# Discussion 6 - Gauss' Law

**Problem 1.** A very long, solid cylinder with radius $R$ has positive charge uniformly distibuted throughout it, with charge per unit volume $\rho$.

a. Derive the expression for the electric field inside the volume at a distance $r$ from the axis of the cylinder in terms of the charge density $\rho$.

b. What is the electric field at a point outside the volume in terms of the charge per unit length $\lambda$ in the cylinder?

c. Compare the answers to parts (a) and (b) for $r = R$.

d. Graph the electric-field magnitude as a fuction of $r$ from $r = 0$ to $r = 3R$.

**Problem 2.** An insulating sphere with radius $a$ has a uniform charge density $\rho$. The sphere is not centered at the origin but at $\vec{r} = \vec{b}$. Show that the electric field inside the sphere is given by $\vec{E} = \rho(\vec{r} - \vec{b})/3\epsilon_0$.

**Problem 3.** An insulating sphere of radius $R$ has a spherical hole of radius $a$ located within its volume and centered a distance $b$ from the center of the sphere, where $a < b < R$. (A cross section of the sphere is shown in Figure 1.) The solid part of the sphere has a uniform volume charge density $\rho$. Find the magnitude and direction of the electric field $\vec{E}$ inside the hole, and show that $\vec{E}$ is uniform over the entire hole. Use the principle of superposition and the result of Problem 2.

**Problem 4.** A small conducting spherical shell with inner radius $a$ and outer radius $b$ is concentric with a larger conducting spherical shell with inner radius $c$ and outer radius $d$ as shown in the figure. The inner shell has total charge $+2q$, and the outer shell has charge $+4q$.

a. Calculate the electric field $\vec{E}$ (magnitude and direction) in terms of $q$ and the distance $r$ from the common center of the two shells for every region. Graph the radial component of $\vec{E}$ as a function of $r$.

b. What is the total charge on the inner surface of the small shell, the outer surface of the small shell, the inner surface of the large shell, and the outer surface of the large shell?

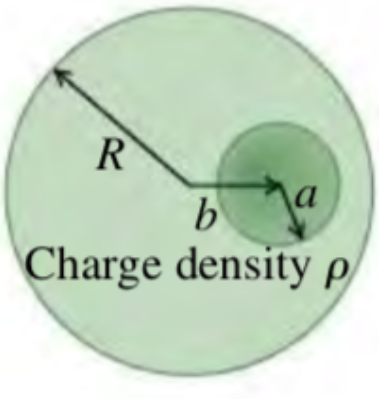


Figure 1: Problem 3

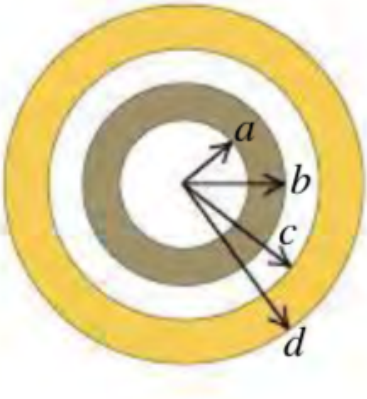


Figure 2: Problem 4