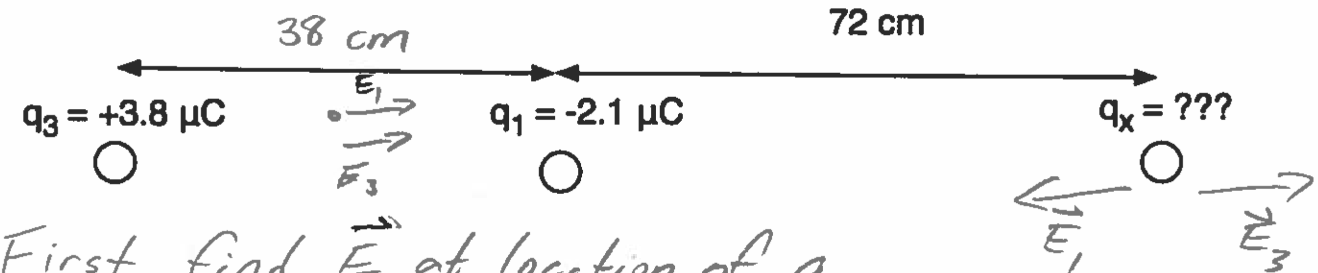
Physics 10164 - Spring 2019 Exam 1D

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 fixed in place in a line as shown.

a) If the electric force on charge q_x is 0.089 N in the +x direction, what is q_x?

b) If q_x were located exactly halfway between q_1 and q_3, what would be the magnitude and direction of electric force it feels?



a) First, find $\vec{E}$ at location of q_x.

$$|E_1| = \frac{(8.99\times10^9)(2.1\times10^{-6})}{.72^2} = 3.642\times10^4$$

$$|E_3| = \frac{(8.99\times10^9)(3.8\times10^{-6})}{1.1^2} = 2.823\times10^4$$

$$E_{TOT} = +|\vec{E}_3| - |\vec{E}_1| = 8.19\times10^3, -x \text{ dir}$$

Since F_E points $+x$, q_x must be negative

$$.089 = |q_x(8.19\times10^3)| \Rightarrow \boxed{q_x = -1.1\times10^{-5}\,C}$$

b)

$$|E_1| = \frac{(8.99\times10^9)(2.1\times10^{-6})}{.19^2} = 5.230\times10^5$$

$$|E_3| = \frac{(8.99\times10^9)(3.8\times10^{-6})}{.19^2} = 9.463\times10^5$$

$$E_{TOT} = +|\vec{E}_1| + |\vec{E}_3| = \boxed{1.5\times10^6\,N, +x \text{ dir}}$$

$$F_E = qE_{TOT} = \boxed{17\,N, -x \text{ dir}}$$

2. (35 pts) A ball with charge -38 μC and mass 23 grams is dropped from rest at a height 1.7 meters above the ground. The ball moves down toward the ground and has a speed of 4.3 m/s the instant before it hits the ground. Assume gravity and the electric force are the only relevant forces.

a) What is the magnitude and direction of the uniform electric field through which the ball moves?

b) If the voltage and ground level is exactly 0.0 Volts, what is the voltage at the ball's initial position?

a) $\Delta y = 1.7\ m$

$V_0 = 0$

$V = 4.3\ m/s$

$a = ?$

$t = ?$

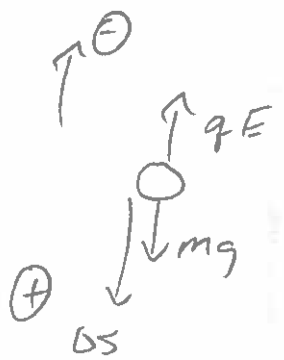
$4.3^2 = 0^2 + 2a(1.7)$

$\Rightarrow a = 5.44\ m/s^2 < 9.8$

So F_E must point ↑

and E must point ↓

since q is negative.

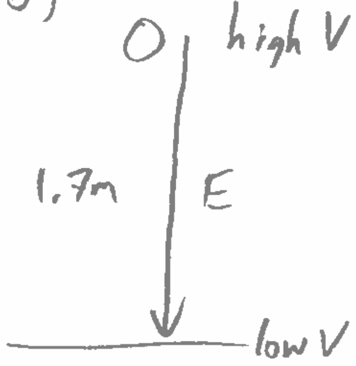


$\Sigma F_y = |mg| - |qE| = ma$

$(.023)(9.8) - (38 \times 10^{-6})E = (.023)(5.44)$

$E = 2600\ V/m$, ↓

b)



$\Delta V = -Ed$

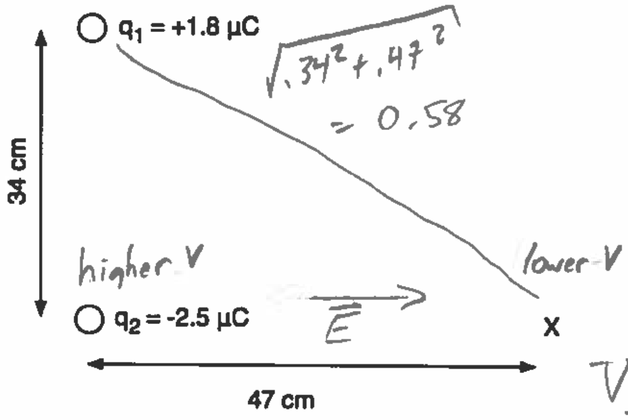
$= -4500\ V = V_f - V_i$ (0)

so $V_i = +4500$ Volts

3. (35 pts) For the arrangement shown below, assume charge q_2 has a mass of 75 grams, and you can assume the only relevant force is the electric force.

a) How much work would be done by the electric force if charge q_2 moved from its location shown to location X?

b) If charge q_2 starts at rest and is free to move from its position shown below, how fast is q_2 moving when it is only 17 cm away from charge q_1?



$$V_i = \frac{k_e q_1}{r_1} = \frac{(8.99\times10^9)(1.8\times10^{-6})}{.34} = 4.76\times10^4$$

$$V_f = \frac{(8.99\times10^9)(1.8\times10^{-6})}{.58} \approx 2.79\times10^4$$

a)

$$W_E = -q_2\,\Delta V_1$$

$$= -(-2.5\times10^{-6})(2.79\times10^4 - 4.76\times10^4)$$

$$= -4.9\times10^{-2} \text{ or } \boxed{-.049\text{ J}}$$

Since $\vec{E}$ points →, F_E points ← for q_2.

So $\vec{F}_E$ + $\vec{\Delta s}$ opposite ⇒ W_E should be negative.

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b) $V_i = 4.76\times10^4$, $V_f = \frac{(8.99\times10^9)(1.8\times10^{-6})}{.17} = 9.52\times10^4$

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

$$-q_2\,\Delta V_1 = \tfrac{1}{2}mv^2 - 0$$

$$-(-2.5\times10^{-6})(9.52\times10^4 - 4.76\times10^4) = \tfrac{1}{2}(.075)v^2$$

$$0.119 = \tfrac{1}{2}(.075)v^2 \Rightarrow \boxed{v = 1.8\text{ m/s}}$$