PHYS 216 – Assignment #1 – Due Sept 23

Chapter 5: Electric Charges and Fields

Problem 1. A line of uniform charge density λ lies along the x-axis as shown.

a. Find the total charge of the distribution.

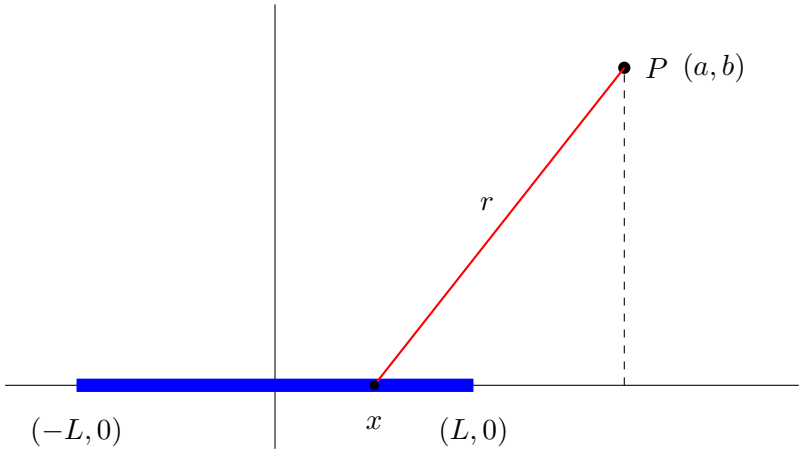
b. Find the electric field at point P by integrating the distribution over x. Show your work.

c. Now consider the special case where P lies directly above the centre of the rod, so that $a = 0$.

i. Simplify your answer from part (b) for this case. What happens to the x-component?

ii. Show that when $b \gg L$ your simplified result reduces to the field of a point charge, and state what that charge is.

iii. Now take the *opposite* limit, $b \ll L$. What does your result become and how does the way the field falls off with b differ from part (ii)?



Problem 2. Point charges $Q_1 = +2.0\,\mu\text{C}$ and $Q_2 = -3.0\,\mu\text{C}$ are located at

$$\vec{r}_1 = (5.0\hat{\imath} + 1.0\hat{\jmath} + 3.0\hat{k})\,\text{m}$$

and

$$\vec{r}_2 = (3.0\hat{\imath} - 2.0\hat{\jmath} - 3.0\hat{k})\,\text{m}.$$

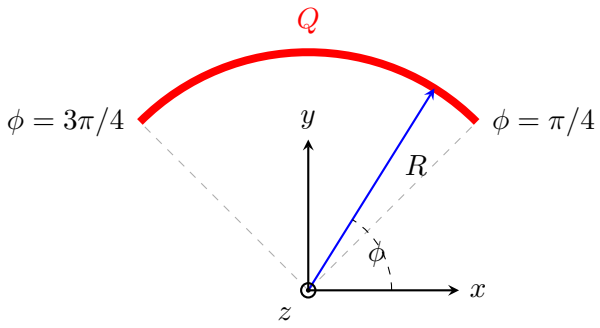
What is the force of Q_2 on Q_1? Give both the magnitude and write a unit vector (using $\hat{\imath}, \hat{\jmath}$ and $\hat{k}$) to express the direction of the force.

Problem 3. An arc of radius R has a total charge Q uniformly distributed along its length. The x-axis points to the right, the y-axis points to the top of the page, and the z-axis points toward you. The arc is centred on $(0, 0, 0)$ and extends from $\phi = \pi/4$ to $\phi = 3\pi/4$.

a. What is the linear charge density λ of the arc?

b. What is the electric field $\mathbf{E}(0, 0, 0)$ at the centre of the arc? Before integrating, state which component(s) of $\mathbf{E}$ must vanish and why.

c. What is the electric field $\mathbf{E}(0, 0, z)$ along the axis of the arc, at a distance z above the page?

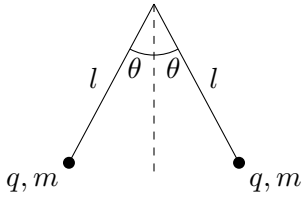


Problem 4. Each of the balls shown below carries a charge q and has a mass m. The length of each thread is l, and at equilibrium the balls are separated by an angle 2θ.

a. Draw a free-body diagram for one of the balls and show that θ satisfies

$$\sin^2\theta \tan\theta = \frac{q^2}{16\pi\epsilon_0 g l^2 m}.$$

b. Find q as a function of the measured angle θ (and m, l).



Problem 5. A proton enters the uniform electric field produced by the two charged plates shown below. The magnitude of the electric field is $4.0 \times 10^5\,\mathrm{N/C}$, and the speed of the proton when it enters is $1.5 \times 10^7\,\mathrm{m/s}$. What distance d has the proton been deflected downward when it leaves the plates?

