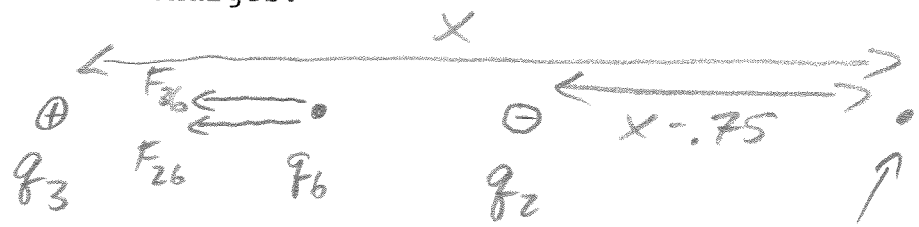
Physics 10164 - Exam 1B

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. (35 pts) Charge q3 = +3.0 μC is located at the origin. Charge q2 = -2.0 μC is located at x = 75 cm.

a) Find the location along the x-axis (other than infinity) where the net electric field due to the two charges is zero.

b) If a charge q6 = -6.0 μC is located at x = 44 cm, what is the magnitude and direction of the net electric force on q6 due to the other two charges?



a) Only to the right of q_2 can the electric fields of each charge cancel. See Ch 15, #27 for example.

$$|\vec{E}_3| = |\vec{E}_2|$$

$$\frac{kq_3}{x^2} = \frac{kq_2}{(x-.75)^2}$$

$$\frac{q_3}{q_2} = \frac{x^2}{(x-.75)^2}$$

$$\sqrt{1.5} = \frac{x}{x-.75}$$

$$1.22x - 0.92 = x$$

$$0.22x = 0.92$$

$$x = 4.2\text{ m}$$

b) $$|F_{36}| = \frac{kq_3q_6}{.44^2}$$

$$\vec{F}_{36} = \frac{(9\times10^9)(3\times10^{-6})(6\times10^{-6})}{.44^2} = 0.837,\ -x\text{ dir}$$

$$|F_{26}| = \frac{kq_2q_6}{.31^2}$$

$$\vec{F}_{26} = \frac{(9\times10^9)(2\times10^{-6})(6\times10^{-6})}{.31^2} = 1.124,\ -x\text{ dir}$$

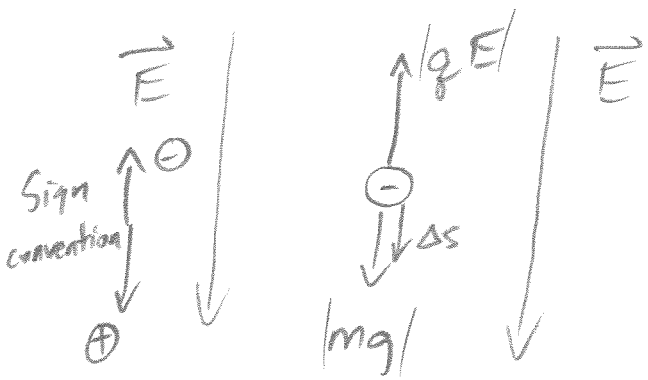
$$F_{TOT} = -0.837 - 1.124$$

$$= -2.0\text{N},\ \text{or}\ 2.0\text{N},\ -x\text{ dir}$$

2. (30 pts) A 4.5 gram object with a charge q = -2.0 μC is initially at rest in a uniform electric field of magnitude 5500 Volts/meter pointing directly downward. Both gravity and the electric force are significant in the particle's motion. After the particle moves 22 cm, answer the following:

a) What is the magnitude and direction of the particle's velocity?

b) If the initial potential at the location of the particle is +450 Volts, what is the potential at the particle's final location?



$|F_g| = (.0045)(9.8) = .0441\ N$

$|F_E| = (2.0 \times 10^{-6})(5500) = .011\ N$

$|F_g| > |F_E|$, so particle moves down

a) Forces

$\Sigma F_y = mg - qE = ma$

$= .0441 - .011 = (.0045)a$

$a = 7.36\ m/s^2$

$v^2 = v_0^2 + 2a\Delta y$

$v^2 = 0 + 2(7.36)(.22)$

$v = 1.8\ m/s$, down

Energy

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

$W_g = |mg||\Delta s|\cos 0^\circ$ or $+mgh$

$= (.0045)(9.8)(.22)(1)$

$= .0097\ J$

$W_E = |qE| \cdot |\Delta s| \cdot \cos 180^\circ$

$= (2.0 \times 10^{-6})(5500)(.22)(-1)$

$= -.0024\ J$ $\quad v_0 = 0$

$.0097 - .0027 = \frac{1}{2}(.0045)v^2 - 0$

$v = 1.8\ m/s$, down

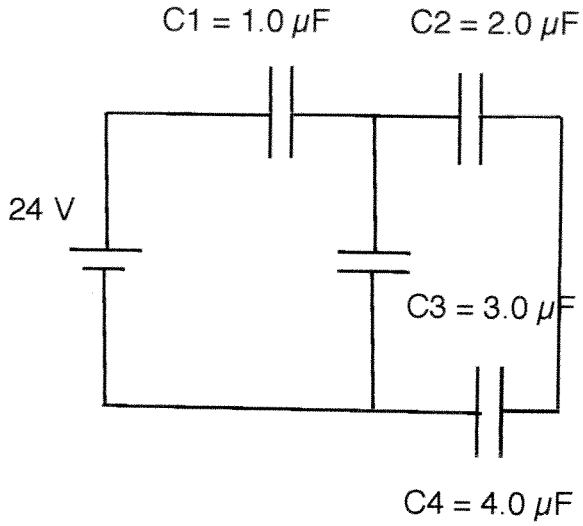
b) As particles moves in direction of $\vec{E}$, V will decrease.

$\Delta V = Ed = -1210$

$V_f - V_i = -1210$

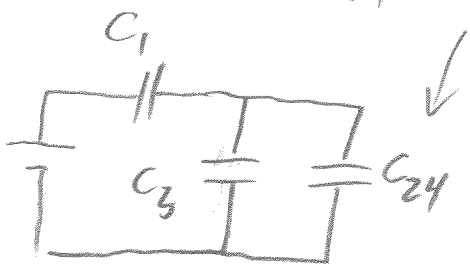
$V_f = -760$ Volts

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

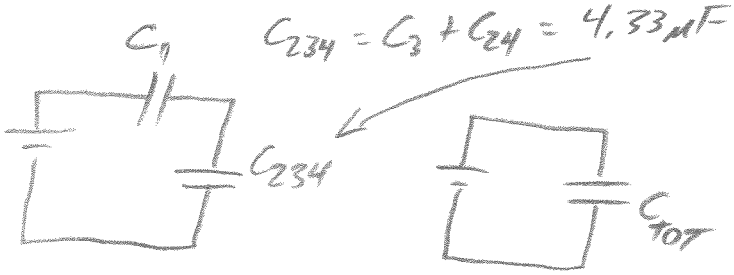


$\frac{1}{C_{24}} = \frac{1}{C_2} + \frac{1}{C_4}$

$C_{24} = 1.33\,\mu F$



$C_{234} = C_3 + C_{24} = 4.33\,\mu F$



$\frac{1}{C_{TOT}} = \frac{1}{C_1} + \frac{1}{C_{234}} = .813\,\mu F$

$Q_{TOT} = C_{TOT}\,\Delta V_{TOT}$

$= 19.5\,\mu C$

$\Rightarrow Q_1 = Q_{234} = 19.5\,\mu C$

$Q_1 = 20\,\mu C$

$\Delta V_{234} = \frac{Q_{234}}{C_{234}} = 4.5\ Volts$

$Q_3 = C_3 \Delta V_3 \Rightarrow Q_3 = 14\,\mu C$

$\Rightarrow \Delta V_3 = \Delta V_{24} = 4.5\ Volts$

$Q_{24} = C_{24}\,\Delta V_{24} = 6.0\,\mu C$

$Q_2 = 6.0\,\mu C$

$\Rightarrow Q_2 = Q_4 = 6.0\,\mu C$

$Q_4 = 6.0\,\mu C$