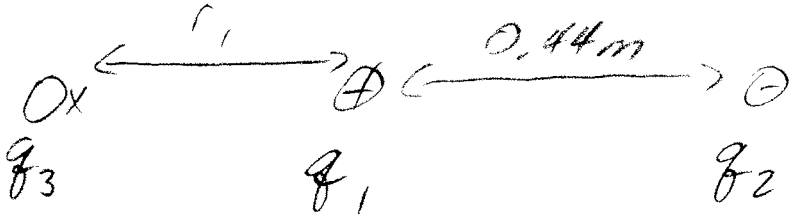
Physics 10164 - Exam 1A

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. (40 pts) A +4.5 nC charge is located at the origin. A -6.3 nC charge is located at the coordinate x = 44 cm.

a) At what point along the x-axis would the net electric force on a 2.0 nC charge equal zero?

b) At what point would the net force be zero on a -2.0 nC charge?



$r_2 = r_1 + 0.44$

At x, $|F_1| = |F_2|$

$$\frac{k|q_1||q_3|}{r_1^2} = \frac{k|q_2||q_3|}{(r_1+0.44)^2}$$

$$\frac{|q_1|}{|q_2|} = \frac{r_1^2}{(r_1+0.44)^2} \Rightarrow \frac{4.5}{6.3} = \frac{r_1^2}{(r_1+0.44)^2}$$

$$\Rightarrow 0.845 = \frac{r_1}{r_1+0.44}$$

$$0.845 r_1 + 0.372 = r_1$$

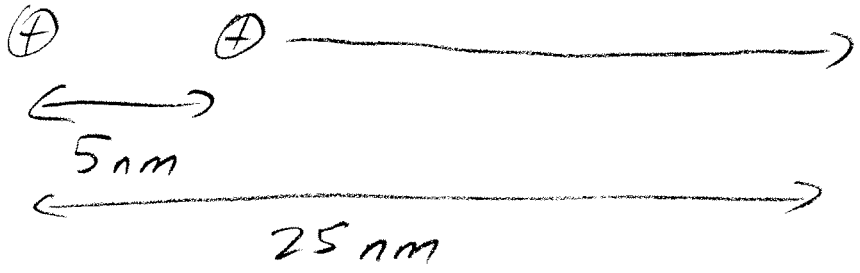
$$0.372 = 0.155 r_1$$

$$r_1 = \frac{0.372}{0.155} = 2.4, \text{ so } \boxed{x = -2.4\,m}$$

b) same, since q_3 cancels

alpha particle

2. (30 pts) A ~~proton~~ is fixed at the origin. A ~~second~~ proton is initially at rest at a coordinate x = 5.0 nm (5.0×10^{-9} m). If the ~~second~~ proton is allowed to move freely, what will its speed be when it reaches an x coordinate x = 25 nm?



$W_E = -q\Delta V = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$ ($v_0 = 0$ initially at rest)

$V_i = \frac{k|2e|}{r_i} = \frac{(9\times10^9)(2)(1.6\times10^{-19})}{(5\times10^{-9})} = 0.576$ Volts

$V_f = \frac{k|2e|}{r_f} = 0.115$ Volts

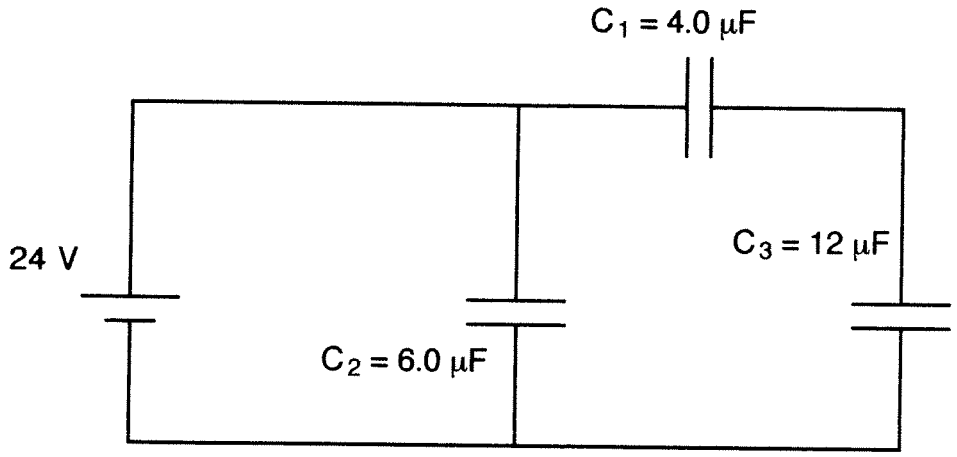
$-(1.60\times10^{-19})(0.115 - 0.576) = \frac{1}{2}(1.67\times10^{-27})v^2$

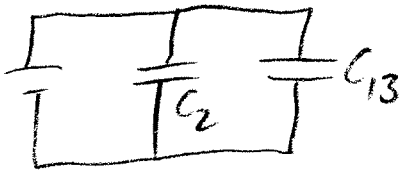
$7.37\times10^{-20} = 0.835\times10^{-27}v^2$

$v^2 = 8.83\times10^7$

$v = 9400$ m/s

3. (40 pts) For the system below, determine the charge and voltage drop across each capacitor.





$$\frac{1}{C_{13}} = \frac{1}{4} + \frac{1}{12}$$

$$C_{13} = 3\ \mu F$$

$C_{123} = C_2 + C_{13} = 9\ \mu F$

Thus, $Q_{123} = C_{123}\,\Delta V_{123} = (9)(24\ \mu F) = 216\ \mu C$

Since C_2 & C_{123} are parallel,

$\Delta V_2 = 24$ Volts

$Q_2 = C_2 \Delta V_2 = 144\ \mu C$

$\Delta V_{13} = 24$ Volts

$Q_{13} = C_{13}\,\Delta V_{13} = 72\ \mu C$

Since C_1 & C_3 are in series

$Q_1 = 72\ \mu C$

$\Delta V_1 = \frac{Q_1}{C_1} = 18$ Volts

$Q_3 = 72\ \mu C$

$\Delta V_3 = \frac{Q_3}{C_3} = 6$ Volts