Homework 15

Electric potential

The potential energy where of two charges separated by a distance *r* is

$$P = k\frac{q_1 \cdot q_2}{r} \quad (1)$$

Let us keep one of the charges, say, q1 fixed and change the charge q2. Since there is a product of the charge magnitudes in the numerator of formula (1), the potential energy will increase or decrease together with the charge magnitude of q_2. We can now calculate the potential energy *per unit charge*. For this we will divide the potential energy of the interacting charges q1 and q2 by the magnitude of q2:

$$\frac{P}{q_2} = k\frac{q_1 \cdot q_2}{r} \div q_2 = k\frac{q_1}{r} \quad (2)$$

We can imagine that each point of space around the charge q_1 can be characterized by the potential energy of a positive unit charge in this point. The electrostatic potential energy of a positive unit charge in a certain point is called "***electric potential"*** in this point. The electric potential is a scalar.

The electric potential $\boldsymbol{\varphi}$ created by the point charge $\boldsymbol{q}$ is:

$$\boldsymbol{\varphi = k\frac{q}{r}} \quad (3)$$

If the charge q is negative, the potential will be negative as well.

The formula (3) means that a unit positive point charge placed at the distance r from the charge q will have potential energy $\boldsymbol{\varphi}$. If we will place an arbitrary charge Q at the distance r (instead of a unit charge) then the potential energy of the charge Q can be calculated as:

$$\boldsymbol{P = k\frac{q}{r} \cdot Q = \varphi \cdot Q} \quad \textbf{(4)}$$

As we can see from the formula (3) the potential created by a point charge depends on the distance to the point charge. Difference of potentials taken in points A and B equals to the difference of potential energy of a unit positive charge in these points. As (I hope) you remember difference of potential energy of an object in points B and A is also equal to the work W_{AB} of the electric force to transfer the unit positive charge from point A to point B. If a charged object with a charge q moves from point A to point B, the work of the electric force is:

$$W_{AB} = P_A - P_B = q\varphi_A - q\varphi_B = q(\boldsymbol{\varphi_A - \varphi_B}) = qU_{AB}$$

Here P_A, P_B –electrostatic potential energies in points A and B; φ_A, φ_B – the electrostatic potentials, $U_{AB} = \boldsymbol{\varphi_A - \varphi_B}$ is the potential difference which is also called "*voltage between points A and B"*.

Problems:

1. An object with a charge of 0.01C being accelerated by electrostatic force moves from point A to point B and gains kinetic energy of 6J. Find the potential difference between points A and B.

2. There is a point charge of -1C (see picture below). The distance between the charge and the point A is 100m, the distance between the points A and B is also 100m. Find the potential difference between points A and B.