PHY 122 HW 1

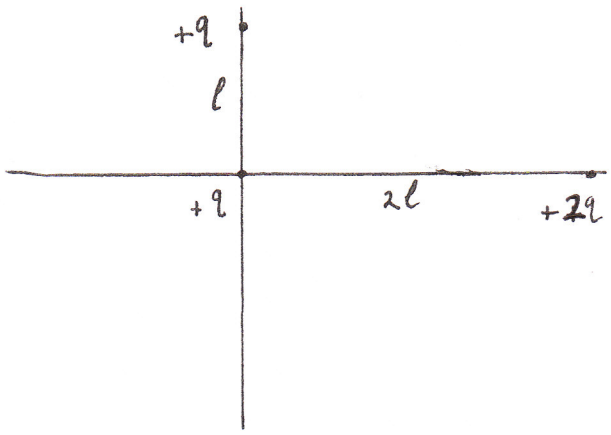
1. We have seen that Coulomb's Law, $F_E = \frac{kQ_1Q_2}{r^2}$ where $k = 9 \times 10^9 \ \frac{N \cdot m^2}{C^2}$, appears to be very similar to Newton's Law of Gravitation, $F_G = \frac{Gm_1m_2}{r^2}$ where $G = 6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}$.

   (a) Approximately how many times larger is k than G?

   (b) Consider 2 electrons which are separated by a distance of 1 nm (10^{-9} m). What is the magnitude of the electrostatic force, F_E, acting on one charge due to the other? What is the magnitude of the gravitational force, F_G? What is the ratio of F_E to F_G?

   (c) With this in mind, provide some thoughts on why we feel a strong pull of gravity from the Earth, but experience no noticeable electrostatic force.

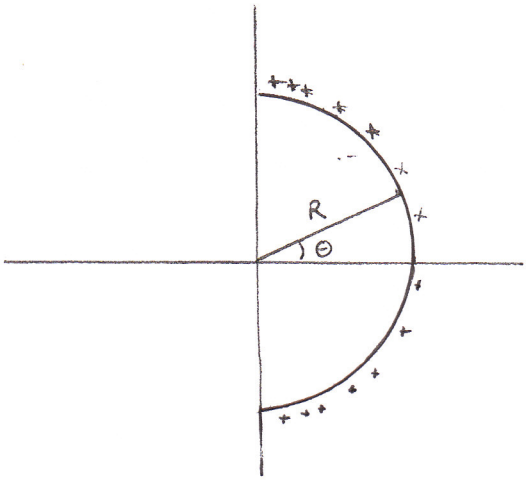
2. Consider the following charge distribution:



   (a) What is the direction of the force on the charge located at the origin?

   (b) What is the magnitude of that force in terms of l and Q?

3. Given that the half ring of charge shown below has a linear charge density $\lambda = \lambda_0 sin^2\theta$, what is the magnitude and direction of the electric field at the origin?



4. Consider a charge $q = 1\ C$ located at the origin of a Cartesian (x,y) coordinate system.
   (a) Calculate the magnitude of the electric field at $y = 1\ m$ and at $y = -1\ m$.
   (b) Consider a spherical shell, centered at the origin, of radius $1\ m$. Is the magnitude of the electric field the same everywhere on the surface of this sphere?
   (c) What is the magnitude from part (b) multiplied by the surface area of the shell? (For a spherical shell, $A = 4\pi r^2$).
   (d) Repeat parts (b) and (c) for a spherical shell, centered at the origin, of radius $2\ m$. Compare to the results for the shell of radius $1\ m$.

5. An electric dipole in the x-y plane is constructed from two opposite charges of magnitude $2\ \mu C$ separated by 10cm. The dipole is placed in the uniform electric field $\vec{E} = 10\frac{N}{C}\hat{x}$. The direction of $\vec{p}$ is given by the unit vector $\frac{1}{\sqrt{2}}(\hat{x} + \hat{y})$.
   (a) Determine the magnitude and direction of the torque on the dipole.
   (b) How much work will you have to do to move the dipole from $45°$ to $180°$?

6. Which force is greater: the force between two $+2\ \mu C$ charges 1 m apart, or the force between two $+4\ \mu C$ charges 2 m apart?

7. What do we mean when we say that the electric field is the force per unit charge?