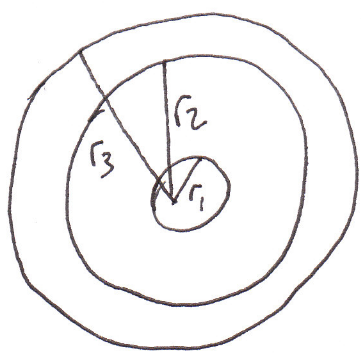
PHY 122 HW 2

1. For a spherical surface centered around a point charge, the formula for electric flux $\phi_E = \oint \mathbf{E} \cdot \mathbf{dA}$ simplifies to $\phi_E = EA$. Why? If our spherical surface is surrounding an electric dipole rather than a point charge, this simplification does not work. Why?

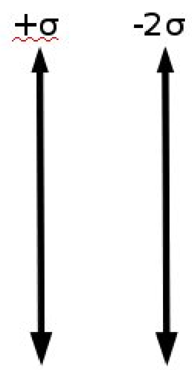
2. In the diagram below, the region $0 < r < r_1$ is a charged insulating sphere with uniform charge density ρ_E, the region $r_1 < r < r_2$ contains free space, and the region $r_2 < r < r_3$ is an insulating spherical shell with uniform charge density $-\rho_E$.



   What is the electric field in the regions:

   (a) $0 < r < r_1$
   (b) $r_1 < r < r_2$
   (c) $r_2 < r < r_3$
   (d) $r_3 < r$
   (e) For which regions does the electric field have the same r dependence as the field due to a point charge?

3. Two oppositely charged infinite planes with surface charge density σ and -2σ respectively are held apart a small distance d as shown below:



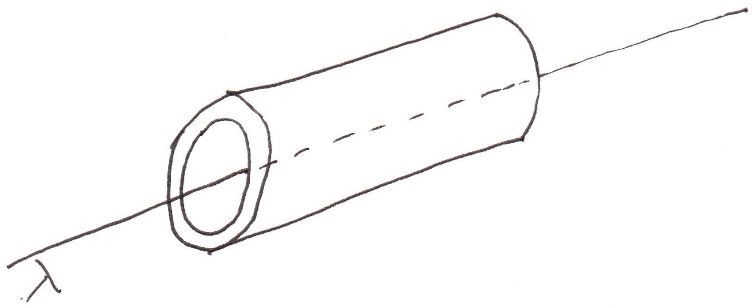
   (a) Will the $\vec{E}$ from the two plates partially cancel in the center or constructively add together?

(b) What is the magnitude and direction of $\vec{E}$ between these plates?

(c) What is $\vec{E}$ at a point just to the right of the negatively charged plate?

(d) What is the force on an electron between the plates? (Use $q = -e$)

4. In the diagram below, a thin wire with linear charge density λ is surrounded by a conducting cylindrical shell.



   (a) If the electric field must be zero inside a conductor, is the electric field due to the wire shielded from extending beyond the conducting shell?

   (b) Find the electric field as a function of distance r from the thin wire.

5. A simple Geiger counter is constructed out of a setup similar to what we just used in problem 4. A thin wire with a linear charge density λ is held in the center of a cylindrical tube, which is filled with an inert gas. When a high speed particle coming from a radioactive decay, cosmic ray, etc. enters the gas-filled tube, collisions with the gas knock electrons off of their atoms. The free electrons then accelerate towards the positively charged wire, and collide with other gas atoms causing them to lose electrons as well. This leads to a cascade of electrons accelerating towards the wire, which will be turned into a measurable current upon reaching the wire. For this problem, the tube has a radius of 1 cm and is 10 cm long; the wire has a radius of 10 μm and $\lambda = 10^{-8} C/\mathrm{m}$.

   (a) What is the force on a free electron located at the outer wall of the tube?

   (b) What is the force on an electron immediately next to the thin wire?

   (c) What is the work done on an electron pulled from the outer wall of the tube to the wire?

   (d) Calculate the electric flux through the walls of the tube perpendicular to the wire (i.e. the walls the wire is attached to).

   (e) Calculate the electric flux through the surface of the tube parallel to the wire. Would this value change if the Geiger counter were box shaped rather than cylindrical?