

## Homework 18

### Coulomb's law.

We have learned how to calculate the magnitude of the electrostatic force between two 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:

$$F = k \frac{q_1 \cdot q_2}{r^2} \quad (1)$$

Here  $q_1$  and  $q_2$  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  $8.99 \times 10^9 \text{ Nm}^2/\text{C}^2$ . Here is a “dangerous point” – some people believe that two charges of 1 C each separated by the distance of 1 m will interact with the electrostatic force of 1 N. This is not correct. In fact, the interaction force in this case is much more -  $8.99 \times 10^9 \text{ N}$ !

Looking at the Coulomb's law (Formula 1) 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  $6.673 \times 10^{-11} \text{ m}^3/(\text{kg s}^2)$ .

1. What must be the distance  $r$  between two point charges  $Q_1=7.0 \times 10^{-6} \text{ C}$  and  $Q_2=5.0 \times 10^{-5} \text{ C}$  for the electrostatic force between them to have magnitude  $3.0 \text{ N}$ ?
2. Three charged particles 1, 2 and 3 lie on a straight line. Particle 2 is between particles 1 and 3. The charges on the particle 1 is  $Q_1=5.0 \times 10^{-6} \text{ C}$ , the charge of particle 2 is  $Q_3=2.0 \times 10^{-6} \text{ C}$ . All 3 particles have positive charge. The positions of particles 1 and 3 are kept fixed. Find the position of equilibrium for particle 2, i.e. what fraction of the total distance is supposed to be between particles 1 and 2 (or 2 and 3) in the equilibrium. Is this equilibrium stable?