Discussion 5 - Electric Fields

Problem 1. A thin disk with a circular hole at its center, called an *annulus*, has inner radius R_1 and outer radius R_2 as shown in the figure. The disk has a uniform positive surface charge density σ on its surface.

a. Determine the total electric charge on the annulus

b. The annulus lies in the yz-plane, with its center at the origion. For an arbitrary point on the x-axis (the axis of the annulus), find the magnitude and direction of the electric field $\vec{E}$. Consider points both above and below the annulus.

c. Show that at points on the x-axis that are sufficiently close to the origin, the magnitude of the electric field is approximately proportional to the distance between the center of the annulus and the point. How close is "sufficiently close"?

d. A point particle with mass m and negative charge -q is free to move along the x-axis (but cannot move off the axis). The particle is originally placed at rest at $x = 0.01R_1$ and released. Find the angular frequency of oscillation of the particle.

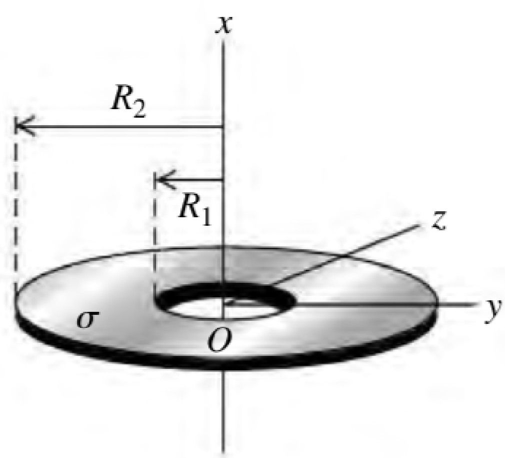

Figure 1: Problem 1

Problem 2. A hemispherical surface with radius r in a region of uniform electric field $\vec{E}$ has its axis aligned parallel to the direction of the field. Calculate the flux through the surface.

Problem 3. An electric dipole with dipole moment $\vec{p}$ is in a uniform external electric field $\vec{E}$. The dipole consists of two particles of equal mass m a distance d form one another.

a. Find the orientations of the dipole for which the torque on the dipole is zero.

b. Which of the orientations in part (a) is stable, and which is unstable?

c. Find the frequency of oscillations for the dipole rotating (small angles) about the stable equilibrium in the electric field. Assume the electric field is constant.