13. THE STUDY OF THE PROPERTIES OF THE ELECTRIC FIELD

ASSIGNMENT

1. Picture the equipotential lines of electric field between two electrodes
2. Draw the electric lines

THEORETICAL PART

The electromagnetic force between charged particles is one of the fundamental forces in the nature. A number of simple experiments can be performed to demonstrate the existence of electric forces and charges. In 1785, Charles Coulomb established the fundamental law of electric force between the stationary, charged particles. This law is called the Coulomb law and it is in form

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

where k is a constant called **the Coulomb constant** and its value is 8.9875x10^9 Nm^2 C^{-2} , $|q_1|,|q_2|$ are the charged particles and r is the separation between the two particles. Equation (1) gives the magnitude of the force that either object exerts on the other. When dealing with Coulomb's law, we must remember that force is a vector quantity. The direction of this force depends on the signs of the charged particles. Furthermore, note that Coulomb's law in this form applies exactly only to point charges or particles. It means that the size of charged objects is much smaller than the distance between them

According to Michael Faraday experiments an electric field extends outward from every charge and permeates all of space. When the second charge is placed near the first charge, it feels a force because an electric field is there. The electric field at the location of the second charge is considered to interact directly with the charge to produce the force. This field like as gravitational field is characterized with two physical quantities, electric field vector E and scalar quantity called electric potential *V*.

The electric field vector $\overline{E}$ at a point in space is defined as the electric force F acting on a positive test charged placed at that point in space that is to be examined divided by the magnitude of the test charge q_0:

$$\vec{E} = \frac{F}{q_0} \qquad (2)$$

The electric potential V at any arbitrary point *P* equals the work required bring a positive charge from infinity to that point:

$$V_P = \frac{U}{q_0} = -\int_{\infty}^{P}\vec{E}.\vec{dr} \qquad (3)$$

The potential difference between the point *A* and *B* is define as the change in potential energy divided by the test charge q_0

$$V_B - V_A = -\int_{0}^{B}\vec{E}.\vec{dr} - \left(-\int_{0}^{A}\vec{E}.\vec{dr}\right) = -\int_{A}^{B}\vec{E}.\vec{dr} \qquad (4)$$

A convenient aid for visualizing electric field is to draw lines pointing in the same direction as the electric field vector at any point. This lines are called **electric field lines** and they are related to the electric field in any region of space in the following manner:
1. The electric field vector E is tangent to the electric field line at each point

2. The number of lines per unit area through the surface perpendicular to the lines is proportional to the strength of the electric field in that region. The electric potential can be represented graphically by drawing equipotential lines or, in the three dimensions equipotential surfaces. Continues distribution of points having the same potential defines the equipotential surface.

We now show how to calculate the electric field if the electric potential is known in certain region. From equation (3) follows the relationship between the electric field vector E and potential difference dV in form

$$dV = - E.dr \quad (5)$$

From this expression follows that no work is done in moving the charge between two points on an equipotential surface since the change in electric potential dV =0. An equipotential surface must be perpendicular to the electric field at any point in space. If that is not so that is if there were a component of E parallel to the surface, it would require work to move the charge along the surface again this component of E.

If we introduce the unit vector n_0 perpendicular to equipotential surface directed to the higher potential (see Fig. 1) then the change in potential is by the definition equals

$$dV = - E.dn = En_0.dr = E.dr.\cos\alpha = E.dn \quad (6)$$

Therefore, eq 6 becomes into vector as

$$E = - \frac{dV}{dn}\vec{n}_0 \quad (7)$$

That is, the electric field is equal to the negative of the derivative of the potential with respect to some direction or coordinate.

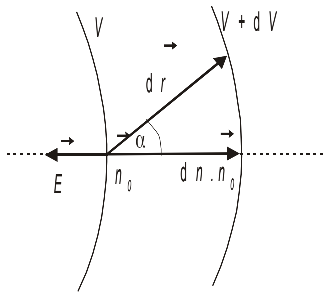

Fig.1

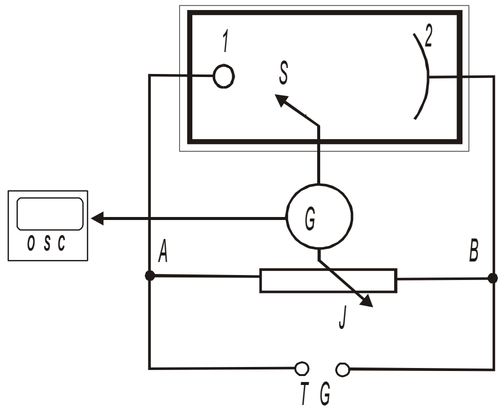

Fig. 2

THE METHOD-PRACTICAL PART

The device for the investigation of the electric field is shown in Fig.2

It consists from two electrodes placed into the tank containing the water. The electrodes are connected to the source of voltage and the arbitrary points with the same potential are detected with the oscilloscope. The potential difference between the electrodes is regulated by the potentiometer

MEASUREMENT

Apparatus: tank filled with the water, two electrodes, tone generator, potentiometer, oscilloscope, voltmeter, graph paper

Draw the position and shape of the electrodes on the graph paper. Connect the apparatus Set up the potential difference between the electrodes. Find a few points that have the same potential by the help of the indicator connected to the oscilloscope if the system is balanced. Repeat your measurement for various values of the potential difference between the electrodes. Draw these points on the graph paper.

CALCULATION

Connect the plotted points with curved lines. These are lines of equipotential. Draw in a set of lines everywhere perpendicular to these equipotential lines. This latter set represents lines of electric field and of the force in the electric field, too. Summarize and analyze your results.