Name_______________________________________

Physics 111 Quiz #2, January 17, 2025

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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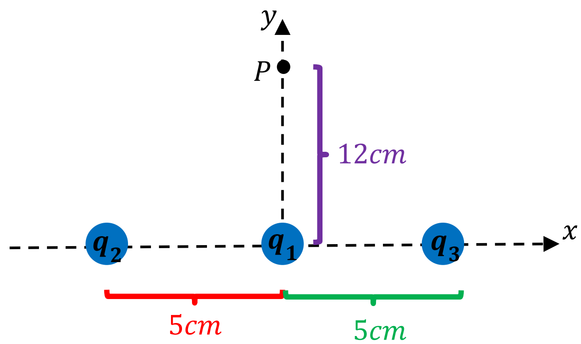
1. Three identical positively charged point-charges line in a straight line along the x-axis as shown below. The magnitudes of all the point-charges are $q_1 = q_2 = q_3 = 5nC$. Point-charge q_1 is located at the origin, point-charge q_2 is at $x = -5cm$, and point-charge q_3 is at $x = +5cm$. What is the magnitude of the net electric field at point P with coordinates $P = (x, y) = (0,12)cm$?



$$E_{net,x} = -E_{3x} + E_{2x} = -\frac{kq_3}{r_{3P}^2}\cos\theta + \frac{kq_2}{r_{2P}^2}\cos\theta = 0$$

$$E_{net,y} = E_1 + E_{2y} + E_{3y} = \frac{kq_1}{r_{1P}^2} + \frac{kq_2}{r_{2P}^2}\sin\theta + \frac{kq_3}{r_{3P}^2}\sin\theta = kq_1\left[\frac{1}{r_{1P}^2} + \frac{2}{r_{2P}^2}\sin\theta\right]$$

$$E_{net,y} = 9\times10^9\frac{Nm^2}{C^2}\times5\times10^{-9}C\left[\frac{1}{(0.12m)^2} + \frac{2}{(0.13m)^2}\left(\frac{12cm}{13cm}\right)\right] = 8040.8\frac{N}{C}$$

$$E_{net} = \sqrt{E_{net,x}^2 + E_{net,y}^2} = 8040.8\frac{N}{C}$$

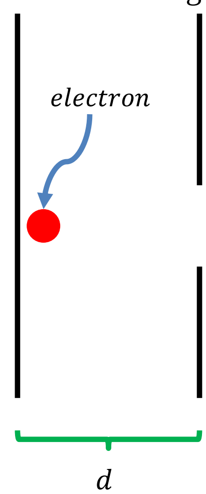
2. What is the direction of the net electric field at point P with coordinates $P = (x, y) = (0,12)cm$?

$\phi = \tan^{-1}\left(\frac{E_{net,y}}{E_{net,x}}\right) = \tan^{-1}\left(\frac{8040.8N}{0N}\right) = \tan^{-1}(\infty) = 90^0$ or vertically up the y-axis.

3. Suppose that a point-charge $q_4 = -3nc$ were placed at point P with coordinates $P = (x, y) = (0,12)cm$. What net electric force would q_4 feel?

   $F_{net,q_4} = q_4 E_{net} = -3 \times 10^{-9} C \times 8040.8 \frac{N}{C} = -2.4 \times 10^{-5} N$ or $2.4 \times 10^{-5} N$ in the negative y-direction.

4. Suppose instead you had the following situation in which two parallel metal plates are separated by a distance $d = 5cm$. A uniform electric field $\vec{E}$ exists between the plates. An electron is accelerated from rest, by this electric field, starting at the left plate and exiting out of the hole on the right plate with a speed $1.2 \times 10^7 \frac{m}{s}$. What is the magnitude $|\vec{E}| = E$ of the uniform electric field between the plates? Hint: How much work was done on the charge by the electric field?



   $W = \Delta K \rightarrow F \cdot \Delta x = qE \cdot d = \frac{1}{2} m v_f^2$

   $$E = \frac{m v_f^2}{2ed} = \frac{9.11 \times 10^{-31} kg \times \left(1.2 \times 10^7 \frac{m}{s}\right)^2}{2 \times 1.6 \times 10^{-19} C \times 0.05 m} = 8200 \frac{N}{C}$$

5. Explain the direction of the uniform electric field needed between the plates to accomplish the motion in part 4. Be sure to explain your reasoning fully.

   Since the work done on the electron by the electric field is positive (the change in kinetic energy is positive), and the electron has a negative charge, the electric field must point from the right plate to the left plate. This makes sense. To move the electron from the left to the right plate, the left plate would have to have a negative charge on it and the right plate a positive charge. Since electric fields point from plus to minus charges, the electric field would point right to left.