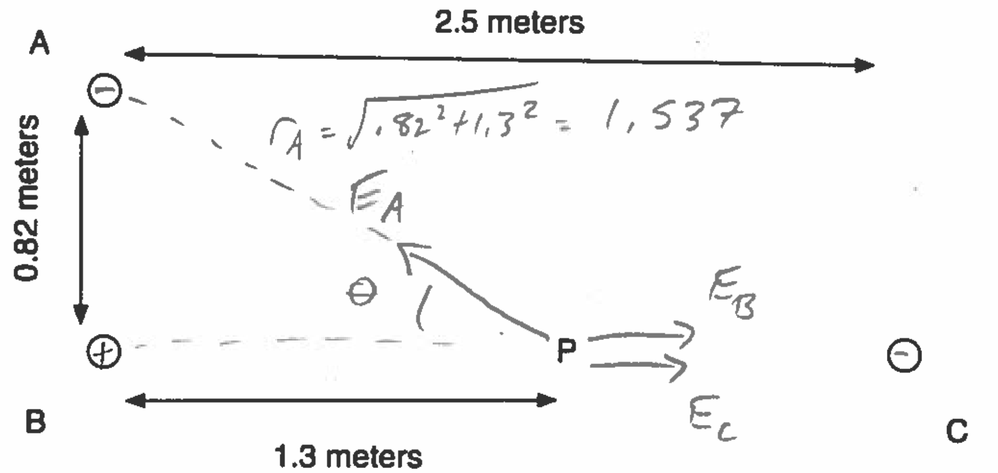
# Physics 10164 - Summer 2019 - Exam #1B

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) In the arrangement below, find the magnitude and direction of the electric field at point P, which is 1.3 meters away from charge $q_B$ and 1.2 meters away from charge $q_C$ as shown.

$q_A = -56$ nC, $q_B = 35$ nC, $q_C = -22$ nC.

$$\theta = \tan^{-1}\left(\frac{.82}{1.3}\right) = 32.2^\circ$$




$$|E_A| = \left|\frac{k_c q_A}{r_A^2}\right| = \frac{(9\times10^9)(+56\times10^{-9})}{1.537^2} = 213.35,\ 32.2^\circ \text{ above } -x$$

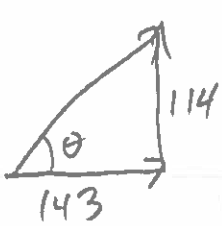
$$|E_B| = \left|\frac{k_c q_B}{r_B^2}\right| = \frac{(9\times10^9)(35\times10^{-9})}{1.3^2} = 186.39,\ \rightarrow$$

$$|E_c| = \left|\frac{k_c q_c}{r_c^2}\right| = \frac{(9\times10^9)(22\times10^{-9})}{1.2^2} = 137.50,\ \rightarrow$$

$$E_{Ax} = -213.35\cos 32.2^\circ = -180.54$$

$$E_{Ay} = +213.35\sin 32.2^\circ = 113.69 = E_{TOT,y}$$

$$E_{TOT,x} = -180.54 + 186.39 + 137.50 = 143.35$$




$$E_{TOT} = \sqrt{E_x^2 + E_y^2} = \boxed{180\ N/c}$$

$$\theta = \tan^{-1}\left(\frac{113.69}{143.35}\right) = \boxed{38^\circ \text{ above } +x}$$

2. (30 pts) A parallel-plate capacitor has a cross-sectional area of 3.8 $cm^2$ and a plate separation of 4.7 mm. It is connected to a 12-Volt battery.

a) What is the charge on the positive plate of the capacitor?
b) What is the magnitude of the electric field between the plates?
c) Keeping the capacitor plates connected to the battery, the plates are pulled apart to a new separation of 7.5 mm. What happens to the charge on the positive plate? Justify your answer qualitatively or mathematically.
d) The capacitor is restored to its original 4.7 mm separation. Now a dielectric with K = 4.0 is inserted between the plates, and the system is allowed time to reach a new equilibrium with the plates still connected to the battery. What is the new charge on the positive plate?
e) What is the electric field between the plates after they have reached equilibrium with the dielectric inserted?

a) $\vec{E} = \frac{\Delta V}{d} = \frac{4\pi k Q}{\text{Area}}$

$$\frac{12}{4.7\times10^{-3}} = \frac{4\pi(9\times10^{9})Q}{3.8\times10^{-4}}$$

$$\Rightarrow \boxed{Q = 8.6\times10^{-12}\ C}$$

b) $|\vec{E}| = \frac{12}{4.7\times10^{-3}} = \boxed{2600\ N/C}$

c) $C = \frac{\text{Area}}{4\pi k_e d}$ If $d\uparrow$, $C\downarrow$, so $\boxed{Q \text{ also } \downarrow}$

since $\Delta V$ remains same from battery

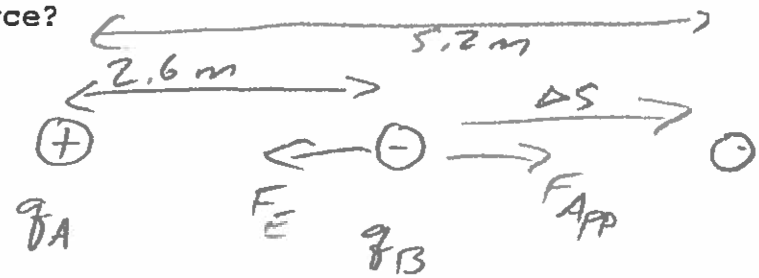
d) $C_{new} = 4.0\, C_{old}$, so $Q_{new} = 4.0\, Q_{old}$

$= \boxed{3.4\times10^{-11}\ C}$

e) $\Delta V$, $d$ same, so $\vec{E}$ still $\boxed{2600\ N/C}$

#3. (35 pts) A 3.0 μC (A) is fixed at the origin. Nearby, at a coordinate x = 2.6 mm, a -4.8 μC charge (B) with a mass of 270 grams is initially at rest. An applied force acts on charge B as well as the electric force, and the charge B moves to coordinate x = 5.2 mm. When it arrives at x = 5.2 mm, the charge now has a speed of 12 m/s in a direction away from the origin.

Assuming only the electric force at the applied force are relevant in this problem, how much work is done by the applied force?




$$\Sigma W_F = W_E + W_{App} = \Delta K$$

$$-q_B \Delta V_A + W_{App} = \tfrac{1}{2}(.270)(12)^2 - 0$$

$$-(-4.8\times10^{-6})\left(\frac{k_c q_A}{r_f} - \frac{k_c q_A}{r_i}\right) + W_{App} = 19.44$$

$$-(-4.8\times10^{-6})(9\times10^{9})(3.0\times10^{-6})\left(\frac{1}{.0052} - \frac{1}{.0026}\right) + W_{App} = 19.44$$

$$0.1296(-192.31) + W_{App} = 19.44$$

$$-24.92 + W_{App} = 19.44$$

$$\boxed{W_{App} = 44\ J}$$