Physics 10164 - Summer 2017 - Exam #1

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.

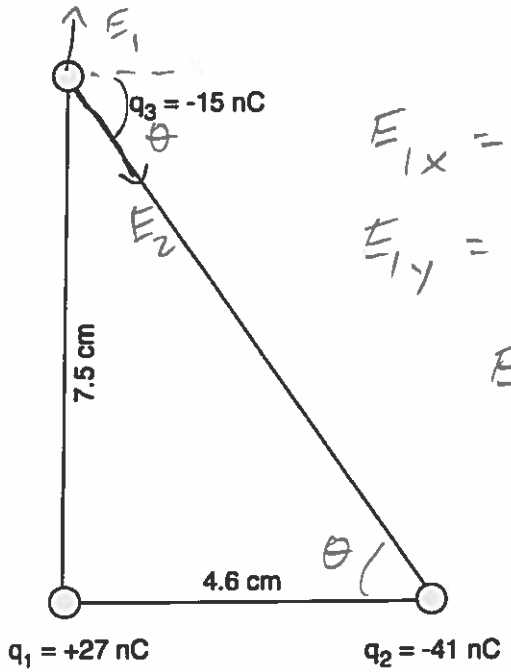
1. (35 pts) Three charges are arranged in a right-triangle as shown and fixed in place. The lengths of two sides of the triangle are given.

a) Determine the magnitude and direction of the electric field at the location of the -15 nC particle due to the other charges.

b) Determine the magnitude and direction of the electric force acting on the -15 nC particle.

$\theta = \tan^{-1}\left(\frac{7.5}{4.6}\right) = 58.48°$ $E_1 = \left|\frac{k_c q_1}{r_1^2}\right| = 43{,}200$ +y dir

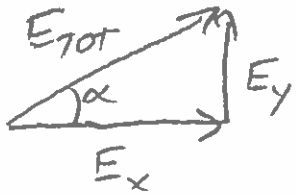
$r_2 = \sqrt{4.6^2 + 7.5^2} = 8.8\text{ cm}$ $E_2 = \left|\frac{k_c q_2}{r_2^2}\right| = 47{,}650,\ 58.48°$ below +x



$E_{1x} = 0$ $E_{2x} = 24{,}911$

$E_{1y} = 43200$ $E_{2y} = -40{,}619$

$E_{TOT,x} = 24{,}911$ $E_{TOT,y} = 2581$



$E_{TOT} = \sqrt{24911^2 + 2581^2} = \boxed{25{,}000\ N/C}$

$\alpha = \tan^{-1}\left(\frac{2581}{24911}\right) = \boxed{5.9°\text{ above } +x}$

b) $F_E = |qE|$

$= \boxed{3.8 \times 10^{-4}\ N,\ 5.9°\text{ below } -x}$

opposite dir from $\vec{E}$ since it is a Θ charge.

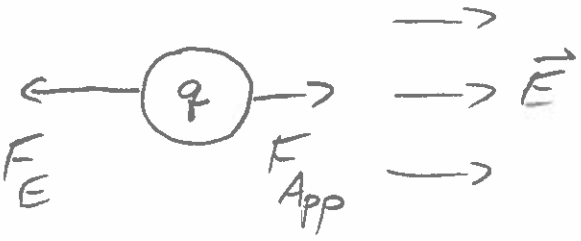
2. (35 pts) A Helium-filled balloon has a mass of 85 grams, and it is blown horizontally by a steady breeze that results in a 7.5 Newton applied force in the +x direction. Assume the balloon has a charge of -34 μC.

The balloon is moving through an electric field of 240,000 N/C that points in the +x direction. Since the balloon is moving horizontally, you can ignore both gravity and the buoyant force in this problem. They just cancel out. Only the applied force and electric force are relevant.

a) In which direction does the balloon move, assuming it starts at rest?
b) How fast is the balloon moving after it has travelled 51 cm?
c) If the electric potential (voltage) at the initial position of the balloon is 59,000 Volts, what is the voltage at the final position of the balloon?

a) $|F_E| = |qE|$

$= 8.16\,N$



Since $F_E > F_{App}$, balloon moves in <u>-x dir</u>

b) $\Sigma W_F = W_E + W_{App} = \frac{1}{2}mv^2 - 0$

$(8.16)(.51) - (7.5)(.51) = \frac{1}{2}(.085)v^2$

$0.3366 = .0425v^2$

$\boxed{v = 2.8\ m/s}$

c) Since $\vec{E}$ points from higher V → lower V + balloon moves against $\vec{E}$ lines, V_f must be larger $V_f - V_i = +Ed$

$V_f = 59000 + (240000)(.51) = \boxed{180{,}000\ V}$

#3. (30 pts) A circuit loop contains a 120-Volt battery, a switch (initially open), a 35,000 Ohm resistor and a capacitor. After some experimentation, you realize that if the switch is closed at t = 0, the voltage drop across the resistor is 55 Volts after 5.0 seconds have passed.

a) What is the capacitance of the capacitor?
b) What is the voltage drop across the capacitor at t = 5.0 seconds?
c) At what time will the voltage drop across the capacitor be 98 Volts?

a) $\mathcal{E} = 120$ Volts

$R = 35{,}000\,\Omega$

At $t = 5.0\,s$, $\Delta V_R = 55$ Volts

$\Delta V_R = IR \Rightarrow I = .00157\,A$

$I_{max} = \mathcal{E}/R = .00343\,A$

$I(t) = I_{max} e^{-t/RC}$

$0.458 = e^{-t/RC}$

$-0.781 = -\frac{t}{RC}$

$C = \frac{t}{.781R}$

$= \boxed{1.8 \times 10^{-4}\,F}$

b) $\Delta V_R + \Delta V_C = 120 \Rightarrow \boxed{\Delta V_C = 65 \text{ Volts}}$ (loop rule)

c) $\Delta V_C = \frac{Q}{C}$, $Q = Q_{max}(1 - e^{-t/RC})$

$\Delta V_C = \frac{C\mathcal{E}}{C}(1 - e^{-t/RC}) = 120(1 - e^{-t/6.3})$

$98 = 120(1 - e^{-t/6.3})$

$0.817 = 1 - e^{-t/RC}$

$0.183 = -e^{-t/6.3}$

$1.7 = \frac{t}{6.3} \Rightarrow \boxed{t = 11\,s}$