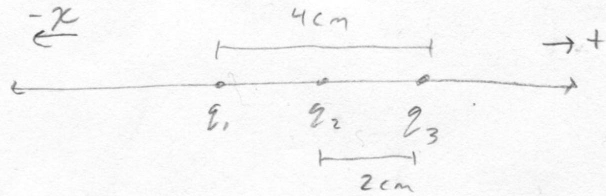
Quiz 1A Solutions



And, $q_1 = +.125\,C$ $q_2 = +2C$ $q_3 = -.125C$

$\vec F_{net\,on\,q_3} = \vec F_{q_1\to q_3} + \vec F_{q_2\to q_3} = \vec F_{13} + \vec F_{23}$ Now, recall $|\vec F| = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_2|}{r^2}$! don't forget absolute sign

Note, $\vec F_{13}$ and $\vec F_{23}$ point in the same direction, so we add the two forces.

$$|\vec F_3| = \frac{1}{4\pi\epsilon_0}\left[\frac{(.125)(.125)}{(4\times10^{-2})^2} + \frac{2(.125)}{(2\times10^{-2})^2}\right] \simeq (9\times10^9)\left[\frac{1}{(8\times4)^2\times10^{-4}} + \frac{2}{(8\times4)\times10^{-4}}\right]$$

$$= 9\times10^9\left[10^4\left(\frac{1}{32}\right)\left[\frac{1}{32}+2\right]\right] = \frac{9\times65}{(32)^2}\times10^{13} = \frac{585}{1024}\times10^{13}$$

since q_1, q_2 pull q_3 in "$-x$" direction $\Rightarrow$ $\boxed{\vec F_{13} \simeq 5.7\times10^{12}(-\hat i)[N]}$

or $-5.7\times10^{12}\,\hat i$

Now, recall $\vec F_{elec} = q\vec E$

Since, $\vec E_{at\,q_3} = \vec E_{13} + \vec E_{23}$ with $\vec E_{13} = \frac{1}{4\pi\epsilon_0}\frac{1}{8(4\times10^{-2})^2}\hat i$ ($\vec E_1$ points in "$+x$" direction at q_3)

$\vec E_{23} = \frac{1}{4\pi\epsilon_0}\frac{2}{(2\times10^{-2})^2}\hat i$ (same)

thus, $\vec E_3 = (9\times10^9)\left[10^4\left(\frac{1}{8\times16}+\frac{1}{2}\right)\right]\hat i$

$\Rightarrow 9\times10^{13}\left[\frac{1}{2}\left(\frac{1}{64}+1\right)\right] = \frac{9\times65}{128}\times10^{13}$

$= \frac{585}{128}\times10^{13}$

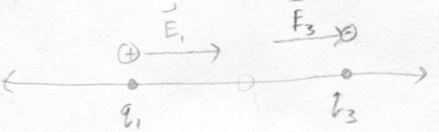
$\boxed{\vec E_3 \simeq 4.57\times10^{13}\,\hat i\left[\frac{N}{C}\right]}$

Once more, $\vec F_2 = \vec F_{12} + \vec F_{32}$ but notice $|\vec F_{12}| = |\vec F_{32}|$, with $\vec F_{12} = -\vec F_{32}$

So, $\vec F_2 = 0$. Here, Symmetry saves the day!

And $\vec E_2 = \vec E_{12} + \vec E_{32} = \frac{1}{4\pi\epsilon_0}\frac{.125}{4\times10^{-4}}\hat i + \frac{1}{4\pi\epsilon_0}\frac{.125}{4\times10^{-4}}\hat i = 9\times10^{13}\left(\frac{1}{16}\right)\hat i$

$\boxed{\vec E_2 = \frac{9}{16}\times10^{13}\,\hat i\left[\frac{N}{C}\right]}$



! Draw a picture!

Now, recall that $U = -\vec{p} \cdot \vec{E}$ where $\vec{p}$ = electric dipole moment

$= -pE\cos\phi$

here, $|\vec{p}| = p_{13} = (.125)(4\times10^{-2})$ [C·m]

$|\vec{E}| = 5\times10^{5}$ $\left[\frac{N}{C}\right]$

Now, the minimum occurs when $\cos\phi$ is at its maximum because of the minus sign. So, $\cos\phi = 1$ which is its maximum value at $\phi = 0$.

This means $\vec{E} \parallel \vec{p}$!

units of work

thus $U_{min} = -\left(\frac{4}{8}\right)(5)\left(\frac{10^5}{10^2}\right)$ [N·m] $= -2.5\times10^{3}$ [N·m]

Conceptual Question

Points:

1. charge cannot move through an insulator, and so it builds up

+1. conversely, charge can move through a conductor, eliminating build-up.