Physics 370  Homework 3  Due Friday, February 10, 2017

Reading: Griffiths pages 59-75.

Problem 1  A line charge distribution extends along the $x$-axis from $x = -2L$ to $x = L$. It has a uniform (constant) charge density per unit length $\lambda$. Find the electric field at points on the positive $z$-axis, as a function of $z$. Check that your answer is the expected one for $z \gg L$. Also interpret your result in the limit $z \ll L$. In each of these two limiting cases, keep the leading non-zero term.

Problem 2  A flat annular disc region of inner radius $a$ and outer radius $b$ lies in the $xy$ plane with its center at the origin. The disc carries a uniform (constant) surface charge density, with total charge $Q$. What is the surface charge density $\sigma$? Find the electric field a distance $z$ above the center. Check that your answer is the expected one for $z \gg R$, uskeeping the leading non-zero term.

Problem 3  A hollow spherical shell carries charge density $\rho = kr$ in the region $a \leq r \leq b$. Use Gauss' Law in integral form to find the electric field in the three regions: (i) $r < a$, (ii) $a < r < b$, (iii) $r > b$. Check your answers by computing $\nabla \cdot \vec{E}$ everywhere. Make a graph of $|\vec{E}|$ as a function of $r$.

Problem 4  Consider two concentric thin spherical shells with radii $R$ and $2R$, carrying charges $-Q$ and $2Q$ respectively. There is also a point charge $Q$ located at $r = 0$ (the center of the spheres). Use Gauss' law to find the electric field everywhere. You must consider separately the three regions $r < R$, $R < r < 2R$, and $r > 2R$.

Problem 5  Suppose that in some region of space the electric field is found to be $\vec{E} = kr\hat{r}$, in cylindrical coordinates. ($k$ is a constant.)
(a) What are the metric system units of $k$?
(b) Find the charge density $\rho$ in the region.
(c) Find the total charge enclosed in a cylinder of radius $R$ and length $L$, centered on the $z$ axis, by using Gauss' Law in integral form applied to the given $\vec{E}$.
(d) Find the total charge enclosed in a cylinder of radius $R$ and length $L$, again. But this time do it by integrating the result you found in part (b).