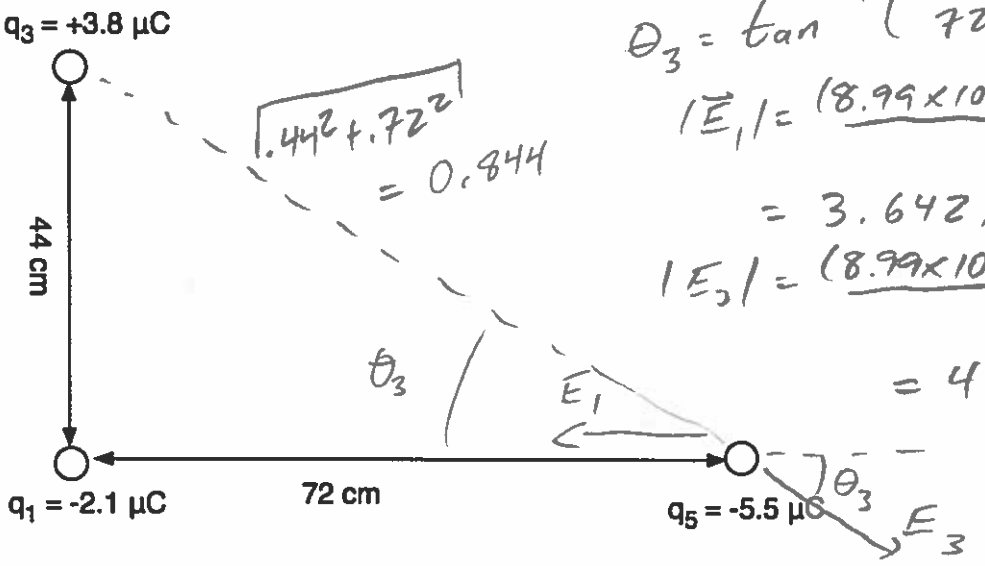
Physics 10164 - Spring 2019 Exam 1E

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) Three charges are fixed in place as shown below.

a) What is the magnitude and direction of the electric field at the location of charge q_5 due to charges q_1 and q_3?

b) If q_5 has a mass of 320 grams, what acceleration does it experience as a result of the electric field? Give both magnitude and direction.



$\theta_3 = \tan^{-1}\left(\frac{44}{72}\right) = 31.4°$

$|\vec{E}_1| = \frac{(8.99\times10^9)(2.1\times10^{-6})}{.72^2}$

$= 3.642\times10^4$ N/C

$|E_3| = \frac{(8.99\times10^9)(3.8\times10^{-6})}{.844^2}$

$= 4.796\times10^4$ N/C

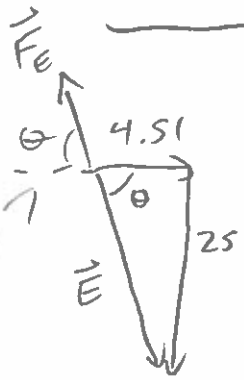
$E_{1x} = -3.642\times10^4 \quad E_{1y} = 0$

$E_{2x} = (4.796\times10^4)\cos 31.4° = 4.093\times10^4$

$E_{2y} = -(4.796\times10^4)\sin 31.4° = -2.5\times10^4$

4.51×10^3

-2.5×10^4 or -25×10^3



$\vec{E} = \sqrt{4.51^2 + 25^2} = \boxed{2.5\times10^4 \text{ N/C}}$

$\theta = \tan^{-1}\left(\frac{25}{4.5}\right) = \boxed{80° \text{ below } +x}$

b) $|\vec{a}| = \frac{|qE|}{m} = \frac{(5.5\times10^{-6})(2.5\times10^4)}{.320} = \boxed{0.44 \text{ m/s}, 80° \text{ above } -x}$

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 0.35 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?

$\Delta y = 1.7\ m$

$V_0 = 0$

$V = 0.35\ m/s$

$a = ?$

$t = ?$

$0.35^2 = 0^2 + 2a(1.7)$

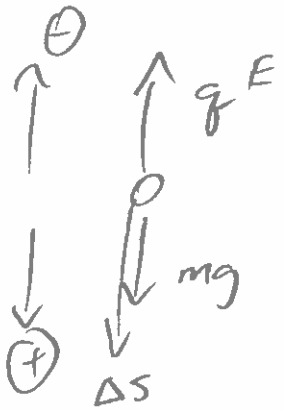
$a = .036 < 9.8$

so F_E must point ↑

and E must point ↓

since moving q is negative

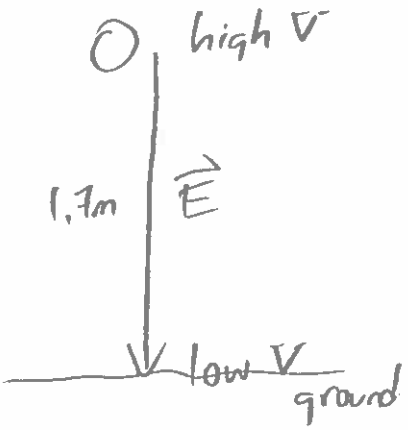
Signs



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

$(.023)(9.8) - (38 \times 10^{-6})E = (.023)(.036)$

$\boxed{E = 5900\ V/m,\ \downarrow}$



$\Delta V = -Ed$

$V_f - V_i = -10047$

$\boxed{V_i = +1.0 \times 10^4\ Volts}$

3. (30 pts) A parallel-plate capacitor has a charge of 0.25 nC on its positive plate and is connected to a 120-Volt battery. If the plate area is 24 cm²…

a) What is the magnitude of the electric field between the plates?
b) What is the capacitance of the capacitor?
c) What is the separation between the plates?

a) $E = \frac{4\pi k_c Q}{A} = \frac{4\pi(9\times10^9)(.25\times10^{-9})}{24\times10^{-4}} = \boxed{1.2\times10^4\ N/C}$

b) $C = \frac{Q}{\Delta V} = \frac{0.25\times10^{-9}}{120} = \boxed{2.1\times10^{-12}\ F}$

c) $C = \frac{A}{4\pi k_c d} \Rightarrow d = \frac{A}{4\pi k_c C} = \frac{24\times10^{-4}}{4\pi(9\times10^9)(2.1\times10^{-12})}$

$= \boxed{1.0\times10^{-2}\ m}$

or 1.0 cm

The plates are disconnected from the battery, and then some applied force moves the plates further apart, doubling their separation. After the plates are moved…

d) What is the charge on the positive plate?
e) What is the voltage difference between the plates?
f) What is the capacitance of the capacitor?

d) Q same, nowhere for charge to go, $\boxed{Q = .25\ nC}$

e) E same, but d ↑, since $\Delta V = Ed$, ΔV doubles

$\boxed{\Delta V_{new} = 240\ Volts}$

f) $C \propto \frac{1}{d}$, so C is cut in half, $\boxed{C = 1.1\times10^{-12}\ F}$