Conservation of Electric Charge

Principle of Conservation of Electric Charge: $F_g = \frac{G m_1 m_2}{r^2}$

The total electric charge of an isolated system remains constant.

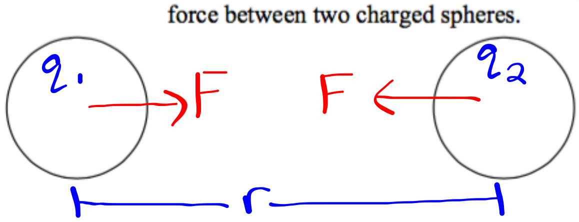
Method of finding final charge:

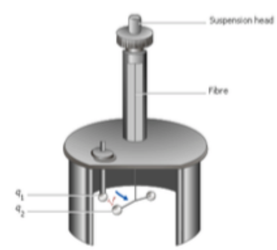
If objects are identical, final charge on each is the average charge (total charge divided by number of objects)

The Electrostatic Force

Coulomb's torsion balance was used to establish the relationship for the electric force between two charged spheres.

Charles Coulomb
(1736 – 1806)



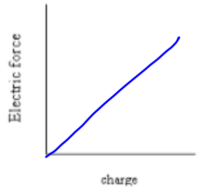


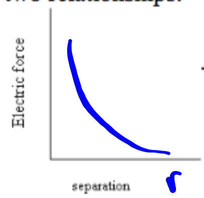
The charged spheres act as if they were *point charges*.

Point charge: An object whose charge is concentrated at a single point (r=0)

Coulomb's torsion balance (youtube)

Experimental data showed the following two relationships:





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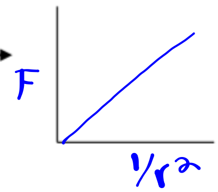


Relationship:

$F \propto \frac{1}{r^2}$

Formula: $F_e = \frac{K q_1 q_2}{r^2}$

Electrostatic Constant (Coulomb's constant):

$K = 8.99 \times 10^9 N\frac{m^2}{C^2}$

Coulomb's Law: The electrostatic force between two charged objects is directly proportional to the product of the two charges and inversely proportional to the square of the distance between their centers and acts along a line joining their centers.

The Electrostatic Force

1. A proton and an electron are placed 1.0 x 10^{-10} meter apart.

   a) Calculate the Coulomb force of attraction between them.

$$F_e = \frac{K|q||q|}{r^2} = \frac{8.99\times10^9 N\frac{m^2}{C^2} \cdot 1.6\times10^{-19}C \cdot 1.6\times10^{-19}C}{(10^{-10}m)^2}$$

$$\approx 2\times10^{-8} N$$

NOTE: neglect +/- on charges - formula uses magnitude only

b) Calculate the gravitational force of attraction between them.

$$F_g = \frac{Gmm}{r^2} \approx 10^{-47} N$$

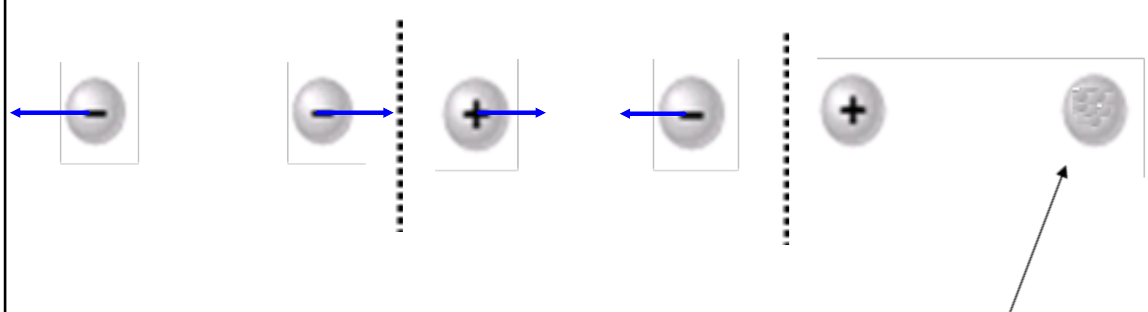
The Electrostatic Force

1. A proton and an electron are placed 1.0×10^{-10} meter apart.

   b) Calculate the gravitational force of attraction between them.

   c) Compare the strengths of the two forces.

2. Sketch the directions of the electrostatic forces and the gravitational forces in each pairing below.



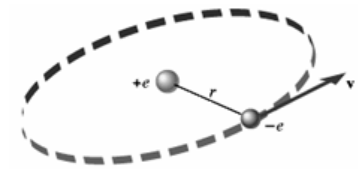
(neutron)

Coulomb's Laws Practice

3. In the Bohr model of the hydrogen atom, the electron (-e) is in orbit about the nuclear proton (+e) at a radius of $r = 5.29\times10^{-11}$ m. Determine the speed of the electron, assuming the orbit to be circular.

$$\Sigma F = \frac{mv^2}{r}$$

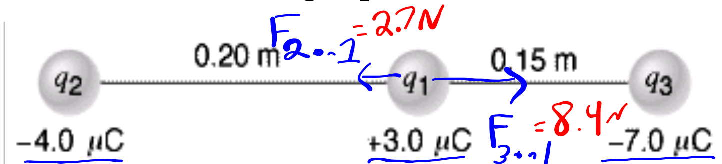
$$\frac{KQ_1Q_2}{r^2} = \frac{mv^2}{r} \Rightarrow V \approx 2.2\times10^{6}\ m/s$$



Coulomb's Laws Practice

4. Three charges are placed along a line at the positions indicated. What is the net force on charge q_1?

$$\Sigma F = 5.7N$$



$F_{2\text{on}1} = 2.7N$

$F_{3\text{on}1} = 8.4N$

$$F_{2\text{on}1} = \frac{KQ_2q_1}{r_{21}^2} = \frac{8.99\times10^{9}\,N\frac{m^2}{C^2}\,4\times10^{-6}C\cdot3\times10^{-6}}{(.2m)^2}$$

$$= 2.7N$$

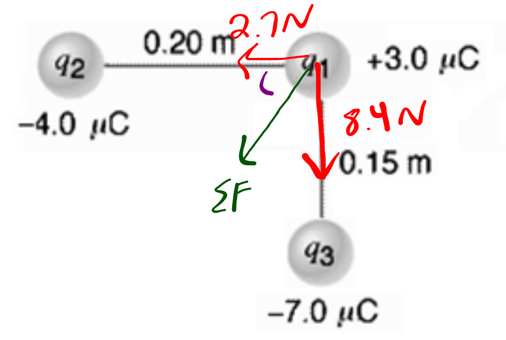
Coulomb's Laws Practice

5. The three charges are now placed at right angles, as shown. What is the net force on charge q_1?

$$\Sigma F = \sqrt{(2.7N)^2 + (8.4N)^2}$$

$$= 8.8N$$

$$\theta = \tan^{-1} \ldots$$



Electric Fields

Electric field: a region in space surrounding a charged object in which a second charged object experiences an electric force

Test charge: a small positive charge used to test electric fields (small enough that its charge does not distort field it's testing)