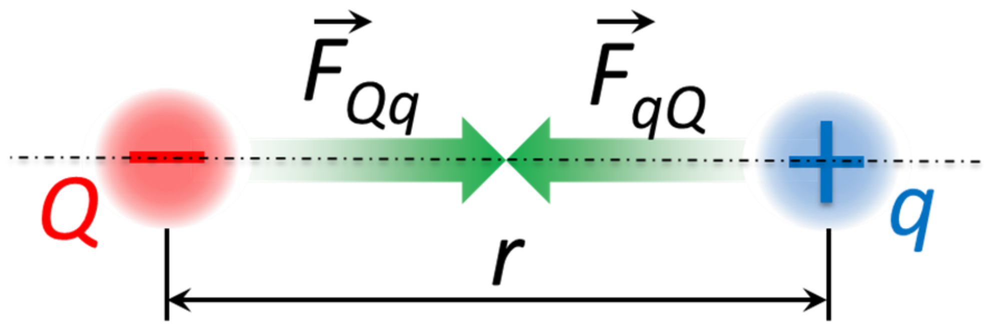
Homework 2

Coulomb's law

We have learned how to calculate the magnitude of the electrostatic force between to point electric charges. Point charges are electrically charged objects whose size is much less than the distance between them. The magnitude of the force is:

$$F = k\frac{Q\cdot q}{r^2} \quad (1)$$



Here *Q* and *q* are the charges of the objects; *r* is the distance between them. The charge is measured in Coulombs (C). This name is given after a French physicist Charles Augustin de Coulomb (1736-1806).

Charles Augustin de Coulomb

The coefficient k is 8.99 x 10^9 Nm^2/C^2. Here is a "dangerous point" – some people believe that two charges of 1 C each separated by the distance of 1m will interact with the electrostatic force of 1 N. This is not correct. In fact, the interaction force in this case is much more - 8.99 x 10^9 N!

Looking at the Coulomb's law (Formula1) we see that if the charges will have same sign, that the force will be positive; in the case the charges are of opposite signs, the force is negative. We remember that since the force is vector, changing the sign just means changing the direction of the force for the opposite – repulsion is changed for attraction.

The expression for the electrostatic force between two point charges is similar to the expression of gravitational attraction of two masses:

$$F = G\frac{m_1\cdot m_2}{r^2} \quad (2)$$

Here m_1 and m_2 are masses in kilograms, r is the distance between two masses in meters and G is the gravitational constant which is 6.673 x 10^{-11} $m^3/(kg\ s^2)$.

1. Three charged particles 1,2 and 3 lie on a straight line. The particle number 2 is between the particles 1 and 3. The charges on the particles are $Q_1=5.0x10^{-6}C$, $Q_2= 3.0x10^{-6}$ *C*, and $Q_3= 2.0x10^{-6}$ *C* they are of the same type (positive). The distance r_{12} between particle *1* and *2* is *10.0cm*. The positions of particles *1* and *3* are kept fixed. What must be the distance r_{23} between particles 2 and 3 for the net electrostatic force on the particle *2* to be zero? Is this equilibrium stable?
2. What must be the distance *r* between two point charges $Q_1=7.0x10^{-6}$ *C* and $Q_2=5.0x10^{-5}C$ for the electrostatic force between them to have magnitude *3.0 N*?
3. The size of a hydrogen atom consisting of one proton and one electron is ~5x10^{-11}m. What is the magnitude of the electrostatic force between proton and electron in a hydrogen atom? (the charge of a proton equals to this of electron and is 1.6x10^{-19}C).