Physics 4B
Fall 2022

ave. = 5.9
σ = 2.5

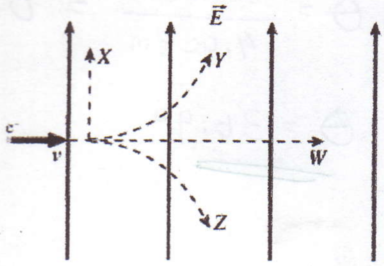
Name: Answer Key

Lab (circle one): 8:00 am 11:15 am 2:30 pm

Quiz #2: Electric Fields

Problem 1 (2 points)
8) An electron is initially moving to the right when it enters a uniform electric field directed upwards. Which trajectory shown below will the electron follow?

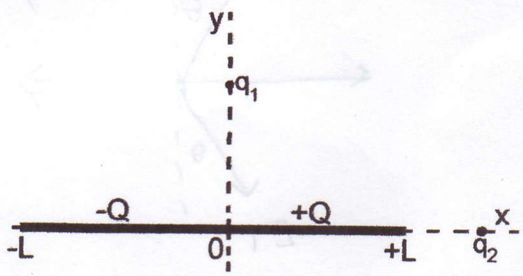
D



a) trajectory *X*
b) trajectory *Y*
c) trajectory *W*
d) trajectory *Z*

from $\vec{F} = q\vec{E}$, the force on a − charge is in the opposite direction as $\vec{E}$

Problem 2 (3 points)
A positive charge +Q is distributed uniformly along the positive x-axis while a negative charge –Q is distributed uniformly along the negative x-axis as shown in the figure below.



The magnitude of the electric field a distance y above the perpendicular bisector of the rod is given by

$$\vec{E} = \frac{\lambda}{2\pi\varepsilon_0}\left(\frac{1}{y} - \frac{1}{(y^2+L^2)^{1/2}}\right)$$

Use the binomial expansion to simplify the above expression for the electric field in the limit that y is much larger than L (y >> L).

$$\frac{1}{(y^2+L^2)^{1/2}} = (y^2+L^2)^{-1/2} = \underbrace{(y^2)^{-1/2}}_{=y^{-1}}(1+L^2/y^2)^{-1/2}$$

$$= (y^{-1})(1+(-\tfrac{1}{2})L^2/y^2) \quad \text{for } y >> L,\ L^2/y^2 << 1$$

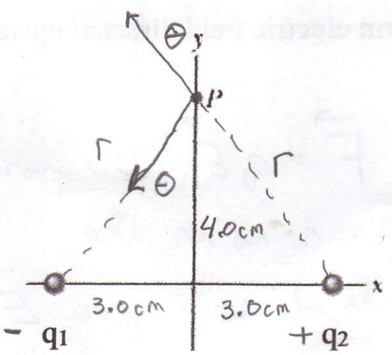
$$(1\pm x)^n \approx 1 + nx \text{ for } x<<1$$

$$\frac{1}{(y^2+L^2)^{1/2}} \approx \left(\frac{1}{y}\right)\left(1 - \frac{L^2}{2y^2}\right)$$

$$E = \frac{\lambda}{2\pi\varepsilon_0}\left(\frac{1}{y} - \frac{1}{(y^2+L^2)^{1/2}}\right) = \frac{\lambda}{2\pi\varepsilon_0}\left[\frac{1}{y} - \frac{1}{y}\left(1 - \frac{L^2}{2y^2}\right)\right]$$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{\lambda L^2}{y^3} \qquad q = \lambda L \longrightarrow \qquad E = \frac{1}{4\pi\varepsilon_0}\frac{qL}{y^3}$$

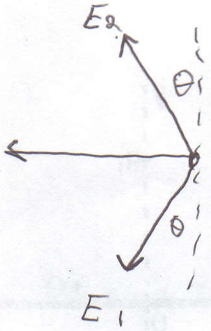
Problem 3 (5 points)
The figure below shows two charged particles on an x-axis: $q_1 = -3.20\ \mu C$ at $x = -3.00$ cm and $q_2 = 3.20\ \mu C$ at $x = +3.00$ cm. What are the magnitude and direction (relative to the +x-axis) of the net electric field produced at point P at y = 4.00 cm?



$r = \sqrt{(3.00\,cm)^2 + (4.00\,cm)^2} = 5.00\,cm$

from diagram: $\tan\theta = \frac{3.00\,cm}{4.00\,cm} = 0.75$

$\theta = 36.9°$



⇒ vertical components cancel

⇒ horizontal components add

↓ opposite side so sin θ

$\vec{E}_{net} = E_1 \sin\theta + E_2 \sin\theta$ in −x direction

$= 2E \sin\theta$ where $E = \frac{1}{4\pi\varepsilon_0}\frac{|q|}{r^2}$

$= 2\left(\frac{1}{4\pi\varepsilon_0}\frac{|q|}{r^2}\right)\sin\theta \quad (-\hat{i})$

$\vec{E}_{net} = 2(8.99\times10^9\ N\,m^2/C^2)\,\frac{(3.2\times10^{-6}\,C)}{(0.050\,m)^2}\sin 36.9° \ (-\hat{i})$

$\vec{E}_{net} = 1.38\times10^7\ N/C\ (-\hat{i})$