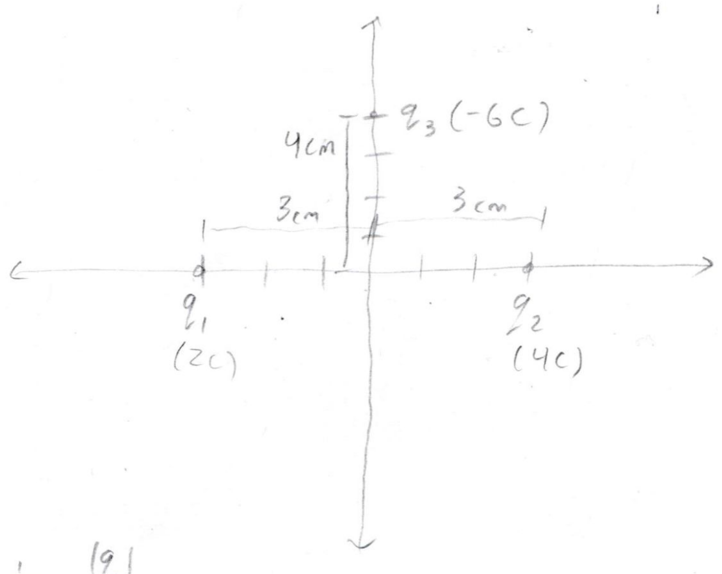
Quiz 1C Solutions



Recall, $E = \frac{1}{4\pi\epsilon_0}\frac{|q|}{r^2}$

By superposition principle, $\vec{E}_{\text{at origin}} = \vec{E}_{q_1\to\text{origin}} + \vec{E}_{q_2\to\text{origin}} + \vec{E}_{q_3\to\text{origin}}$

! It is NOT true that $E_1 + E_2 + E_3 = E$ since $|\vec{E}| \neq |\vec{E}_1| + |\vec{E}_2| + |\vec{E}_3|$ but, $\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3$ → $\vec{E} = |\vec{E}_1 + \vec{E}_2 + \vec{E}_3|$

so, Verify for yourself that $|\vec{E}_1 + \vec{E}_2 + \vec{E}_3| \neq |\vec{E}_1| + |\vec{E}_2| + |\vec{E}_3|$

with $\vec{E}_1 = \frac{1}{4\pi\epsilon_0}\frac{2}{(3\times10^{-2})^2}$ to the right ($+x$ direction or $\hat{i}$)

$\vec{E}_2 = \frac{1}{4\pi\epsilon_0}\frac{4}{(3\times10^{-2})^2}$ to the left ($-x$ direction or $-\hat{i}$)

$\vec{E}_3 = \frac{1}{4\pi\epsilon_0}\frac{6}{(4\times10^{-2})^2}$ up (y direction or $\hat{j}$)

so,

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\left[\left(\frac{1}{9\times10^{-4}}\right)(2-4)\hat{i} + \left(\frac{1}{16\times10^{-4}}\right)(6)\hat{j}\right]\left[\frac{N}{C}\right]$$

$$\boxed{\vec{E} = (9\times10^{13})\left[-\frac{2}{9}\hat{i} + \frac{3}{8}\hat{j}\right]\left[\frac{N}{C}\right]}$$

you may simplify with a calculator...

or $\boxed{\vec{E} = -2\times10^{13}\,\hat{i} + 3.375\times10^{13}\,\hat{j}\left[\frac{N}{C}\right]}$

Grading Key

Direction (+1)

Magnitude of $\vec{E}_1, \vec{E}_2, \vec{E}_3$ (+1)

Vector sum to get $\vec{E}$ (+1)

the net electric force on q_3 .....

Recall $F = \frac{1}{4\pi\epsilon_0}\frac{|q_1||q_2|}{r^2}$ so, by superposition, $\vec{F}_3 = \vec{F}_{13} + \vec{F}_{23}$

Note: $r_{13} = \sqrt{3^2+4^2} = 5 = r_{23}$ [cm] (they form 3-4-5 triangles)

we will also need the direction of r_{13}, r_{23}

$$\hat{r}_{13} = \frac{-(3\times10^{-2})\hat{i} + (4\times10^{-2})\hat{j}}{(5\times10^{-2})} \left[\frac{m}{m}\right] = -\frac{3}{5}\hat{i} - \frac{4}{5}\hat{j} \text{ [Unitless!]}$$

$$\hat{r}_{23} = \frac{-(3\times10^{-2})\hat{i} + (4\times10^{-2})\hat{j}}{(5\times10^{-2})} = +\tfrac{3}{5}\hat{i} - \frac{4}{5}\hat{j}$$ Note the minus sign!

so,

$$\vec{F}_{13} = -(9\times10^{13})\left(\frac{12}{25}\right)\left(\tfrac{3}{5}\hat{i} + \tfrac{4}{5}\hat{j}\right)[N] \quad \vec{F}_{23} = (9\times10^{13})\left(\frac{24}{25}\right)\left(+\tfrac{3}{5}\hat{i} - \tfrac{4}{5}\hat{j}\right)[N]$$

$$\vec{F}_3 = (9\times10^{13})\left[\left(\frac{3}{5}\right)\left(\frac{24}{25} - \frac{12}{25}\right)\hat{i} - \frac{4}{5}\left(\frac{12}{25} + \frac{24}{25}\right)\hat{j}\right][N]$$

$$= \ldots \left[\frac{3}{5}\left(\frac{12}{25}\right)\hat{i} - \frac{4}{5}\left(\frac{36}{25}\right)\hat{j}\right][N]$$

$.288 \simeq .29$ $\quad 1.152 \simeq 1.15$

$$\boxed{\vec{F}_3 \simeq 2.6\times10^{13}\,\hat{i} - 1\times10^{14}\,\hat{j}\ [N]}$$

or 10.35×10^{13}

Note: $\vec{F} = |\vec{F}|\hat{r}$
$= |\vec{F}|_x(\pm\hat{i}) + |\vec{F}|_y(\pm\hat{j})$
$= |\vec{F}_{12}|\hat{r}_{12} + |\vec{F}_{13}|\hat{r}_{13}$
ie $\vec{F} = \vec{F}_{12} + \vec{F}_{13}$

Grad's key

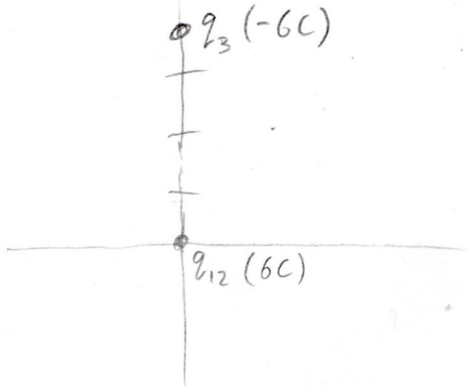
Magnitude of $\vec{F}_{13}, \vec{F}_{23}$ (+1)

direction of $\vec{F}_{13}, \vec{F}_{23}$ or full expression for vectors (+1)

Vector sum to obtain $\vec{F}_3$ (+1)

(+1)

Recall $p = qd$ whee p is the electric dipole, q is the shared magnitude of the charge for either end, and d is the seperation betwen the charges. So, our figure now looks like...



hence the magnitude of the dipole $\vec{p}$ is $p = (6)(4\times10^{-2})\,[C\cdot m]$

$$\boxed{p = 2.4\times10^{-1}\,[C\cdot m]}$$

Now, the net force on a dipole is ZERO in a uniform electric field. If we imagine these two charges assembled together, the net charge of the dipole is also

(+1) ZERO. So, the electrostatic force $\vec{F} = q\vec{E}$ is zero because $q_{dipole} = 0$. Torque, however, is NONZERO.

(or $\Sigma q = 0$)

Conceptual Question

Points

(2) ~~(2/3)~~ • the sphere with a net positive charge will induce a temporary seperation of charges in the neutral sphere, causing the side closest to the charged sphere to have a local negative charge.

or + ← either one can garner full points.

(2) (2/3) • This will cause an attraction force between both spheres.

\+

or optional (0) (2/3) • After they touch, both will have net positive charge, causing a slight repelling force betwen them. ✓

1C-P3