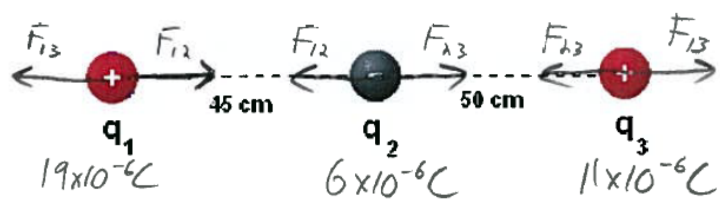
Quiz 10 Electrostatics

Question 1.

Three charges are arranged along a single axis as in the diagram below.
$q_1 = +19\mu C$, $q_2 = -6\mu C$, and $q_3 = +11\mu C$

What is the magnitude of the net force on q_1?



a. **What is the magnitude of the net force on q_1?**

$\Sigma F_1 = F_{12} - F_{13}$

$= \frac{kq_1q_2}{(r_{12})^2} - \frac{kq_1q_3}{(r_{13})^2}$

$= \frac{(9\times10^9)(19\times10^{-6})(6\times10^{-6})}{(.45)^2} - \frac{(9\times10^9)(19\times10^{-6})(11\times10^{-6})}{(.95)^2}$

$\Sigma F_1 = \boxed{2.98N}$

$F_{12} = \frac{kq_1q_2}{(r_{12})^2}$ $\quad r_{12} = 45cm = 0.45m$

$F_{23} = \frac{kq_2q_3}{(r_{23})^2}$ $\quad r_{23} = 50cm = 0.5m$

$F_{13} = \frac{kq_1q_3}{(r_{13})^2}$ $\quad r_{13} = 95cm = 0.95m$

b. **What is the magnitude of the net force on q_2?**

$\Sigma F_2 = F_{23} - F_{12}$

$= \frac{kq_2q_3}{(r_{23})^2} - \frac{kq_1q_2}{(r_{12})^2}$

$= \frac{(9\times10^9)(6\times10^{-6})(11\times10^{-6})}{(.5)^2} - \frac{(9\times10^9)(19\times10^{-6})(6\times10^{-6})}{(.45)^2} = -2.69$

$\boxed{\Sigma F_2 = 2.69N}$

$\uparrow F_{13}$

Question 2.

Two point charges are located on the x axis. The first is a charge $+Q$ at $x = -a$. The second is an unknown charge located at $x = +3a$. The net electric field these charges produce at the origin has a magnitude of $2k_eQ/a^2$. What are the two possible values of the unknown charge?

The electric fields produced by tow charges at a point between them, are in general opposite in directions. Since we know that the charge Q is positive then it field will be pointing in the direction of the positive x (to the right) or in the direction of $+\hat{\boldsymbol{\imath}}$ where $\hat{\boldsymbol{\imath}}$ is the unit vector along the x-axis, i.e.

$$\frac{2k_eQ}{a^2}(\hat{\boldsymbol{\imath}}) = \frac{k_eQ}{a^2}(\hat{\boldsymbol{\imath}}) + \frac{k_eq}{(3a)^2}(-\hat{\boldsymbol{\imath}}) \tag{23.1}$$

The charge q can be $+ve$ or $-ve$. If the total field is positive, then q must be negative and we get:

$$\frac{2k_eQ}{a^2}(\hat{\boldsymbol{\imath}}) = \frac{k_eQ}{a^2}(\hat{\boldsymbol{\imath}}) + \frac{k_eq}{(3a)^2}(-\hat{\boldsymbol{\imath}}) \quad \text{or} \quad \frac{q}{9} = Q - 2Q \quad \text{and} \quad q = -9Q$$

If on the other hand, the total field is negative, then q must be positive and we get:

$$\frac{2k_eQ}{a^2}(-\hat{\boldsymbol{\imath}}) = \frac{k_eQ}{a^2}(\hat{\boldsymbol{\imath}}) + \frac{k_eq}{(3a)^2}(-\hat{\boldsymbol{\imath}}) \quad \text{or} \quad -\frac{q}{9} = -2Q - Q \quad \text{and} \quad q = +27Q$$