Module 02 Homework

1. For this question, you will use the PHeT simulations called "Charges and Fields" which can be found at `https://phet.colorado.edu/en/simulation/charges-and-fields`.
   In the box on the right side of the window, check the "Grid" box to display grid lines and *uncheck* the "Electric Field" box. Let the grid define an $x - y$ coordinate system with the positive x direction pointing right and the positive y direction pointing up. Choose a position were two thick grid lines intersect to be the origin of the coordinate system.
   Place a positive charge at the position $(0\,\text{cm}, -50\,\text{cm})$ and a negative charge at the point $(0\,\text{cm}, 50\,\text{cm})$. Make sure to get the charges centered on the grid lines. This is an electric dipole. You can place a "Sensor" at any point on the grid and it will show the electric field vector. Use Sensors to answer the questions below.
   1. What direction does the field point at the origin?
   2. What direction does the field point at the position $(0\,\text{cm}, -100\,\text{cm})$?
   3. What direction does the field point at the position $(100\,\text{cm}, -50\,\text{cm})$?
   4. What direction does the field point at the position $(50\,\text{cm}, 0\,\text{cm})$?
   5. Is the field stronger at the position A = $(50\,\text{cm}, 0\,\text{cm})$ or position B = $(0\,\text{cm}, 100\,\text{cm})$?
   6. Is the field stronger at the position A = $(100\,\text{cm}, 0\,\text{cm})$ or position B = $(100\,\text{cm}, 100\,\text{cm})$?
2. For this question, consider Figure 2. The figure shows two conducting spheres that have exceess charge on them and the electric field lines produced by the charge.
   1. Do the conductors have positive or negative charge on them?
   2. Have the conductors been brought into contact?
   3. Identify the region(s) where the electric field is weak.
   4. Identify the region(s) where the electric field is strong.
3. A thin wire extends from $x = -a$ to $x = b$ on the x axis and has a charge Q uniformly distributed over it.
   1. Assume $b > a$ and $Q > 0$. What direction will the electric field at a position on the $+y$ axis point?
   2. Determine the electric field along the x axis for positions $x > b$.
   3. Determine the acceleration of an electron placed on the x axis at a position $x > b$.

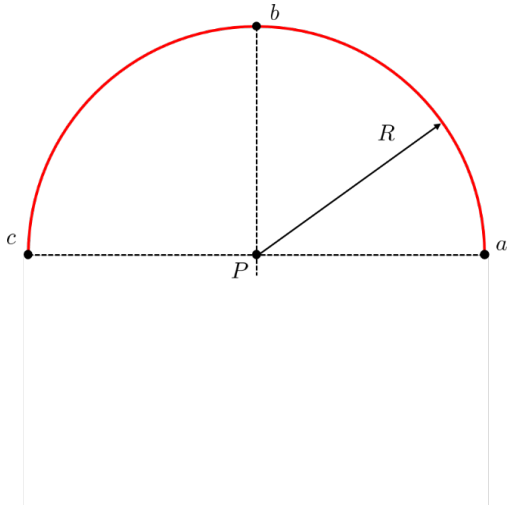

Figure 1:

4. Determine the torque exerted on an electric dipole with length d and charge q centered on the x axis at a position $x > b$, assuming that the dipole is oriented perpendicular to the x axis with the positive charge above the the x axis and the negative charge below it.

4. In Figure 1, a charge of Q is evenly distributed over the line of a semicircle. Determine the direction and magnitude of the net electric field vector at the point P.

5. Consider an electric dipole of charge q that is centered on the origin where the two charges lie on the y axis and are separated by a distance d.

    1. Determine the electric field at positions near the dipole. In other words, determine $\vec{E}(x, y)$.

    2. Determine the acceleration of an electron released from rest at the point $(L, 0)$ near the dipole.

    3. A proton is released from rest at the point $(L, 0)$. Determine the acceleration of the proton at the moment it is released.

6. A line of charge totaling Q is uniformly distributed over the x axis between $x = -b$ and $x = b$.

    1. Determine the electric field at a point on the y axis, $(0, y)$.

    2. Show that at great distances from the line charge ($y >> 2b$), the electric field due to the charge looks like the electric field from a single point charge Q at the center of the line charge.

7. **Example Problem Writeup:** Figure 2 shows two conducting spheres that have excess charge on them and the electric field lines produced by the charge. Assume that the two spheres sit on the x axis with the left sphere centered at the origin. Sketch a graph of the x component of the net electric field along the x axis between the centers of the two spheres.

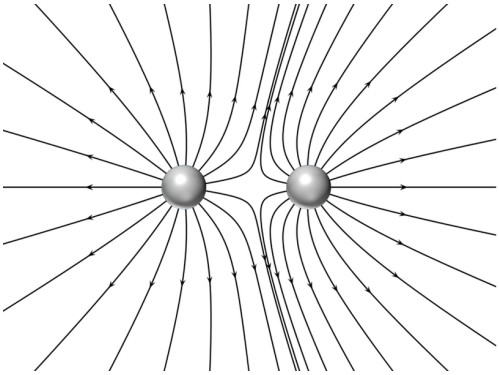

Figure 2: