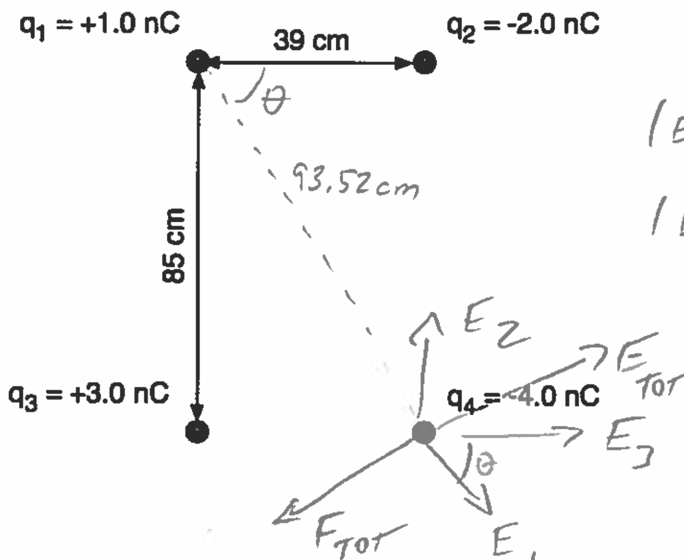
Physics 10164 - Summer 2018 - Exam #1

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (35 pts) Four charges are arranged in a rectangle as shown and fixed in place.

a) Determine the magnitude and direction of the electric field at the location of the ~~+3~~ -4 nC particle due to the other charges.

b) Determine the magnitude and direction of the electric force acting on the ~~+3~~ -4 nC particle.



$\theta = \tan^{-1}\left(\frac{85}{39}\right) = 65.35°$

$|E_1| = \frac{kq_1}{r_1^2} = 10.29$ N/C

$|E_2| = \frac{kq_2}{r_2^2} = 24.91$ N/C

$|E_3| = \frac{kq_3}{r_3^2} = 177.51$ N/C

$E_{1x} = E_1 \cos 65.35° = 4.29$

$E_{1y} = E_1 \sin 65.35° = -9.35$

$E_{2x} = 0$

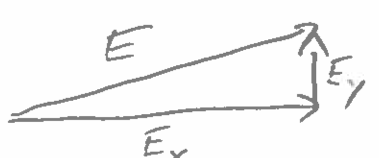
$E_{2y} = +24.91$

$E_{3x} = 177.51$

$E_{3y} = 0$

Σx: 181.8

Σy: 15.56



$E_{TOT} = \sqrt{181.8^2 + 15.56^2} =$ **180 N/C**

$\theta = \tan^{-1}\left(\frac{15.56}{181.8}\right) =$ **4.9° above +x**

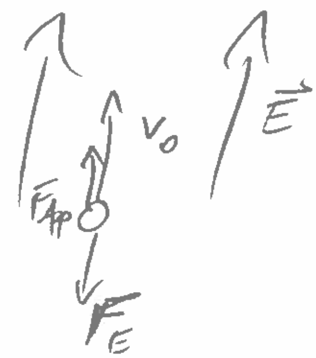
b) $|F| = qE$

= **7.3×10⁻⁷ N**, **4.9° below −x**

2. (35 pts) A 1.46-kg hovercraft on a smooth, horizontal, frictionless surface carries a charge of -355 μC. The device is initially moving in the +y direction with a speed of 4.40 m/s. The device is moving through a uniform electric field of 8520 N/C pointing in the +y direction. There is also a constant applied force from the engine of the device of 5.50 N pointing in the +y direction. The applied force and the electric force are the only relevant forces in this problem.

a) After the device has moved 5.00 meters, what its new speed?
b) How much work has been done by the electric force during this motion?
c) If the voltage at the initial position of the device is 24,500 Volts, what is the voltage at the final position?

$\Sigma W_F = W_E + W_{App} = \Delta K$



$W_E = -|qE\Delta y|$

$= -(355\times10^{-6})(8520)(5.0)$

$= -15.12\ J$

$W_{App} = +F_{App}\cdot\Delta y$

$= (5.50)(5.00) = 27.50\ J$

$K_i = \frac{1}{2}(1.46)(4.40)^2 = 14.13\ J$

$-15.12 + 27.50 = K_f - 14.13$

$K_f = \frac{1}{2}(1.46)v^2 = 26.52\ J \Rightarrow \boxed{v = 6.03\ m/s}$

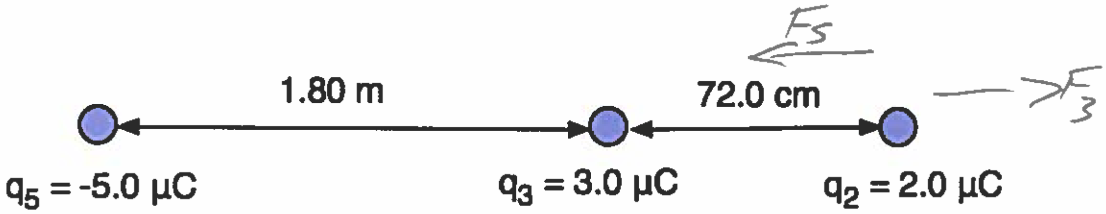
b) $\boxed{W_E = -15.1\ J}$ from above

c) $|\Delta V| = E\cdot\Delta y = 42600$ $\qquad V_i \qquad V_f$

$V_F - V_i = -42600$ since $\vec{E}$ points from high $V \rightarrow$ low V

$V_F - 24500 = -42600 \qquad \boxed{V_F = -18100\ Volts}$

#3. (30 pts) Three point charges are arranged in a line as shown below. The charges q_5 and q_3 are fixed, and q_2 (starting from rest) is free to move. After q_2 (which has a mass of 1.30 kg) has moved a distance of 55.0 cm, what is its final velocity?



q_2 will move →
since $F_3\ (.104) > F_5\ (.0142)$

$$V_i = \frac{k_c q_5}{r_5} + \frac{k_c q_3}{r_3}$$

$$= -17857 + 37500 = 19643 \text{ Volts}$$

$$V_f = \frac{k_c q_5}{3.07} + \frac{k_c q_3}{1.27}$$

$$= -14658 + 21260 = 6602 \text{ Volts}$$

$$\Sigma W_F = W_E = \Delta K$$

$$-q_2 \Delta V = \tfrac{1}{2} m v^2 - 0$$

$$-(2.0\times10^{-6})(6602 - 19643) = \tfrac{1}{2}(1.30)v^2$$

$$.0261 = \tfrac{1}{2}(1.30)v^2$$

$$\boxed{v = 0.200\ m/s}$$