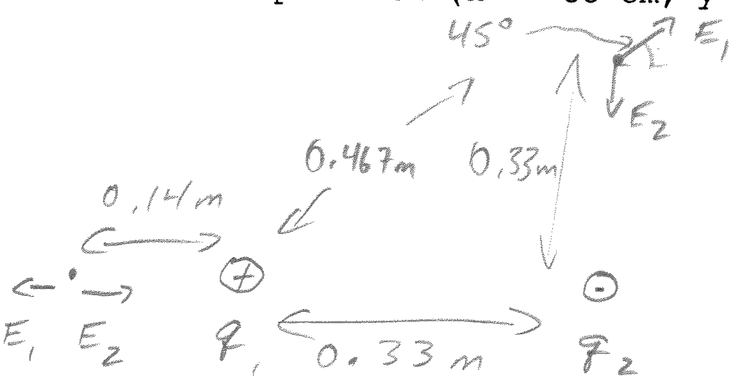
Physics 10164 - Exam 1C

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) A +3.5 μC charge is located at the origin. A -5.3 μC charge is located at x = 33 cm.

a) What is the magnitude and direction of the electric field at the position x = -14 cm?

b) What is the magnitude and direction of the electric field at the position (x = +33 cm, y = +33 cm)?



a) $E_1 = \left|\frac{k_c q_1}{.14^2}\right| = 1.61\times10^6 \frac{N}{C}, -x$

$E_2 = \left|\frac{k_c q_2}{.47^2}\right| = 2.16\times10^5 \frac{N}{C}, +x$

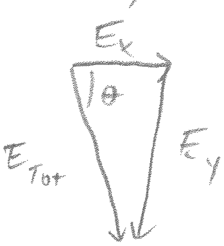
$E_{TOT} = -1.4\times10^6 \frac{N}{C}$ or $1.4\times10^6 \frac{N}{C}$, $-x$ dir

b) $E_1 = \left|\frac{k_c q_1}{.467^2}\right| = 1.44\times10^5 \frac{N}{C}$, 45° above $+x$

$E_2 = \left|\frac{k_c q_2}{.33^2}\right| = 4.38\times10^5 \frac{N}{C}, -y$ dir

$E_{TOT,x} = 1.44\times10^5 \cos 45° = 1.02\times10^5 \frac{N}{C}$

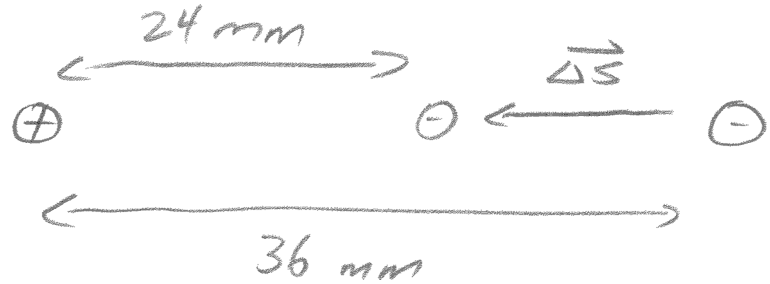
$E_{TOT,y} = 1.44\times10^5 \sin 45° - 4.38\times10^5 = -3.36\times10^5 \frac{N}{C}$



$|\vec{E}_{TOT}| = \sqrt{1.02^2 + 3.36^2} = 3.5\times10^5 \frac{N}{C}$

$\theta = \tan^{-1}\left(\frac{3.36}{1.02}\right) = 73°$ below $+x$

2. (35 pts) A proton is located at the origin. An electron is initially at rest at x = 36 mm. The only force in this problem that is relevant is the electric force. After the electron moves a distance of 12 mm in response to the proton's electric field, how fast is the electron moving?



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

$$-\Delta U_E = -q_e \Delta V_p = \frac{1}{2} m_e v^2 - \frac{1}{2} m_e v_0^2$$

$$-q_e (V_f - V_i) = \frac{1}{2} m_e v^2 - 0$$

$$-q_e \left(\frac{k q_p}{.024} - \frac{k q_p}{.036} \right) = \frac{1}{2} m_e v^2$$

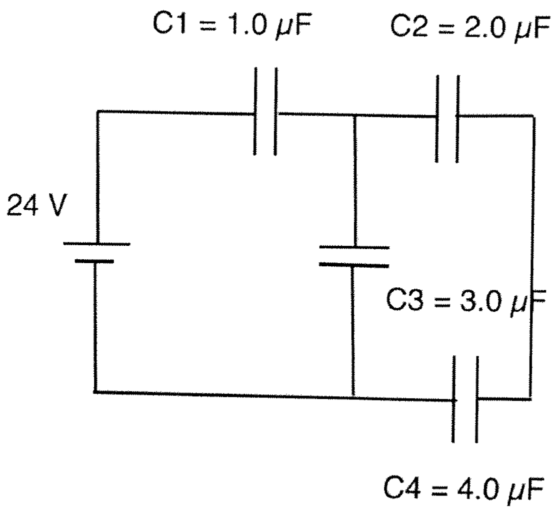
$$-(-1.6 \times 10^{-19})(9 \times 10^9)(1.6 \times 10^{-19}) \left(\frac{1}{.024} - \frac{1}{.036} \right) = \frac{1}{2} (9.11 \times 10^{-31}) v^2$$

$$2.3 \times 10^{-28} \left(\frac{1}{.024} - \frac{1}{.036} \right) = \frac{1}{2} (9.11 \times 10^{-31}) v^2$$

$$3.19 \times 10^{-27} = \frac{1}{2} (9.11 \times 10^{-31}) v^2$$

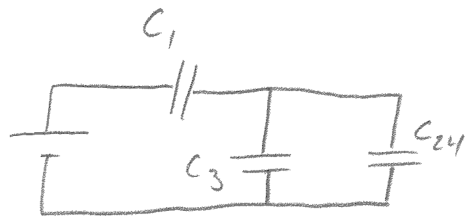
$$v = 84 \text{ m/s}$$

#3. (30 pts) For the circuit shown below, determine the voltage difference across the capacitor C3.



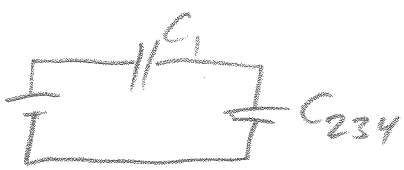
$$\frac{1}{C_{24}} = \frac{1}{C_2} + \frac{1}{C_4}$$

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



$$C_{234} = C_3 + C_{24}$$

$$= 4.33\ \mu F$$



$$\frac{1}{C_{1234}} = \frac{1}{1} + \frac{1}{4.33}$$

$$C_{1234} = 0.812\ \mu F$$

$$\Delta V_{1234} = 24\ V \quad (\text{given})$$

$$\Rightarrow Q_{1234} = 19.5\ \mu C$$

Thus $Q_1 = Q_{234} = Q_{1234} = 19.5\ \mu C$ (series)

If $Q_{234} = 19.5\ \mu C$ + $C_{234} = 4.33\ \mu F$,

then $\Delta V_{234} = 4.5$ Volts

$\Delta V_{234} = \Delta V_3 = \Delta V_{24}$ (parallel)

$\Delta V_3 = 4.5$ Volts