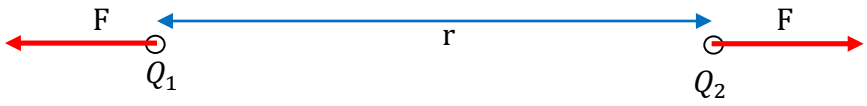
7.5 Coulomb's Law

When we bring charged objects together, they feel an electrostatic force of attraction or repulsion.



Opposite charges will feel an attractive force and like charges will feel a repulsive force. The magnitude of this force is given by the relationship:

$$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r^2}$$

This is known as Coulomb's Law.

Where Q_1= charge (in coulombs) of the first charge, Q_2= charge of second charge, r = distance between charges, and ε_0 is the permittivity of free space = $8.85\text{x}10^{-12}\text{Fm}^{-1}$.

A positive force signifies that the force is repulsive, and a negative force signifies that a force is attractive.

(1) What is the force felt by charges of $+4.0\text{x}10^{-6}$C and $-3.0\text{x}10^{-6}$C, separated by a distance of 0.3m?

(2) How is the equation, above, similar to the equation for the gravitational attraction between 2 masses?

(3) How is the equation different to the equation for the gravitational attraction between 2 masses?

The permittivity constant ε_0 is for 'free space'. This means that it is the value for a vacuum. The permittivity of air is almost indistinguishable to that of a vacuum.

(4) The separation between an electron and a proton in an atom is of the order $1\text{x}10^{-10}$m. Work out the electrostatic force of attraction between them.

(5) Work out the gravitational force of attraction between the electron and proton. (You will need to use the rest mass of a proton and an electron.)

(6) How does the electrostatic force compare to the gravitational force?

We have seen for gravity that a spherical mass can be replaced in calculations by a 'point mass' located at the centre of the sphere.

The same method can be used for a charge distributed uniformly on a sphere. We just use the total charge located at the centre of the sphere in our calculations.

(7) A charge of $+3.0 \times 10^{-6}$C is located on the surface of a charged sphere with a radius of 0.2m. The sphere has a charge density of $+0.2 \times 10^{-6}$C per metre squared. What force is felt by the $+3.0 \times 10^{-6}$C charge?