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Problems set # 3 **Physics 167** February 14, 2023

1. A point charge q is located at the center of a uniform ring having linear charge density λ and radius a, as shown in Fig. 1. Determine the total electric flux through a sphere centered at the point charge and having radius R, where $R < a$.

2. An insulating solid sphere of radius a has a uniform volume charge density and carries a total positive charge Q. A spherical gaussian surface of radius r, which shares a common center with the insulating sphere, is inflated starting from $r = 0$. *(i)* Find an expression for the electric flux passing through the surface of the gaussian sphere as a function of r for $r < a$. *(ii)* Find an expression for the electric flux for $r > a$. *(iii)* Plot the flux versus r. [Part *(iii)* is optional. You have to figure out how the flux behaves at small and large radii.]

3. A solid insulating sphere of radius a carries a net positive charge $3Q$, uniformly distributed throughout its volume. Concentric with this sphere is a conducting spherical shell with inner radius b and outer radius c, and having a net charge $-Q$, as shown in Fig. 2. *(i)* Construct a spherical gaussian surface of radius $r > c$ and find the net charge enclosed by this surface. *(ii)* What is the direction of the electric field at $r > c$? *(iii)* Find the electric field at $r \geq c$. *(iv)* Find the electric field in the region with radius r where $b < r < c$ *(v)* Construct a spherical gaussian surface of radius r, where $b < r < c$, and find the net charge enclosed by this surface. *(vi)* Construct a spherical gaussian surface of radius r, where $a < r < b$, and find the net charge enclosed by this surface. *(vii)* Find the electric field in the region $a < r < b$. *(viii)* Construct a spherical gaussian surface of radius $r < a$, and find an expression for the net charge enclosed by this surface, as a function of r. Note that the charge inside this surface is less than $3Q$. *(ix)* Find the electric field in the region $r < a$. *(x)* Determine the charge on the inner surface of the conducting shell. *(xi)* Determine the charge on the outer surface of the conducting shell. *(xii)* Make a plot of the magnitude of the electric field versus r.

4. Consider a long cylindrical charge distribution of radius R with a uniform charge density ρ. *(i)* Find the electric field at distance r from the axis where $r < R$.

5. Two infinite, nonconducting sheets of charge are parallel to each other, as shown in Fig. 3. The sheet on the left has a uniform surface charge density σ, and the one on the right has a uniform charge density $-\sigma$. Calculate the electric field at points *(i)* to the left of, *(ii)* in between, and *(iii)* to the right of the two sheets. *(iv)* Repeat the calculations when both sheets have positive uniform surface charge densities of value σ.

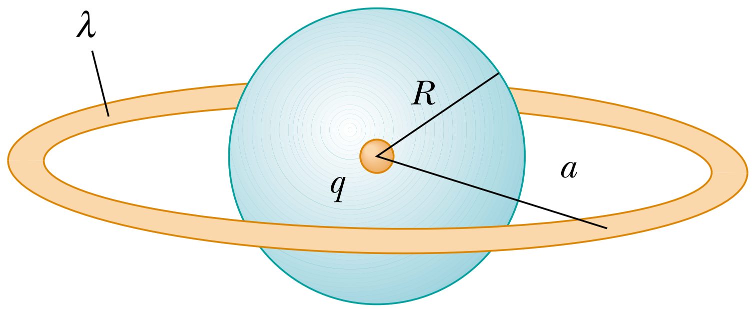

Figure 1: Problem 1.

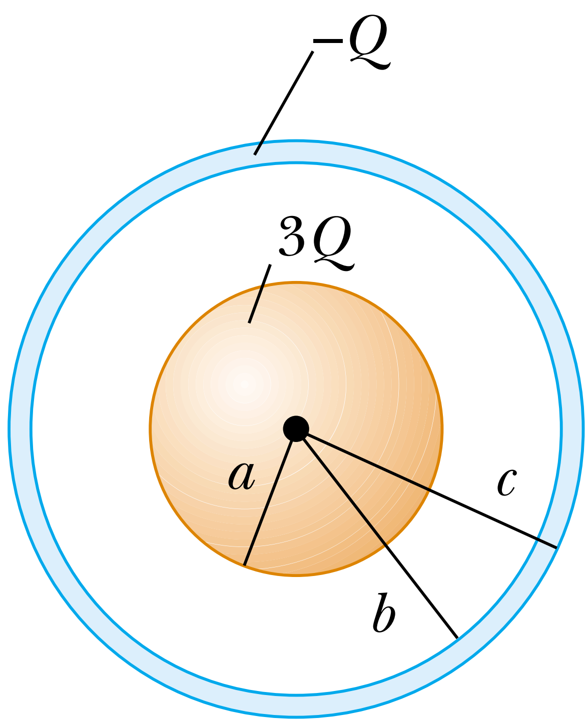

Figure 2: Problem 3.

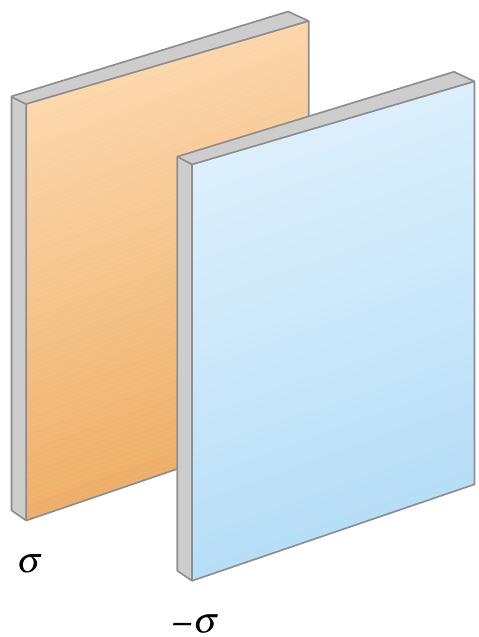

Figure 3: Problem 5.