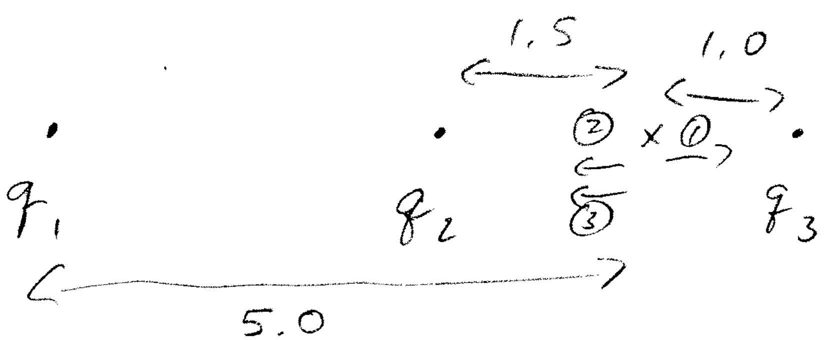
Physics 10164 - Exam 1

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. (20 pts) A +3.5 nC charge is located at the origin. A -2.2 nC charge is located on the x-axis at x = 3.5 cm. A +1.7 nC charge is located on the x-axis at x = 6.0 cm.

Find the magnitude and direction of the electric field at the point x = 5.0 cm.



$$E_1 = \frac{(9\times10^9)(3.5\times10^{-9})}{.05^2} = 12600\ \frac{V}{m},\ +x$$

$$E_2 = \frac{(9\times10^9)(2.2\times10^{-9})}{.015^2} = 88000\ \frac{V}{m},\ -x$$

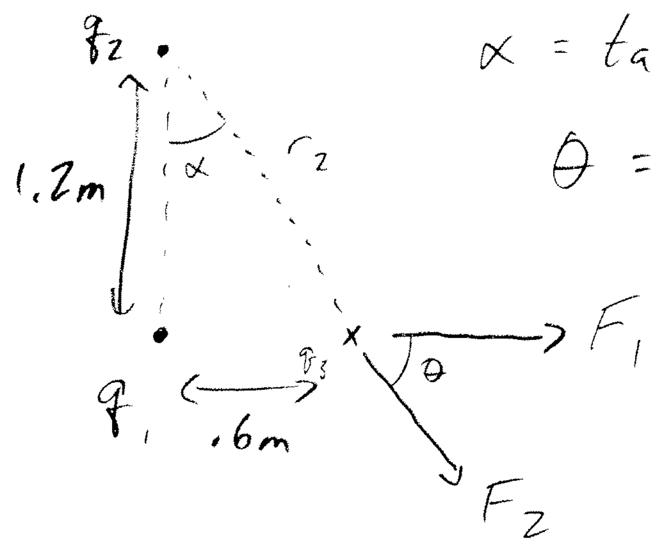
$$E_3 = \frac{(9\times10^9)(1.7\times10^{-9})}{.01^2} = 153000\ \frac{V}{m},\ -x$$

-2.3×10^5

$$E_{TOT} = 12600 - 88000 - 153000 = -230000\ \frac{V}{m}$$

or $\boxed{2.3\times10^5\ \frac{V}{m},\ -x\ \text{dir}}$

2. (30 pts) A 2.2 nC charge is located at the origin. A 3.8 nC charge is located at the coordinate y = 1.2 meters. Find the magnitude and direction of the electric force on a 1.4 nC charge located at the coordinate x = 0.6 meters.



$$\alpha = \tan^{-1}\left(\frac{.6}{1.2}\right) = 26.6^\circ$$

$$\theta = 90 - \alpha = 63.4^\circ$$

$$r_2 = \sqrt{.6^2 + 1.2^2} = 1.34$$

$$F_1 = \frac{k q_1 q_3}{r_1^2} = \frac{(9\times10^9)(2.2\times10^{-9})(1.4\times10^{-9})}{0.6^2}$$

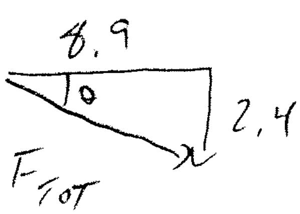
$$= 7.7\times10^{-8}, \ +x \text{ dir}$$

$$F_2 = \frac{k q_2 q_3}{r_2^2} = \frac{(9\times10^9)(3.8\times10^{-9})(1.4\times10^{-9})}{1.34^2}$$

$$= 2.7\times10^{-8}, \ 63.4^\circ \text{ below } +x$$

$$F_{TOT,x} = 7.7\times10^{-8} + 2.7\times10^{-8}\cos 63.4 = 8.9\times10^{-8}$$

$$F_{TOT,y} = -2.7\times10^{-8}\sin 63.4^\circ = -2.4\times10^{-8}$$



$$F_{TOT} = \sqrt{8.9^2 + 2.4^2} = \boxed{9.2\times10^{-8}\ N}$$

$$\theta = \tan^{-1}\left(\frac{2.4}{8.9}\right) = \boxed{15^\circ \text{ below } +x}$$

3. (20 pts) Two oppositely-charged parallel plates are separated by a distance of 3.0 cm. The potential difference between the plates is 120 Volts, and the electric field between the plates is uniform. A proton starts from rest at the positive plate and is accelerated toward the negative plate. With what speed does the proton strike the negative plate?

$$E = \frac{120 \text{ Volts}}{.03 \text{ m}} = 4000 \text{ Volts/meter}$$

proton moves from high initial V to low final V

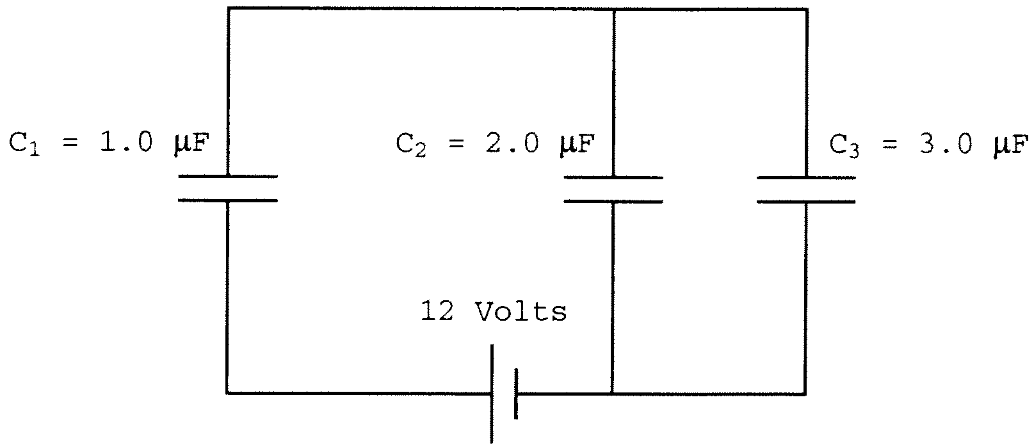
$$W_E = -q\Delta V = \frac{1}{2}mv^2 - 0$$

$$= -(1.6\times10^{-19})(-120) = \frac{1}{2}(1.67\times10^{-27})v^2$$

$$v^2 = 2.30\times10^{10}$$

$$\boxed{v = 1.5\times10^{5} \text{ m/s}}$$

4. (30 pts) Three capacitors are arranged into a circuit as shown below. Find the voltage drop across each capacitor.



First, combine C_2 + C_3 into C_{23}

$$C_{23} = C_2 + C_3 = 5.0\,\mu F$$

$$C_{TOT}: \frac{1}{C_{TOT}} = \frac{1}{C_1} + \frac{1}{C_{23}} \Rightarrow C_{TOT} = 0.83\,\mu F$$

$$Q_{TOT} = C_{TOT}\,\Delta V_{TOT} = 10\,\mu C$$

Since C_1 + C_{23} are in series, $Q_1 = Q_{23}$

so $Q_1 = 10\,\mu C$ and thus $\boxed{\Delta V_1 = \frac{Q_1}{C_1} = 10 \text{ Volts}}$

$Q_{23} = 10\,\mu C$, so $\Delta V_{23} = \frac{Q_{23}}{C_{23}} = 2$ Volts

Since C_2 + C_3 are parallel

$\Delta V_2 = 2$ Volts

$\Delta V_3 = 2$ Volts