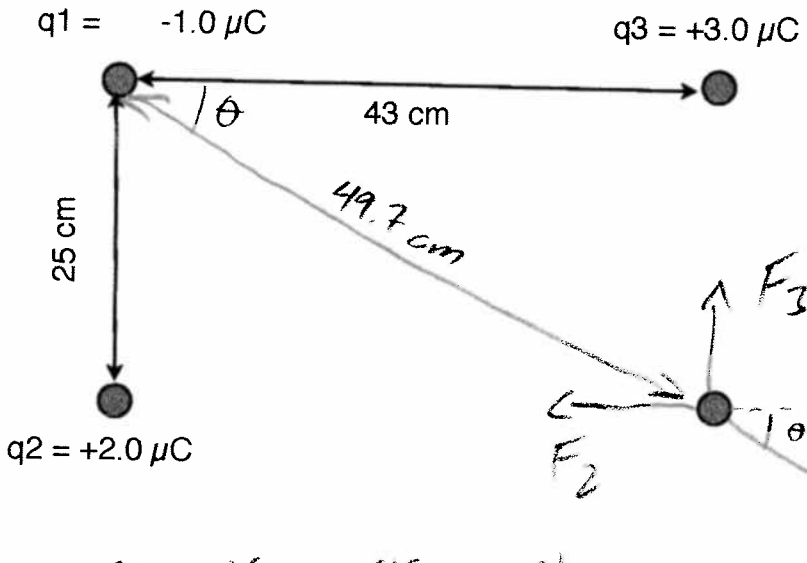
Physics 10164 – Exam 1A

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. (30 pts) Four charges are arranged in a rectangle as shown below. Find the magnitude and direction of the electric force acting on charge q4 in the bottom right corner. q4 has a charge of -4.0 μC.



$$|F_1| = \left| \frac{kq_1 q_4}{r_{14}^2} \right|$$

$$= \frac{(9\times10^9)(1.0\times10^{-6})(4.0\times10^{-6})}{.497^2}$$

$$= 0.146$$

$$\theta = \tan^{-1}\left(\frac{25}{43}\right)$$

$$= 30.2^\circ$$

$$|F_2| = \frac{(9\times10^9)(2\times10^{-6})(4\times10^{-6})}{.43^2} = 0.389$$

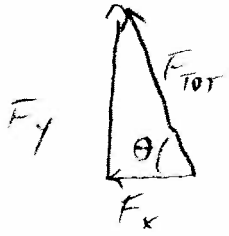
$$|F_3| = \frac{(9\times10^9)(3\times10^{-6})(4\times10^{-6})}{.25^2} = 1.728$$

$F_{1x} = 0.146 \cos 30.2^\circ = 0.126$ $\quad F_{1y} = -0.146 \sin 30.2^\circ = -.073$

$F_{2x} = -0.389$ $\quad F_{2y} = 0$

$F_{3x} = 0$ $\quad F_{3y} = +1.728$

$F_{TOT,x} = -0.263$ $\quad F_{TOT,y} = 1.655$



$$F_{TOT} = \sqrt{.263^2 + 1.655^2} = \boxed{1.7\ N}$$

$$\theta = \tan^{-1}\left(\frac{1.728}{0.263}\right) = \boxed{81^\circ \text{ above } -x}$$

2. (35 pts) A 5.0 nF capacitor is connected to a circuit so that a potential difference of 0.012 Volts exists between the two plates, which are separated by 0.50 millimeters.

a) What is the charge on the positive plate?

b) What is the surface area of the positive plate?

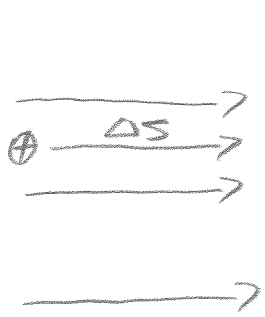
c) If a proton starts from rest at the positive plate and strikes the negative plate, what speed will the proton have when it hits the negative plate?

a) $E = \frac{.012\ V}{.5\times10^{-3}\ m} = 24\ \frac{V}{m}$

$Q = C\Delta V = (5\times10^{-9})(.012) = 6.0\times10^{-11}\ C$

b) $24 = \frac{4\pi k Q}{A} \Rightarrow A = \frac{4\pi(9\times10^{9})(6\times10^{-11})}{24}$

$= 0.28\ m^2$

c) 

$\Sigma W_F = W_E = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 \to 0$

$qEd = \frac{1}{2}mv^2$

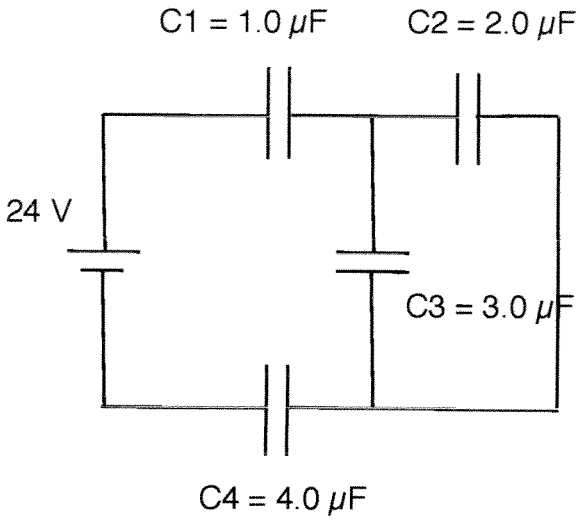
$(1.6\times10^{-19})(24)(.5\times10^{-3}) = \frac{1}{2}(1.67\times10^{-27})v^2$

$1.92\times10^{-21} = \frac{1}{2}(1.67\times10^{-27})v^2$

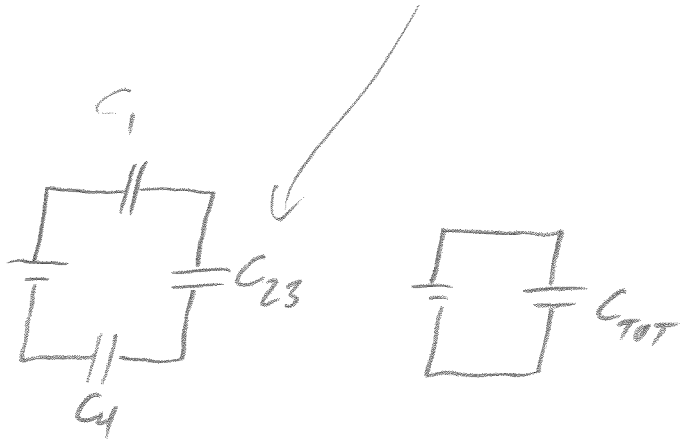
$2.3\times10^{6} = v^2$

$v = 1500\ m/s$

3. (35 pts) For the combination of capacitors pictured below, find the charge on each of the four capacitors.



$C_{23} = C_2 + C_3 = 5\,\mu F$



$$\frac{1}{C_{TOT}} = \frac{1}{1} + \frac{1}{5} + \frac{1}{4} \Rightarrow C_{TOT} = 0.69\,\mu F$$

$$Q_{TOT} = C_{TOT}\,\Delta V_{TOT} = 16.6\,\mu C$$

$$\Rightarrow Q_1 = Q_{23} = Q_4 = 17\,\mu C$$

$Q_1 = 17\,\mu C$

$Q_4 = 17\,\mu C$

$$\Delta V_{23} = \frac{Q_{23}}{C_{23}} = \frac{16.6\,\mu C}{5\,\mu F} = 3.31\ \text{Volts}$$

$$\Rightarrow \Delta V_2 = \Delta V_3 = 3.31\,V$$

$$Q_2 = C_2\,\Delta V_2 = 6.6\,\mu F$$

$$Q_3 = C_3\,\Delta V_3 = 9.9\,\mu F$$

$Q_2 = 6.6\,\mu F$

$Q_3 = 9.9\,\mu F$