Department of Physics, Shiv Nadar Institution of Eminence

Spring 2025

PHY102: Introduction to Physics-II

Tutorial – 5

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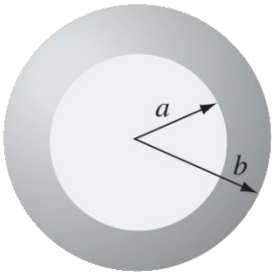
1. Suppose the electric field in some region is found to be $\mathbf{E} = \mathrm{kr}^3\hat{\mathbf{r}}$ in spherical coordinates (k is some constant).
   a) Find the charge density ρ.
   b) Find the total charge contained in a sphere of radius R, centered at the origin.

2. A thick spherical shell carries charge density

$$\rho = \frac{k}{r^2}\ ;\ (a \le r \le b)$$

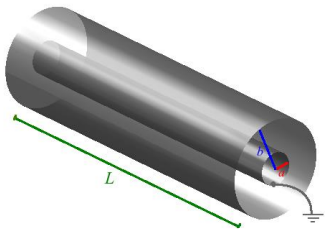


a) Find the electric field in the three regions:
(i) r < a, (ii) a < r < b, (iii) r > b.

b) Plot |**E**| as a function of ***r***, for the case ***b = 2a***

3. The volume charge density of a solid sphere of radius R varies as $\rho = \rho_0\left(\frac{r}{R}\right)$, where ρ_0 is a constant (of appropriate unit) and r is the radial distance measured from the center of the sphere. Find out the electric field at a distance $'s'$ from the center of the sphere using the ***Gauss's law***. Consider both $0 \le s \le R$ and $s \ge R$ cases.

4. (a) Consider two conducting coaxial cylindrical shells of radii a and b, (a < b), as shown in figure below. The length of both cylinders is L which much larger than (b-a), the separation between the cylinders, so that edge effects can be neglected. The inner cylinder is grounded (electric potential = 0), while the outer cylinder is supplied a charge -Q which gets distributed uniformly on the surface (Again, we are neglecting edge effects). As a consequence a charge +Q (drawn from the ground) gets induced uniformly on the inner cylinder. Calculate the electric field as well as the electric potential in the regions (i) 0 ≤r < a, (ii) a < r < b, and (iii) r ≥ b. Here r is the radial (perpendicular) distance measured from the common axis of the cylinders.



[For the regions (i) and (iii) assume, in addition, that L >>a, b. Moreover, for region (iii) the observation point should be close to the outer cylinder | it should not be at a distance comparable to- or larger than the system dimension, i.e., $r - b << L$.]

(b) Verify the discontinuity of electric field and continuity of the electric potential at the surfaces of the two cylindrical shells in the above problem.

(c) What is the capacitance of the coaxial cylinder system? Does the answer depend on Q?