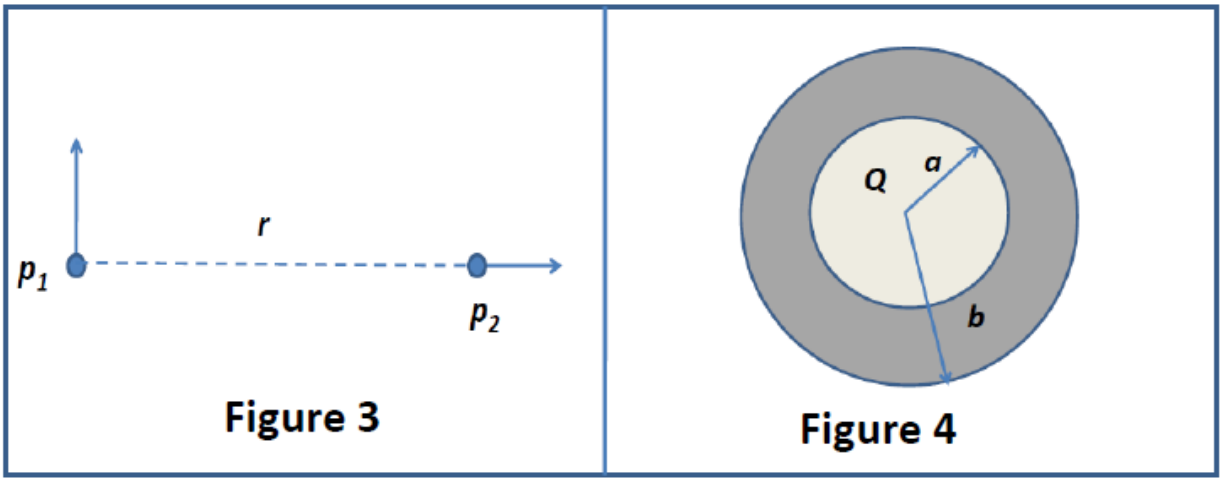


Figure 3

Figure 4

7. A sphere of linear dielectric material has embedded in it a uniform free charge density ρ. Find the potential at the center of the sphere (relative to infinity), if its radius is *R* and its dielectric constant is ε_r. [10]

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