Homework 5.

Electric field.

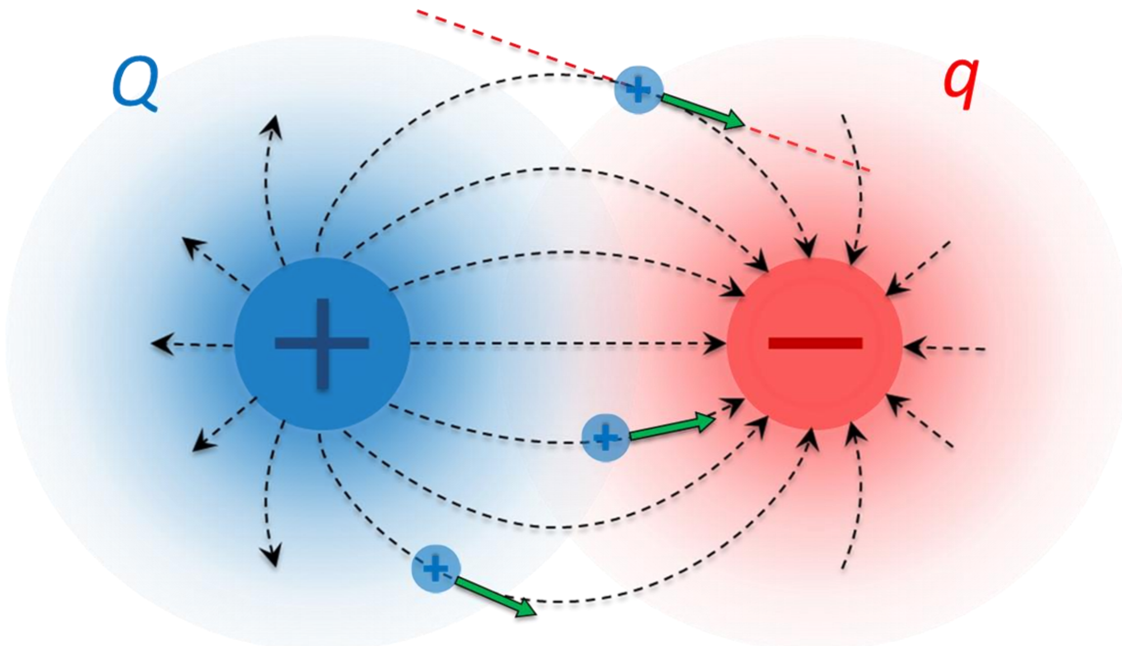

Figure 1.

Numerous experiments demonstrate that charged objects exert forces on each other. There were two major points of view on the nature of this interaction. Some scientists believed that the charged objects interact directly through the empty space. Now it is commonly accepted that the charged objects interact through special kind of matter called electric field. An important property of electric field is that it exerts a force on a charged object. Any charged object is surrounded by electric field. Through this field the objects exerts a force to other charged objects. We can measure the force applied to a charged object in each point of a certain area and make a 3-dimensional "map" of the electric field.

Electric field is a vector. The direction of the electric field is the direction of electrical force applied by the field to a ***positively*** charged object. The magnitude of electric field in a certain point is the magnitude of force exerted to the ***unit*** charge placed in this point. Electric field may change from point to point in space. To find the magnitude of the electric field in a certain point we have to take a positively charged object, place it the point measure the magnitude of the electrical force and divide this magnitude by the charge of the object. Practically it is impossible to do since there is infinite number of points even within a microscopically small volume. It usually helps to use symmetry considerations.

For example, let us find the electric field of negative point charge ***Q***. Let us take a positive charge ***q*** and place it at a distance ***r*** from the ***Q.*** According to the Coulomb's law the magnitude of the electrostatic force applied to the charge ***q*** is:

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

The magnitude of the electric field ***E*** is the magnitude of force applied to the unit charge, so we have to divide ***F*** by ***q:***

$$E = \frac{F}{q} = k\frac{Q}{r^2} \qquad (2)$$

This is the magnitude of the electric field. The direction of the electric field is the direction of force applied to a positive charge. Since a negative charge attracts positive charge, the field created by a negative charge is directed toward the charge.

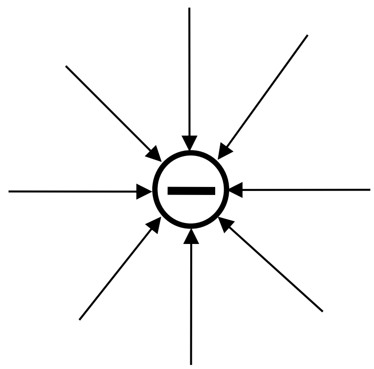

Figure 2. Electric field of a negative point charge.

According to the symmetry considerations the magnitude of the electric field does not depends on direction, but it depends on the distance to the charge (according to the formula (2)). There is no special name for the electric field units. This time we will use the unit N/C which is newton/coulomb.

Electric field lines provide a convenient way to show the presence of the electric field in a picture. An example of the electric field lines is shown in Figure 1. Electric field vector in any point is directed along the tangent line to the electric field line, passing through this point – see green arrows in Figure 1. Electric field lines have direction – they started at positive charges and terminated at the negative ones. In areas where the magnitude of the electric field is higher, the electric field lines are more dense.

Problems:

1. Show schematically the direction of the electric field near positive point charge. The point charge is 1C. Find the electric field at a distance of 10m from the point charge.

2. The electric field created by a negative point charge of -1C in the point A is 36N/C, in the point B is 9N/C (See figure 2). Find the electric field in the point C which is in the middle between A and B.

There is a challenging variant of this problem: actually, one does not need to know the charge which creates electric field to find the solution. Volunteers can try solving the problem using only the magnitudes of the electric field in points A and B.

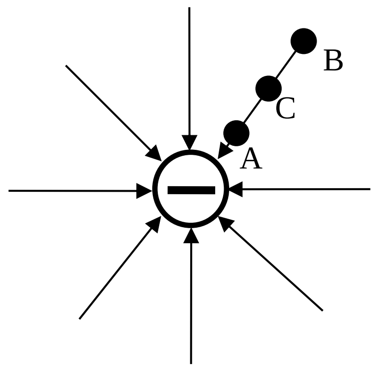

Figure 2

3. Try to draw the direction of the electric field near the surface of
   a) positively charged metal ball
   b) negatively charged infinite straight wire
   c) positively charged infinite thin plane