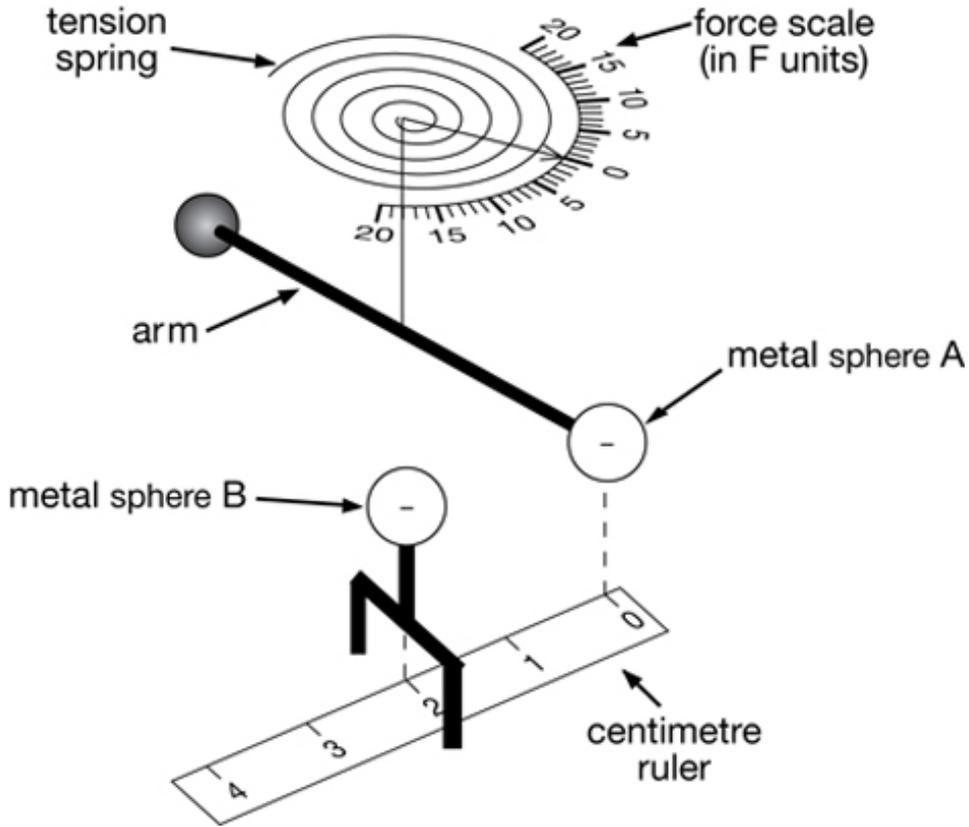


L02 - Coulomb's Law in 1-Dimension

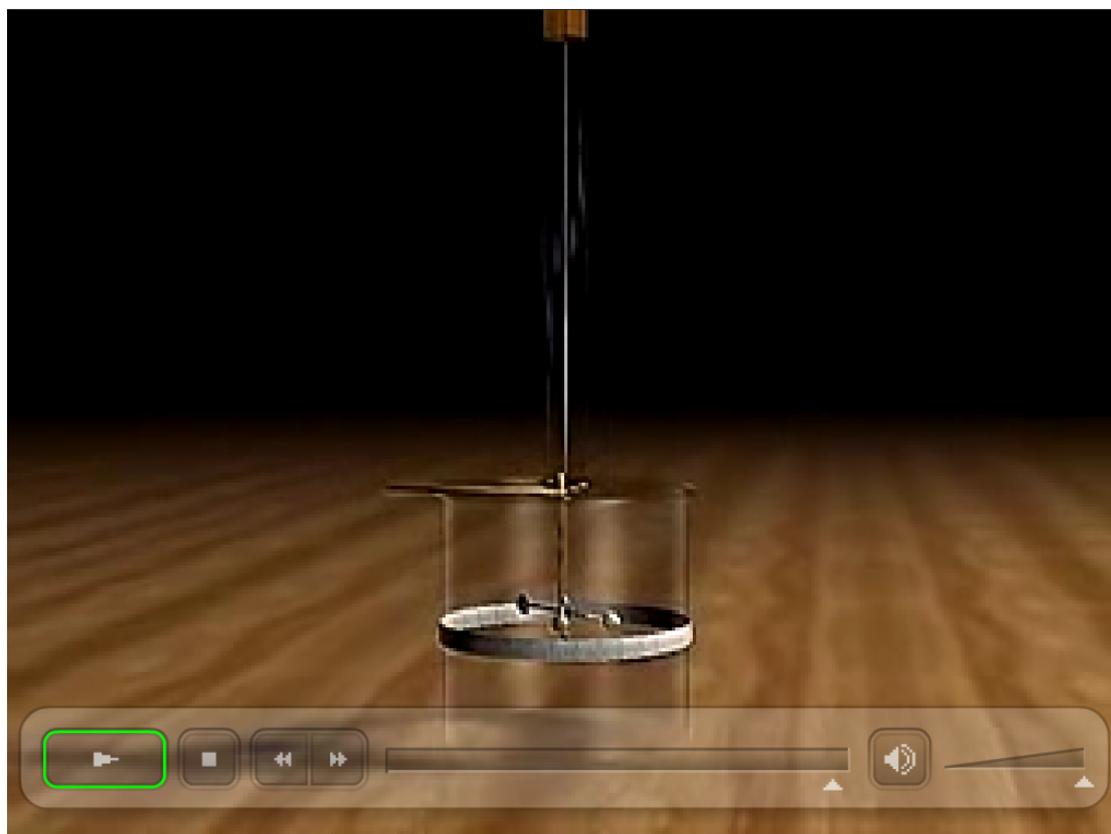
Coulomb's Torsion Balance Experiment



$$\begin{array}{c} 10C \\ \circlearrowleft \\ q \end{array} + \begin{array}{c} 0C \\ \circlearrowleft \\ \end{array} = \begin{array}{c} 5C \\ \circlearrowleft \\ \frac{1}{2} q \end{array} \begin{array}{c} 5C \\ \circlearrowleft \\ \frac{1}{2} q \end{array}$$

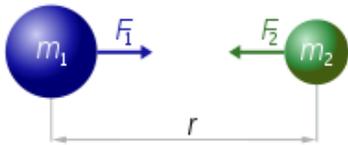
$$\begin{array}{c} 5C \\ \circlearrowleft \\ \frac{1}{2} q \end{array} + \begin{array}{c} 0C \\ \circlearrowleft \\ \end{array} = \begin{array}{c} 2.5C \\ \circlearrowleft \\ \frac{1}{4} q \end{array} \begin{array}{c} 2.5C \\ \circlearrowleft \\ \frac{1}{4} q \end{array}$$

Coulomb's Torsion Balance Experiment



The "Inverse r^2 " Relationship

Gravitational Force



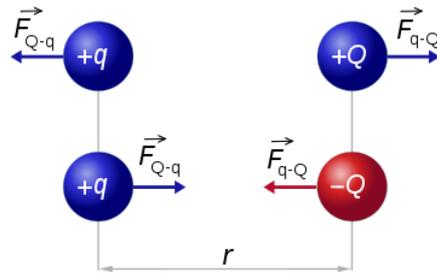
$$|\vec{F}_g| = \frac{G m_1 m_2}{r^2}$$

G ← mass → mass

Gravitational Constant $G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$



Electrostatic Force

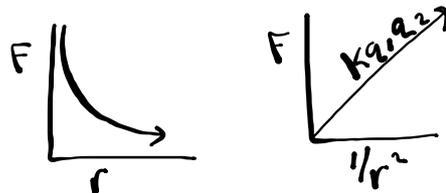


$$|\vec{F}_e| = \frac{k q_1 q_2}{r^2}$$

k ← charged → Charge

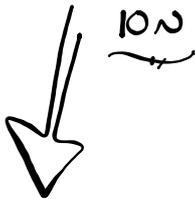
Coulomb's Law Constant .. $k = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$

Elementary Charge $e = 1.60 \times 10^{-19} \text{ C}$



Q1: Two charged spheres, separated by a certain distance, attract each other with an electrostatic force of 10 N. What will be the new force if the charge on both spheres is doubled and the separation distance is halved.

$$F_e = \frac{kq_1q_2}{r^2}$$



Triple q_1
 $\frac{3}{2}$ dist.

$$\begin{aligned} F_{new} &= \frac{k(3q_1)q_2}{\left(\frac{3}{2}r\right)^2} \\ &= \frac{3kq_1q_2}{\frac{9}{4}r^2} \\ &= \frac{4}{3} \left(\frac{kq_1q_2}{r^2} \right) \\ &= 13.\bar{3}N \end{aligned}$$

$$F_{new} = \frac{k(2q_1)(2q_2)}{\left(\frac{1}{2}r\right)^2} = \frac{4kq_1q_2}{\frac{1}{4}r^2}$$

$$(ab)^2 = a^2b^2$$

$$\frac{4}{1} \left(\div \frac{1}{4} \right) = \frac{4}{1} \times \frac{4}{1} = \frac{16}{1}$$

$$F_{new} = 16 \left(\frac{kq_1q_2}{r^2} \right) = 16(10N) = 160N$$

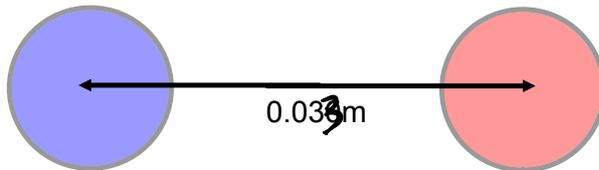
$$3 \div \frac{9}{4}$$

$$3 \div 9 \left[\frac{4}{1} \right] = 4 \div 3$$

Q2: A small metal sphere with a negative charge of $2.10 \times 10^{-6} \text{ C}$ is brought near an identical sphere with a positive charge of $1.50 \times 10^{-6} \text{ C}$ so that the distances between the centers of the two spheres is 3.30 cm. Calculate the magnitude and type of force acting on each sphere.

$$q = -2.10 \times 10^{-6} \text{ C}$$

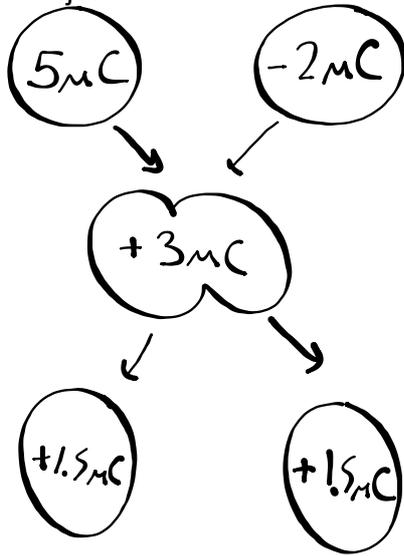
$$q = +1.50 \times 10^{-6} \text{ C}$$



$$F_e = \frac{kq_1q_2}{r^2} = \frac{(8.99 \times 10^9)(2.1 \times 10^{-6})(1.5 \times 10^{-6})}{(0.033)^2} = \frac{6.0283185}{0.001089}$$

$$F_e = 26.00 \text{ N} \text{ attractive}$$

Q3: A sphere of charge $+5\mu\text{C}$ is momentarily brought into contact with a second sphere of $-2\mu\text{C}$. They are then separated to a distance of 20cm . What is the magnitude of the force between the two objects?



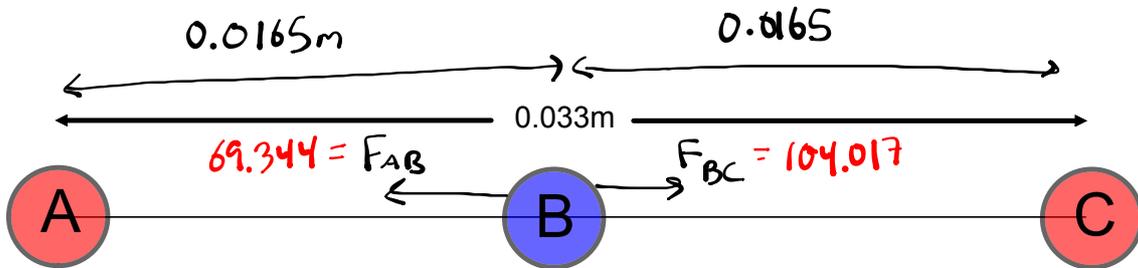
$$1.5\mu\text{C} = 1.5 \times 10^{-6} \text{C}$$

$$F_e = \frac{kq_1q_2}{r^2} = \frac{(8.99 \times 10^9)(1.5 \times 10^{-6})(1.5 \times 10^{-6})}{(20 \times 10^{-2})^2}$$

$$= \frac{0.0202275}{0.04}$$

$$= 0.5056875 \text{N}$$

Q4: A small metal sphere (B) with a negative charge of $2.10 \times 10^{-6} \text{ C}$ is placed midway between two similar spheres (A and C) 3.30 cm apart with positive charges of $1.00 \times 10^{-6} \text{ C}$ and $1.50 \times 10^{-6} \text{ C}$, respectively. Calculate the net electrostatic force on the negative charge.



$$q_A = 1.00 \times 10^{-6} \text{ C}$$

$$q_B = -2.10 \times 10^{-6} \text{ C}$$

$$q_C = 1.50 \times 10^{-6} \text{ C}$$

$$F_{AB} = \frac{k q_A q_B}{r^2} = 69.344 \text{ N}$$

$$F_{BC} = \frac{k q_B q_C}{r^2} = 104.017 \text{ N}$$

$$\begin{aligned} \vec{F}_{\text{net}} &= \vec{F}_{AB} + \vec{F}_{BC} \\ &= (+104.017) + (-69.344) \\ &= 34.672 \text{ N} \end{aligned}$$