Name____

Physics 121 Quiz #1, September 16, 2022

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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1. Two point-charges $q_1 = 3nC$ and $q_2 = unknown$ are placed along the x-axis. Point charge q_1 is placed at a point $(x, y) = (-4,0)$ while point charge q_2 is placed at $(x, y) = (7,0)$, where the distances are measured in centimeters. With the two point-charges in this configuration, the net electric field at the origin $(x, y) = (0,0)$ is known to be zero. What are the magnitude and sign of the point charge q_2 that makes this possible?

   In order for the field to vanish somewhere between the two charges, q_2 has to be *positive*.

$$\vec{E}_{net,P} = \langle 0,0,0\rangle = \vec{E}_{1P} + \vec{E}_{2P} = \frac{kq_1}{r_{1P}^2}\left[\frac{\langle 0,0,0\rangle cm - \langle -4,0,0\rangle cm}{4cm}\right] + \frac{kq_2}{r_{2P}^2}\left[\frac{\langle 0,0,0\rangle cm - \langle 7,0,0\rangle cm}{7cm}\right]$$

$$\vec{E}_{net,P} = \langle 0,0,0\rangle = \frac{kq_1}{r_{1P}^2}\langle 1,0,0\rangle + \frac{kq_2}{r_{2P}^2}\langle -1,0,0\rangle$$

$$0 = \frac{kq_1}{r_{1P}^2} - \frac{kq_2}{r_{2P}^2} \rightarrow q_2 = \left(\frac{r_{2P}}{r_{1P}}\right)^2 q_1 = \left(\frac{7cm}{4cm}\right)^2 \times 3nC = 9.2nC$$

2. Suppose that point-charge q_2 is moved to a point $(x, y) = (2,0)$ along the x-axis, where the distances are still measured in centimeters. What, is the electric field at the origin in this case?

$$\vec{E}_{net} = \vec{E}_1 + \vec{E}_2 = \frac{kq_1}{r_{1P}^2}\left[\frac{\langle 0,0,0\rangle cm - \langle -4,0,0\rangle cm}{4cm}\right] + \frac{kq_2}{r_{2P}^2}\left[\frac{\langle 0,0,0\rangle cm - \langle 2,0,0\rangle cm}{2cm}\right]$$

$$\vec{E}_{net,P} = \frac{kq_1}{r_{1P}^2}\langle 1,0,0\rangle + \frac{kq_2}{r_{2P}^2}\langle -1,0,0\rangle = \langle \frac{kq_1}{r_{1P}^2} - \frac{kq_2}{r_{2P}^2}, 0,0\rangle$$

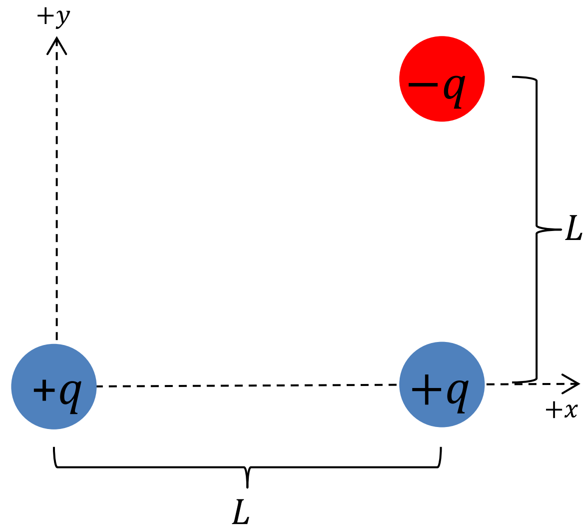
$$\frac{kq_1}{r_{1P}^2} - \frac{kq_2}{r_{2P}^2} = 9 \times 10^9 \frac{Nm^2}{C^2}\left[\frac{3 \times 10^{-9}C}{(0.04m)^2} - \frac{9.2 \times 10^{-9}C}{(0.02m)^2}\right] = -1.9 \times 10^5 \frac{N}{C}$$

$$\vec{E}_{net,P} = \langle -1,9,0,0\rangle \times 10^5 \frac{N}{C}$$

3. A $q_3 = -2nC$ point-charge is placed at the origin with the point charges configured as in part 2. What is the magnitude and direction of the electric force felt by q_3?

$$\vec{F} = q\vec{E} = -2 \times 10^{-9}C \times \langle -1{,}9{,}0{,}0\rangle \times 10^5\frac{N}{C} = \langle -3.8{,}0{,}0\rangle \times 10^{-4}N$$

4. Suppose that you have the situation shown below. Each point-charge has the same magnitude of charge, q, and the sign of each point-charge is shown in the figure. What is the net electric force on the point charge located at the origin?



$$\vec{F}_{net} = \vec{F}_{q,q} + \vec{F}_{-q,q} = \frac{kq^2}{L^2}\left[\frac{\langle 0{,}0{,}0\rangle - \langle L, 0{,}0\rangle}{L}\right] - \frac{kq^2}{2L^2}\left[\frac{\langle 0{,}0{,}0\rangle - \langle L, L, 0\rangle}{\sqrt{2}L}\right]$$

$$\vec{F}_{net} = \frac{kq^2}{L^2}\langle -1{,}0{,}0\rangle + \frac{kq^2}{2L^2}\langle \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, 0\rangle = \langle -0.65\frac{kq^2}{L^2}, 0.35\frac{kq^2}{L^2}, 0\rangle$$

Or as a magnitude and a direction:

$$F_{net} = \sqrt{F_{net,x}^2 + F_{net,y}^2} = \sqrt{(-0.65)^2 + (0.35)^2}\frac{kq^2}{L^2} = 0.74\frac{kq^2}{L^2}$$

$\tan\phi = \frac{F_{net,y}}{F_{net,x}} \to \phi = \tan^{-1}\left(\frac{F_{net,y}}{F_{net,x}}\right) = \tan^{-1}\left(\frac{0.35\frac{kq^2}{L^2}}{-0.65\frac{kq^2}{L^2}}\right) = 28.3^0$ above the negative x-axis.