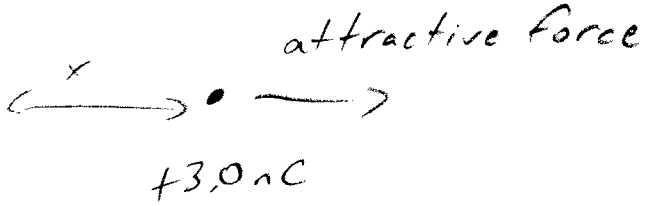
Physics 10164 - Exam 1

Each problem is worth 25 points. 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 of a box and remember to include correct units and significant figures.

1. A +3.0 nC charge is located at the origin. A -5.0 nC charge is located at x = 1.2 meters on the x-axis.

a) Find the magnitude and direction of the electric force that the +3.0 nC charge feels due to the -5.0 charge.

b) Find the location along the x-axis where the net electric field from these two charges is zero.



a) $|F| = \frac{k q_1 q_2}{r^2} = \frac{(9\times10^9)(3\times10^{-9})(5\times10^{-9})}{1.2^2}$

$= \boxed{9.4\times10^{-8}\,N,\ +x\ dir}$

b) $\vec{E} = 0$ to the left of +3.0nC

$|E_3| = |E_5|$

$\frac{k(3)}{x^2} = \frac{k(5)}{(x+1.2)^2} \Rightarrow \frac{3}{5} = \frac{x^2}{(x+1.2)^2}$

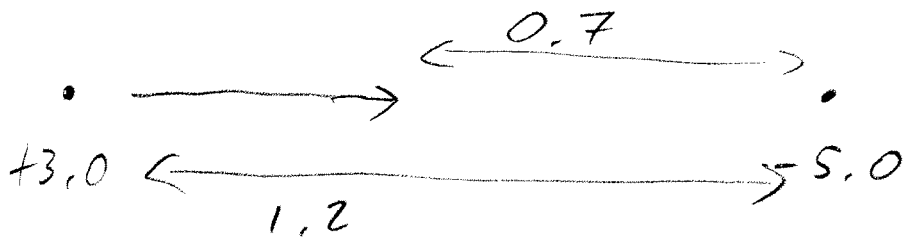
$0.774(x+1.2) = x$

$0.9295 = 0.225x$

$\boxed{x = 4.1\ m \text{ left of } +3.0nC}$

2. Using the same two charges and locations from the previous problem, the +3.0 nC charge is now allowed to move freely (but the -5.0 nC charge remains fixed), and the +3.0 nC charge has a mass of 35 grams.

After the 3.0 nC charge has moved .50 meters, what is the magnitude and direction of its velocity?



Potential due to -5.0 nC charge:

$$V_i = \frac{kq_s}{r_i} = \frac{(9\times10^9)(-5\times10^{-9})}{1.2} = -37.5 \text{ Volts}$$

$$V_f = \frac{kq_s}{r_f} = \frac{(9\times10^9)(-5\times10^{-9})}{.7} = -64.3 \text{ Volts}$$

$$W_E = -q\Delta V = \frac{1}{2}mv^2 - 0$$

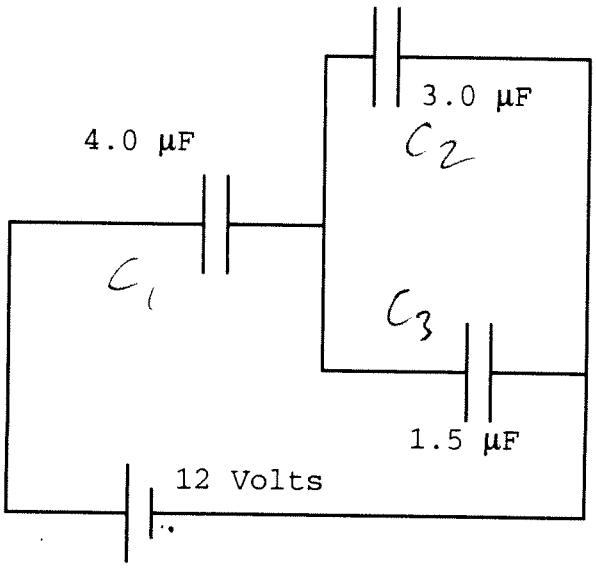
$$-(3.0\times10^{-9})(-26.8 \text{ Volts}) = \frac{1}{2}(.035)v^2$$

$$8.036\times10^{-8} = .0175v^2$$

$$v^2 = 4.59\times10^{-6}$$

$$\boxed{v = 2.1\times10^{-3} \text{ m/s}}$$

3. For the system below, find the charge on the positive plate of the 1.5 μF capacitor.



$C_{23} = 4.5\ \mu F$

$\frac{1}{C_{123}} = \frac{1}{4} + \frac{1}{4.5}$

$C_{123} = 2.12\ \mu F$

$\Delta V_{123} = 12\ Volts$

$Q_{123} = 25.4\ \mu C$

Thus, $Q_{23} = 25.4\ \mu C$

$C_{23} = 4.5\ \mu F$

$\Delta V_{23} = 5.65\ Volts$

Thus

$\Delta V_3 = 5.65\ Volts$

$C_3 = 1.5\ \mu F$

$\boxed{Q_3 = 8.5\ \mu C}$

4. A 750 Watt device is connected with a potential difference of 120 Volts.

a) What is the resistance of the device?

b) If the device operates for 48 hours at a cost of 14 cents per kilowatt-hour, how much will it cost (in cents)?

a) $P = I\Delta V$ or $\frac{\Delta V^2}{R}$

$$750 = \frac{120^2}{R}$$

$$\boxed{R = 19.2\ \Omega}$$

b) $P = 750\ W$

$$E = \frac{750\ J}{s} \cdot \frac{48\ hr}{1} \cdot \frac{3600\ s}{hr}$$

$$= 1.296 \times 10^8\ J$$

$$\text{cost} = 1.296 \times 10^8\ J \cdot \frac{14\ c}{3.60 \times 10^6\ J}$$

$$= \boxed{504\ ¢}$$