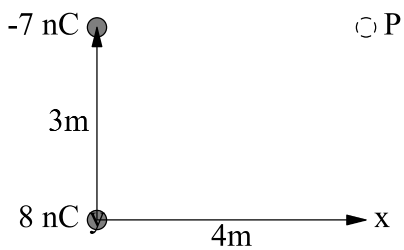
Physics 132 02 (9 am)
September 24, 2004
Test 1

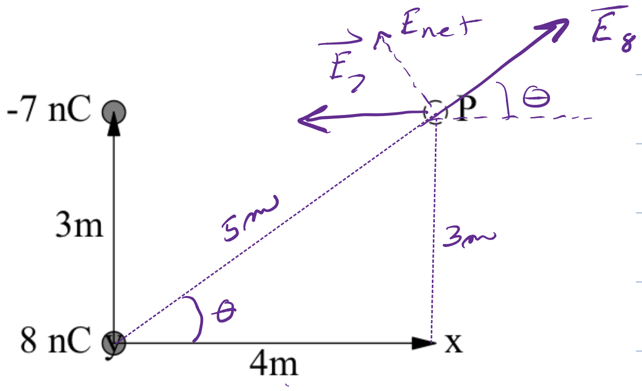
Name: ____

If any question is unclear, *please* ask immediately. Be sure to show your work **clearly** and **draw a box around your answer**. Partial credit may be given for work *if* it can be understood. All answers must have the correct units.

If you get stuck on the **math** at any point, be sure to indicate clearly the **physics** you are using and how you would continue if you could do the math.

1. (20 pts.) Two charges are arranged as shown in the figure.
   a. (10 pts.) What is the electric field at point P?
   b. (10 pts.) Suppose an electron is placed at point P and then released from rest. How fast will it be moving when it is very far away?





$\tan\theta = \frac{3}{4} \Rightarrow \theta = 36.87^\circ$

$$|\vec{E}_7| = E_7 = \frac{K(7nC)}{(4m)^2} = 3.934\ N/C$$

$$\vec{E}_7 = 3.934\ N/C\ @\ -180^\circ$$

$$|\vec{E}_8| = E_8 = \frac{K(8nC)}{(5m)^2} = 2.877\ N/C$$

$$\vec{E}_8 = 2.877\ N/C\ @\ 36.87^\circ$$

$$\vec{E} = \vec{E}_7 + \vec{E}_8$$

x-components: $E_x = E_{7x} + E_{8x}$

$$(3.934\ N/C)\cos(-180^\circ) + 2.877\tfrac{N}{C}\cos(36.87^\circ)$$

$$E_x = -1.632\ N/C$$

y-components: $E_y = E_{7y} + E_{8y}$

$$(3.934\ N/C)\sin(-180^\circ) + 2.877\tfrac{N}{C}\sin(36.87^\circ)$$

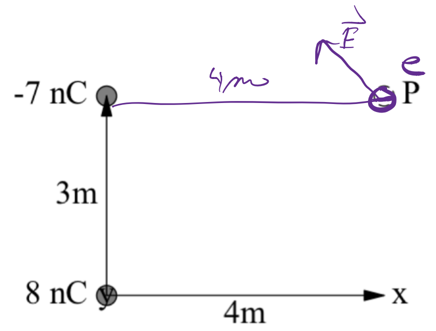
$$E_y = 1.726\ N/C$$

$$E = \sqrt{E_x^2 + E_y^2} = \sqrt{(-1.632)^2 + (1.726)^2}\ N/C$$

$$= 2.38\ N/C$$

$$\theta = \tan^{-1}\left(\frac{E_y}{E_x}\right) = 133^\circ \quad \text{(Note quadrant)}$$

$$\boxed{\vec{E} = 2.38\ N/C\ @\ 133^\circ}$$



Way #1 ? $\vec{F} = m\vec{a}$

$$(-e)\vec{E} = m\vec{a} \Rightarrow \vec{a} = -e\vec{E}/m$$

Problem: $\vec{a}$ is not constant!

$\vec{E}$ gets weaker as you move further away.

Can't use kinematics

Way #2 Energy Conservation

$$Energy_i = Energy_f$$

$$K_i + U_i = K_f + U_f$$

$$K_i + (-e)V_i = K_f + (-e)V_f$$

$$V_{i7} = \frac{KQ_7}{4m} = \frac{(9\times10^9 Nm^2/C^2)(-7\times10^{-9}C)}{4m} = -15.75V$$

$$V_{i8} = \frac{KQ_8}{5m} = \frac{(9\times10^9 Nm^2/C^2)(8\times10^{-9}C)}{5m} = 14.40V$$

$$V_i = V_{i7} + V_{i8} = -1.35V$$

$V_f = ?$ $r_f \to \infty$, so $V_f \to 0$.

$K_i = 0$

$$\cancel{K_i}^{0} + (-e)(-1.35V) = K_f + 0$$

$$1.35\,eV = \frac{1}{2} m v_f^2$$

$$(1.35 \times 1.602\times10^{-19})\,J = \frac{1}{2}(9.11\times10^{-31}\,kg)\,v_f^2$$

$$\boxed{v_f = 6.9\times10^{5}\,m/s}$$

Note: $a \neq$ constant.

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Name: SOLUTIONS

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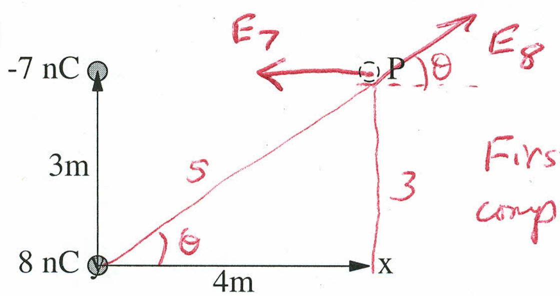
(a)



$\theta = \tan^{-1}\left(\frac{3}{4}\right) = 36.87°$.

First compute magnitudes, and then take components.

$E_7 = \frac{1}{4\pi\epsilon_0} \frac{7\times10^{-9}}{4^2} = 3.934\ \text{N/C}$

$E_8 = \frac{1}{4\pi\epsilon_0} \frac{8\times10^{-9}}{5^2} = 2.877\ \text{N/C}$

x-components: $E_x = -E_7 + E_8 \cos\theta =$ $\boxed{-1.632\ \text{N/C}}$

y-components: $E_y = 0 + E_8 \sin\theta =$ $\boxed{1.726\ \text{N/C}}$

or $E = \sqrt{E_x^2 + E_y^2} =$ $\boxed{2.38\ \frac{N}{C} @\ 133°}$

(b) $K_i + qV_i = K_f + qV_f$. $K_i = 0$, $V_f = 0$. $K_f = \frac{1}{2} m v_f^2$.

$qV_i = -e\left(\frac{-7\times10^{-9}}{(4\pi\epsilon_0)(4)} + \frac{8\times10^{-9}}{(4\pi\epsilon_0)(5)}\right) = -e(1.349\text{V}) =$

$= 2.161\times10^{-19}\text{J}$

$v_f = \sqrt{\frac{2qV_i}{m}} = \sqrt{\frac{2(2.161\times10^{-19}\text{J})}{9.11\times10^{-31}\text{kg}}} =$ $\boxed{6.89\times10^{5}\ \text{m/s}}$

Note: $a \neq$ constant!