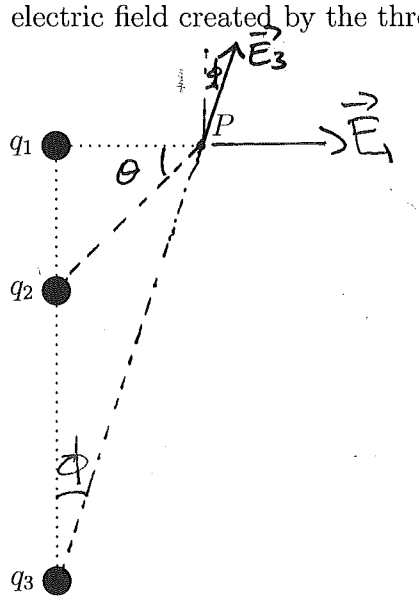
# PHYSICS 161
# TEST 1

Three point charges, $q_1$, $q_2$, and $q_3$ are placed along a straight, vertical line as shown. At the point $P$, which is directly to the right of $q_1$, the net electric field created by the three charges is zero.




$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3$

$q_1$ is positive $\Rightarrow$ $\vec{E}_1$ is $\longrightarrow$ at P

$q_3$ is positive $\Rightarrow$ $\vec{E}_3$ is at $\phi$ $\vec{E}_3$ at P.

(a) If $q_1$ and $q_3$ are both positive charges, is $q_2$ positive or negative? For full points your *explanation* must include a diagram showing the three individual electric fields. *(3pts)*

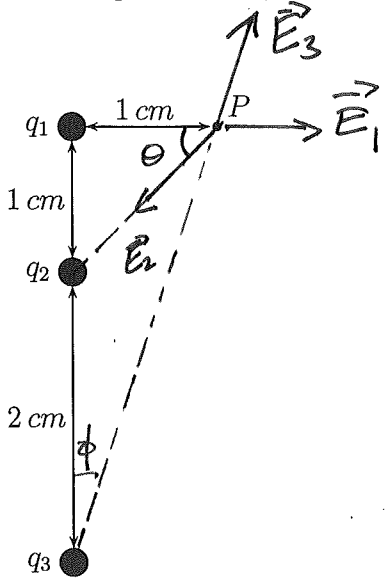
at P, $\vec{E} = 0 \Rightarrow \vec{E}_1 + \vec{E}_2 + \vec{E}_3 = 0 \Rightarrow \vec{E}_2 = -(\vec{E}_1 + \vec{E}_3)$

$(\vec{E}_1 + \vec{E}_3)$ has x-component to right $\Rightarrow$ $\vec{E}_2$ has left x-component

$(\vec{E}_1 + \vec{E}_3)$ has up y-component $\Rightarrow$ $\vec{E}_2$ has Down y-component

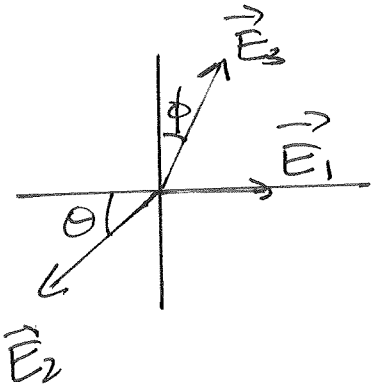
$\therefore$ $\theta$ $\vec{E}_2$ So $\vec{E}_2$ is towards $q_2$ $\Rightarrow$ **$q_2$ Must be Negative**

(b) If $q_1 = 10\,\mu C$ and the distance between the charges are as given in the diagram below, find the values of $q_2$ and $q_3$. *(7pts)*




$\phi = \tan^{-1}\left(\frac{1}{3}\right) = 18.435^\circ$

$\theta = \tan^{-1}\left(\frac{1}{1}\right) = 45^\circ$




$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 = 0$

$E_1 = \frac{kq_1}{r_1^2}$ $\quad r_1 = 1cm = .01m \Rightarrow r_1 = .0001m^2$

$E_2 = \frac{k|q_2|}{r_2^2}$ $\quad r_2 = \sqrt{(.01m)^2 + (.01m)^2} = \sqrt{.0002m^2} \Rightarrow r_2^2 = .0002m^2$

$E_3 = \frac{k|q_3|}{r_3^2}$ $\quad r_3 = \sqrt{(.01m)^2 + (.03m)^2} = \sqrt{.001m^2} \Rightarrow r_3^2 = .001m^2$

$E_{1,y} + E_{2,y} + E_{3,y} = 0 \Rightarrow 0 - E_2 \sin 45^\circ + E_3 \cos 18.435^\circ$

$\therefore E_2 \sin 45^\circ = E_3 \cos 18.435^\circ \Rightarrow \frac{k|q_2|}{r_2^2} \sin 45^\circ = \frac{k|q_3|}{r_3^2} \cos 18.435^\circ$

$$\Rightarrow |q_2| = \frac{r_2^2}{r_3^2}\frac{\cos 18.435^\circ}{\sin 45^\circ} q_3 = \left(\frac{.0002}{.001}\right)\frac{\cos 18.435^\circ}{\sin 45^\circ} q_3 = .2683289\, q_3$$

$$E_{1,x} + E_{2,x} + E_{3,x} = 0 \Rightarrow E_1 - E_2 \cos 45^\circ + E_3 \sin 18.435^\circ = 0$$

$$\Rightarrow -\frac{Kq_3}{r_3^2}\sin 18.435^\circ + \frac{K|q_2|}{r_2^2}\cos 45^\circ = E_1$$

$$\Rightarrow \frac{K|q_2|}{r_2^2}\cos 45^\circ - \frac{Kq_3}{r_3^2}\sin 18.435^\circ = \frac{Kq_1}{r_1^2}$$

$$q_2 = .2683289\, q_3 \Rightarrow q_3\left(\frac{.2683289\cdot\cos 45^\circ}{.0002} - \frac{\sin 18.435^\circ}{.001}\right) = \frac{q_1}{r_1^2}$$

$$\Rightarrow q_3(632.4544) = \frac{10\mu C}{.0001} \Rightarrow \boxed{q_3 = 15.811(10\mu C) = 158.11\mu C}$$

$$q_2 = .2683289\, q_3 = .2683289\,(158.11\mu C) = 42.4264\mu C$$

$$\Rightarrow \boxed{q_2 = 42.4\mu C}$$