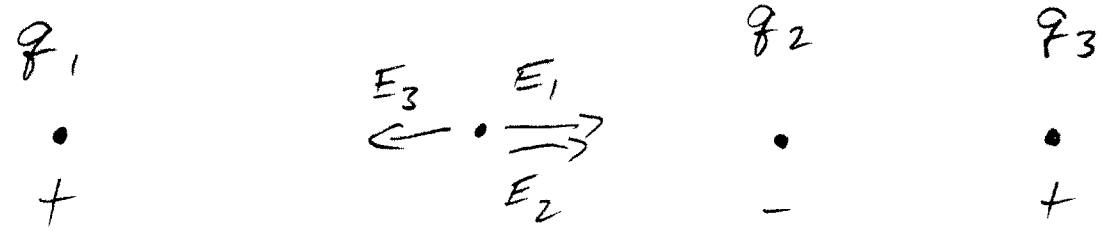
Physics 10164 - Exam 1B

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) Three charges are arranged in a line along the x-axis and remain fixed in place.

Charge #1 is +4.4 μC and is at the origin.
Charge #2 is -3.0 μC and is at x = 55 cm.
Charge #3 is +6.0 μC and is at x = 75 cm.

What is the magnitude and direction of the resulting electric field at x = 35 cm?



$$E_1 = \frac{kq_1}{r_1^2} = \frac{(9\times10^9)(4.4\times10^{-6})}{.35^2} = +323{,}265\ \frac{V}{m}$$

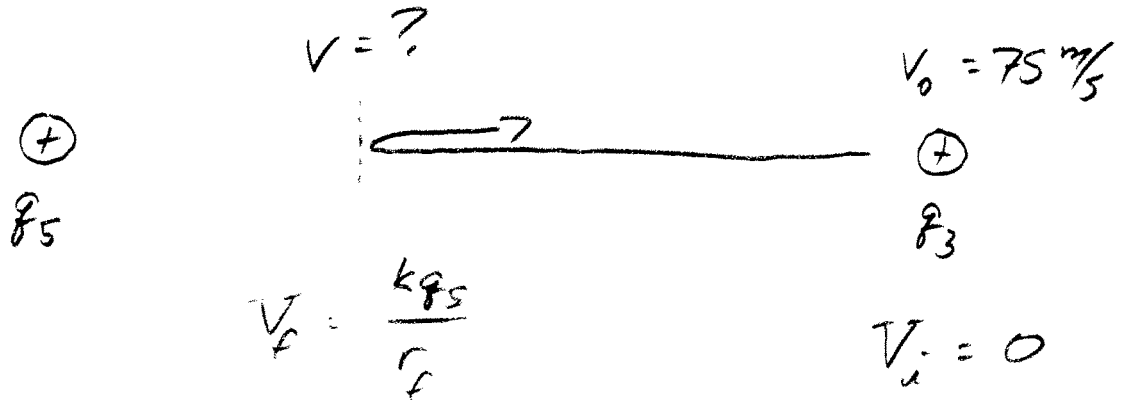
$$E_2 = \frac{kq_2}{r_2^2} = \frac{(9\times10^9)(3\times10^{-6})}{.20^2} = +675{,}000\ \frac{V}{m}$$

$$E_3 = \frac{kq_3}{r_3^2} = \frac{(9\times10^9)(6.0\times10^{-6})}{.40^2} = -337{,}500\ \frac{V}{m}$$

$$E_{TOT} = 323000 + 675000 - 338000$$

$$= \boxed{6.6\times10^5\ \frac{V}{m},\ +x\ dir}$$

2. (40 pts) A +5.0 μC charge is located at the origin. A +3.0 μC charge with a mass of 35 grams is fired toward the origin from a great distance with an initial speed of 75 m/s. How close does the +3.0 μC charge get to the origin before it stops?



$\Sigma W_F = W_E = \Delta K$ (assuming no other forces do work)

$W_E = -\Delta U_E$

$= -q_3 \Delta V_5$

$= -(3.0\times10^{-6})\left(\frac{kq_5}{r_f} - 0\right)$

$= \frac{-(3.0\times10^{-6})(9\times10^{9})(5.0\times10^{-6})}{r_f}$

$V_i = 0$ for $r_i = \infty$ "great distance"

Now set $W_E = \Delta K$

$K_f = 0$ at closest approach "it stops"

$-\frac{0.135}{r_f} = 0 - \frac{1}{2}mv_0^2$

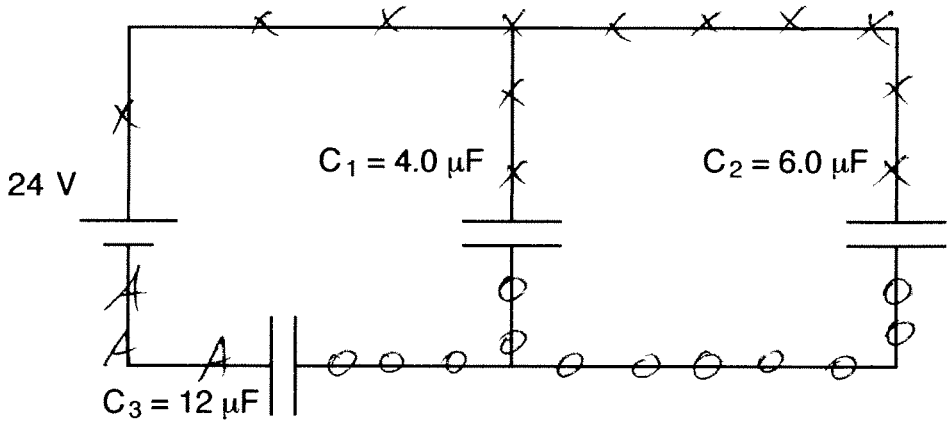
$-\frac{0.135}{r_f} = -\frac{1}{2}(.035)(75)^2$

$-\frac{0.135}{r_f} = -98.44$

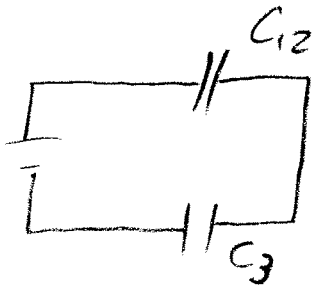
$r_f = 1.4\ mm$

$= 1.4\times10^{-3}\ m$

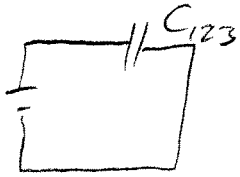
3. (30 pts) For the system of capacitors shown below, determine the charge and voltage drop across each capacitor.



C_1 & C_2 have same ΔV so they are parallel



$$C_{12} = C_1 + C_2 = 10\ \mu F$$



$$\frac{1}{C_{123}} = \frac{1}{10} + \frac{1}{12} = \frac{1}{5.45\ \mu F}$$

1) Combine C_1 & C_2 into C_{12} (parallel)

2) Combine C_{12} & C_3 into C_{123} (series)

3) $Q_{TOT} = C_{TOT}\Delta V_{TOT} = (5.45\ \mu F)(24\ V) = 131\ \mu C$

4) Since C_{12} & C_3 are in series $Q_{12} = \boxed{*Q_3 = 131\ \mu C}$

5) $\Delta V_{12} = \frac{Q_{12}}{C_{12}} = \frac{131\ \mu C}{10\ \mu F} = 13.1\ V$

6) Since C_1 & C_2 are in parallel $\boxed{*\Delta V_1 = \Delta V_2 = 13.1\ V}$

$C_1 = 4.0\ \mu F$	$C_2 = 6.0\ \mu F$	$C_3 = 12\ \mu F$	
$Q_1 = 52\ \mu C$	$Q_2 = 78\ \mu C$	$*Q_3 = 131\ \mu C$	
$*\Delta V_1 = 13.1\ V$ (13)	$*\Delta V_2 = 13.1\ V$ (13)	$\Delta V_3 = 10.9\ V$ (11)	

7) use $Q = C\Delta V$ to solve for each missing unknown