Electric Force

Let's review: A negative charge is caused by an excess of electrons
Whereas a positive charge results from the deficit (shortage) of electrons.

The basic unit of charge is the Coulomb (C).

The charge of a single electron is -1.60×10^{-19} C whereas the charge of a single proton is $+1.60 \times 10^{-19}$ C. The symbol q denotes the total amount of charge on an object.

The Law of Electric Charges states:
Like charges repel, unlike charges attract.

This attractive or repulsive interaction between any two charged objects is called the electric force, F_E, and it is very similar to gravity.

Coulomb determined that the force between two charged objects is directly proportional to their charges and inversely proportional to their distance.

$$F_E = k\frac{q_1 q_2}{r^2}$$

Where k = Coulomb's constant = 8.99×10^9 N·m^2/C^2
q_1 = 1st charge, measured in C
q_2 = 2nd charge, measured in C
r = distance between charges, measured in m

Example: Two point charges of 1.8×10^{-6} C and 2.4×10^{-6} C produce a force of 2.2×10^{-3} N on each other. How far apart are these charges?

$$F_E = k\frac{q_1 q_2}{r^2}$$

$$r^2 = k\frac{q_1 q_2}{F_E}$$

$$r = \sqrt{\frac{k q_1 q_2}{F_E}}$$

$$r = \sqrt{\frac{(8.99\times10^9 \text{ N·m}^2/\text{C}^2)(1.8\times10^{-6})(2.4\times10^{-6})}{2.2\times10^{-3}\text{ N}}}$$

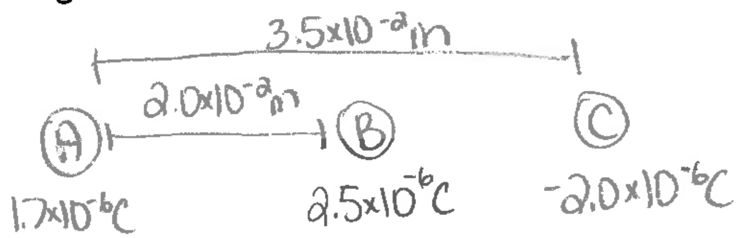
$$= \boxed{4.2\text{ m}}$$

Let's compare...

	Gravitational Force	Electrical Force	Notes
Force formula	$F_g = \frac{Gm_1m_2}{r^2}$	$F_E = \frac{kq_1q_2}{r^2}$	Both are inverse-square laws for distance
Direction of force	only attractive	attractive or repulsive	—
Range	infinity	infinity	Both are action-at-a-distance forces (or non-contact)
Relative strength	1 governs large bodies	10^{37} governs smaller bodies	Gravity is the weakest force in nature $G = 6.67\times10^{-11}\ Nm^2/kg^2$ $k = 8.99\times10^9\ Nm^2/C^2$

Note that when solving for electric force, the signs of the charges are not included. Instead, we determine the direction of the force based on whether it is an attraction or a repulsion.

Example: A charge of 1.7×10^{-6} C is placed 2.0×10^{-2} m from a charge of 2.5×10^{-6} C and 3.5×10^{-2} m from a charge of -2.0×10^{-6} C as shown. What is the net electric force on the 1.7×10^{-6} charge?



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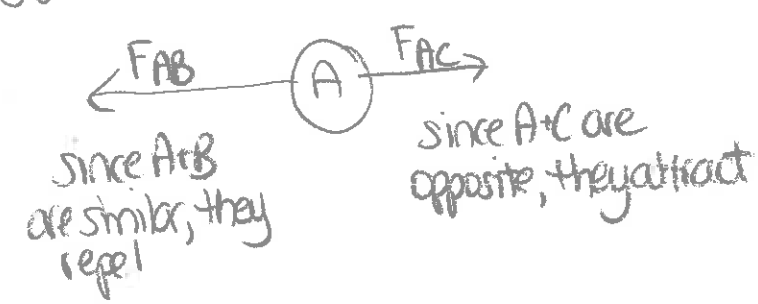

F_{net} = Winner − Loser

$= F_{AB} - F_{AC}$

$= \frac{kq_Aq_B}{r_{AB}^2} - \frac{kq_Aq_C}{r_{AC}^2}$

$= \frac{(8.99\times10^9)(1.7\times10^{-6})(2.5\times10^{-6})}{(2.0\times10^{-6})^2} - \frac{(8.99\times10^9)(1.7\times10^{-6})(2.0\times10^{-6})}{(3.5\times10^{-2})^2}$

don't use negative!

$= 71\ N$