Name_____

Physics 111 Quiz #1, September 9, 2024

Please show all work, thoughts and/or reasoning to receive partial credit. The quiz is worth 10 points total, and all parts may not be of equal weight.

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

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1. Consider an arrangement of three point-charges $q_1 = +3\mu C$, $q_2 = -4\mu C$ and $q_3 = +4\mu C$ placed along the x-axis. Point charge q_1 is located at a point $(x, y) = (0,0)$, point charge q_2 at $(x, y) = (10,0)$, and point charge q_3 at $(x, y) = (30,0)$, where the distances are measured in centimeters. What is the net electrostatic force in magnitude and direction on point-charge q_2?

   x-direction, taking to the right as the positive x-direction:

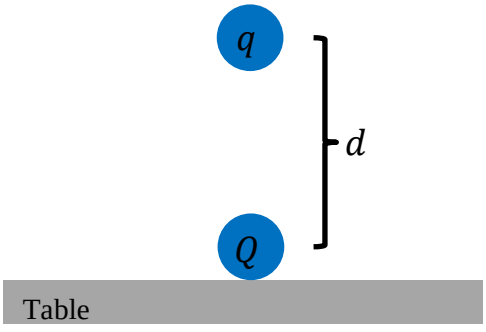
   $$\vec{F}_{net,q_2} = \vec{F}_{q_2,q_1} + \vec{F}_{q_2 q_3} \rightarrow F_{net,q_2} = -F_{q_2,q_1} + F_{q_2,q_3}$$

   $$F_{net,q_2} = -\frac{kq_2q_1}{r_{21}^2} + \frac{kq_2q_3}{r_{23}^2} = 9 \times 10^9 \frac{Nm^2}{C^2} \times 4 \times 10^{-6} C \times \left[-\frac{3 \times 10^{-6} C}{(0.1m)^2} + \frac{4 \times 10^{-6} C}{(0.2m)^2} \right]$$

   $$F_{net,q_2} = -7.2N$$

2. Suppose that you have a point-charge $Q = +7\mu C$ sitting at rest on a table and that directly above this point-charge Q you want to suspend a second point-charge q. If the point-charge q of mass $m = 0.2kg$ is located at a distance of $d = 0.25m$ above point-charge Q explain what the sign of point-charge q would have to be for it to remain at rest above point-charge Q?

   Since has a weight that acts vertically down, to levitate and suspend q, we need to have an equal and opposite force to gravity created by the electrostatic repulsion between the two charges. To create an electric force vertically would have to have the same sign as Q. Thus, q is positive.



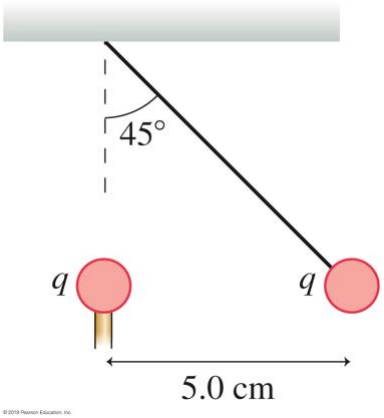
3. What would be the magnitude of point-charge q so that it would be suspended directly above point-charge Q?

   In the y-direction we have:

   $$F_E - F_W = ma_y = 0 \rightarrow F_E = F_W \rightarrow \frac{kQq}{d^2} = mg$$

   $$q = \frac{mgd^2}{kQ} = \frac{0.2kg \times 9.8\frac{m}{s^2} \times (0.25m)^2}{9 \times 10^9 \frac{Nm^2}{C^2} \times 7 \times 10^{-6}C} = 1.9 \times 10^{-6}C = 1.9\mu C$$

4. A $m = 0.020g$ plastic bead hangs from a lightweight thread. Another bead is fixed in position directly below the point where the thread is tied. If both beads have charge q, the movable bead swings out to the position shown. What is the value of the charge q?



   x-direction:

   $$F_E - F_{Tx} = ma_x = 0 \rightarrow F_E = F_{Tx} \rightarrow \frac{kq^2}{r^2} = F_T \sin 45$$

   $$q = \sqrt{\frac{r^2 F_T \sin 45}{k}} = \sqrt{\frac{r^2 \left(\frac{mg}{\cos 45}\right) \sin 45}{k}} = \sqrt{\frac{mgr^2 \tan 45}{k}}$$

   $$q = \sqrt{\frac{\left(0.020g \times \frac{1kg}{1000g}\right) \times 9.8\frac{m}{s^2} \times (0.05m)^2 \tan 45}{9 \times 10^9 \frac{Nm^2}{C^2}}} = 7.4 \times 10^{-9}C = 7.4nC$$

   y-direction:

   $$F_{Ty} - F_W = ma_y = 0 \rightarrow F_{Ty} = F_W \rightarrow F_T \cos 45 = mg \rightarrow F_T = \frac{mg}{\cos 45}$$