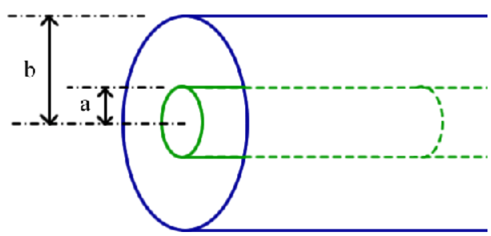
Assignment IV, HONS 158 (Honors Physics II)
Spring 2016
Due 2/3/16 at start of class

As always, please put your answers on separate paper.

1. A spherical ball has radius R and total charge $+Q$. This charge is not, however, uniformly distributed throughout its volume. Instead, it has a charge density that follows the following relationship:

$$\rho(r) = \begin{cases} kr^2 & r \leq R \\ 0 & r > R \end{cases}$$

   a) Find k in terms of R, Q, and fundamental constants.
   b) What are the units of k?
   c) What is the strength of the magnitude of the electric field $\vec{E}$ for some $r > R$? (Leave your answer in terms of r, Q, and fundamental constants).
   d) What is the strength of the magnitude of the electric field $\vec{E}$ for some $r < R$? (Again, leave your answer in terms of r, Q, and fundamental constants. Note, however, that the charge "enclosed" is different for this part than part (c).)
   e) Sketch (by hand) a plot of $E(r)$ as a function of r for this system.



2. Let there be an infinitely long set of concentric cylinders with radii a and b ($a < b$). (See figure above for a sketch of the basic geometry). In the region between the two cylinders (e.g. in the region $a < s < b$) there is a charge density $\rho(s) = ks^2$. (The k for this problem is different than k in the previous problem). For $s < a$ and for $s > b$, the density of charge is zero. (There is only charge between the two cylinders).

   a) Find the total net charge per unit length for this system.
   b) What do the units of k have to be?
   c) Find the magnitude of the resulting electric field as a function of s in the region $0 < s < a$.
   d) Find the magnitude of the resulting electric field as a function of s in the region $a < s < b$.
   e) Find the magnitude of the resulting electric field as a function of s in the region $s > b$.

3. A charge of 24.5 μC is located at 4.40 m$\hat{\imath}$ + 6.22 m$\hat{\jmath}$, and a charge of -11.2 μC is located at -4.50 m$\hat{\imath}$ + 6.75 m$\hat{\jmath}$. What charge must be located at 2.23 m$\hat{\imath}$ $-$ 3.31 m$\hat{\jmath}$ if the electric potential is to be zero at the origin?

4. Why can birds roost on a high voltage wire without getting fried?

5. Four point charges, each of magnitude q, form the vertices of a square, with the distance between adjacent charges given by d. How much energy did it take to construct this charge alignment? You may assume that the five charges already existed some long distance away from each other, and you need to move them into their desired position.

6. A system has a force that has the following form:

$$\vec{F} = (2xy - z^3)\hat{\imath} + x^2\hat{\jmath} - (3xz^2 + 1)\hat{k}$$

   Is this force conservative? Justify your answer. (Don't worry about the units).

7. Let the potential associated with some system take the following form: $V(x, y) = V_\circ e^x \cos(y)$, with $V_\circ$ some constant.

   a) What is $\vec{E}$ for this system?
   b) What is the direction and magnitude of the electric field at $0\hat{\imath} + \pi\hat{\jmath}$?
   c) How much work is done in moving a charge Q from the origin to $3\hat{\imath} - \pi\hat{\jmath}$?