Inhomogeneous electric fields (dipole fields)

Task and equipment

Information for teachers

Learning target

With this experiment the students will investigate the electric field between two circular electrodes. This field corresponds to the attractive field between two point charges. It also referred to as a static dipole field and serves as an example of an inhomogeneous field.

Previous knowledge

To be well prepared for the experiment, the students should be familiar with the concepts of equipotential lines and field lines. They should know that a voltage is equivalent to the difference in electric potentials between two points of an electric field, and that applying a voltage to two electrodes causes an electric field to build up. What is more, they should know that, according to the concept of field lines, the density of the field lines is proportional to the electric field strength, or the strength of the electric force respectively.

Notes on the procedure

- If you put manifold paper and white paper between the carbon paper and the polycarbonate plate, you will be able to push the points of measurement through onto the white paper with the knitting needle. This way the carbon paper can be used multiple times.
- For a symmetric field distribution the electrodes need to be in good contact with the plane of resistance (the carbon paper). Thus check prior to the measurement of the field if the electrodes are pressed equally firmly onto the carbon paper. You should also create a conducting layer of graphite between the electrodes and the carbon paper using a soft pencil.
- The digital multimeter (DMM), which is used to measure the voltage, needs to have a high inner resistance (> 10 MΩ). Lacking this high resistance there will be an electric current in the measuring circuit on the carbon paper between the cathode (0 V) and the knitting needle. This current will change the electric field on the carbon paper and the measurement of the electric potential will be distorted.

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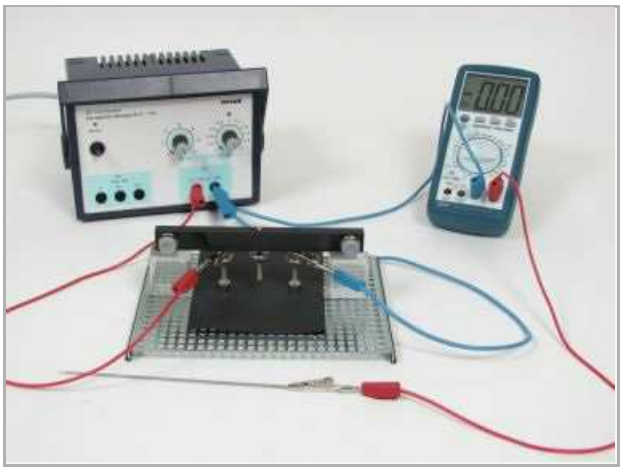
Task

How does the electric field pattern between two circular electrodes look like?

Investigate the electric field, which is created by applying a voltage to two circular electrodes. For this purpose determine the equipotential lines of the electric field between the two electrodes and derive the electric field pattern.



Student's Sheet

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Equipment

Position No.	Material	Order No.	Quantity
1	Mounting plate r, 16cmx21cm	13002-00	1
2	Universal holder, block R	13024-13	2
3	Polycarbonate plate, 136x112x1 mm	13027-05	1
	Set of electrodes with holder for set equipotential lines	13027-24	1
	needed out of it:		
4	Electrode holder		1
5	Circular electrodes		1
6	Knitting needles, 20 pcs	06342-00	1
7	Alligator clips, bare, 10 pcs	07274-03	1
8	Carbon paper f.Equipot.30 sheets	13027-29	1
9	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
10	DMM with NiCr-Ni thermo couple	07122-00	1
11	Connecting cord, 32 A, 250 mm, red	07360-01	2
12	Connecting cord, 32 A, 250 mm, blue	07360-04	2
Additional material			
13	Soft pencil		1

Set-up and procedure

Set-up

To get an impression of the experimental set-up, please view Fig. 1.

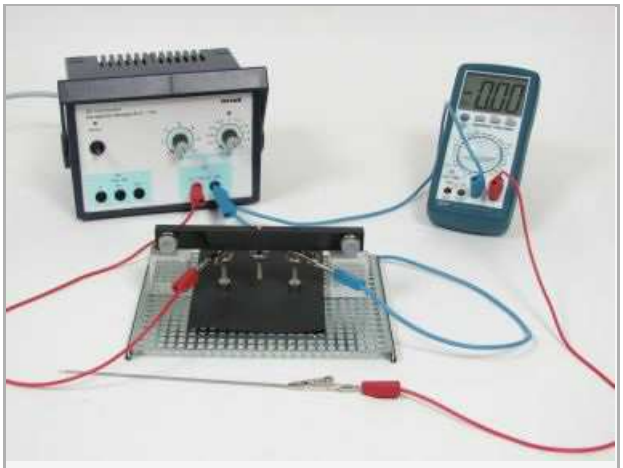

Fig. 1

Setting up the experiment, follow this procedure:

- Put the two universal holders onto the mounting plate, with the polycarbonate plate fitting just inbetween (Fig. 2).

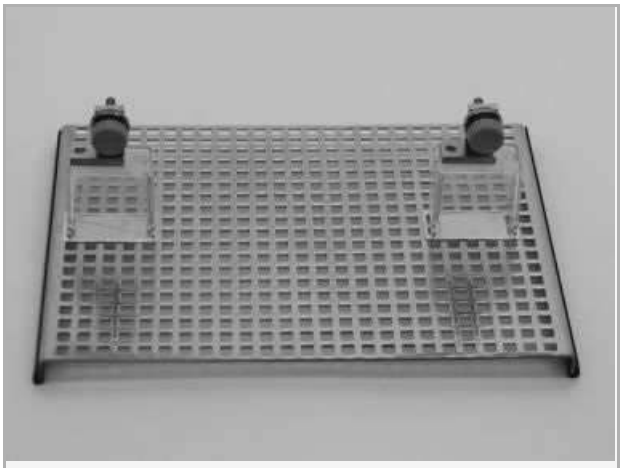

Fig. 2

- Completely loosen the knurled screws on both holders and use them to fix the electrode holder onto the universal holders (Fig. 3-4).

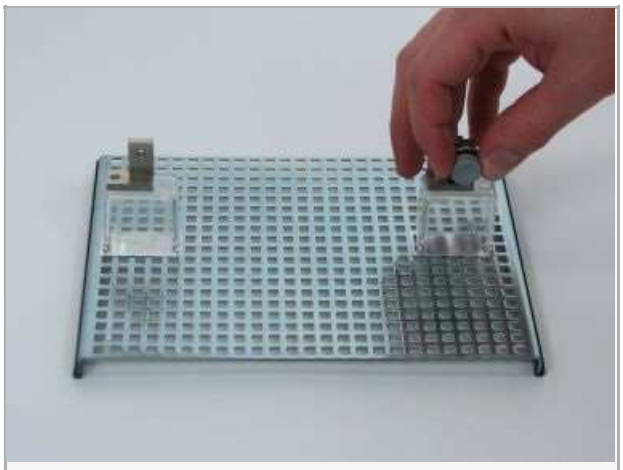

Fig. 3

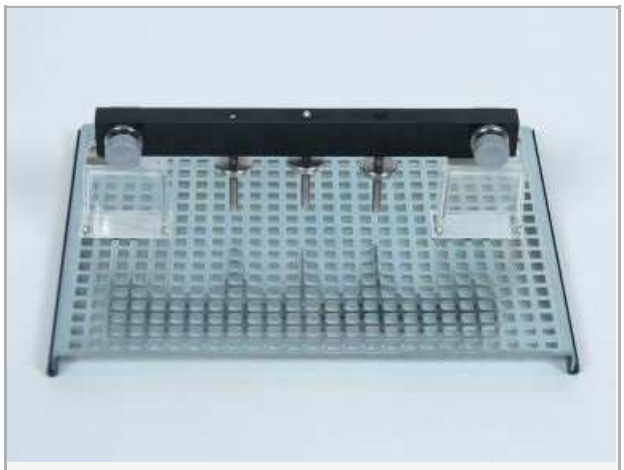

Fig. 4

- Cut a sheet of carbon paper, with a size of 130 mm x 100 mm, and put in on top of the polycarbonate plate (Fig. 5-6).

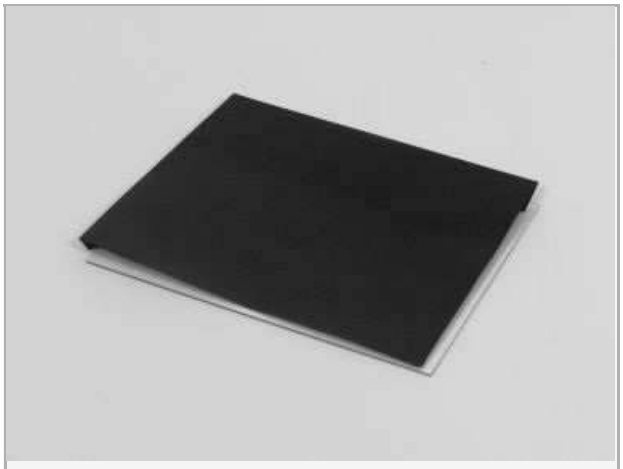

Fig. 5

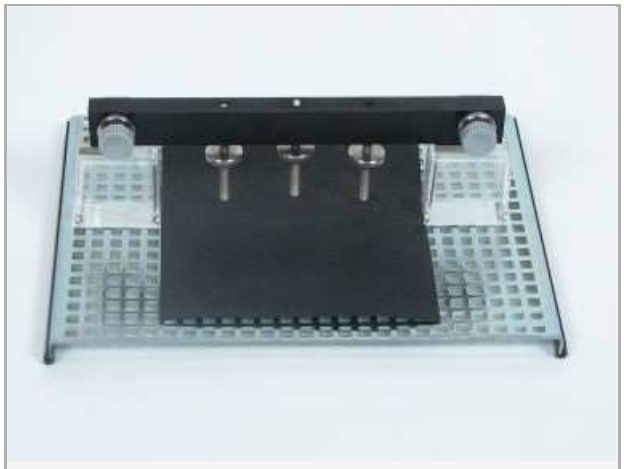

Fig. 6

- Place the two circular electrodes below the outer knurled screws. By tightening the knurled screws, press both electrodes equally firmly onto the underlying plate (Fig. 7).

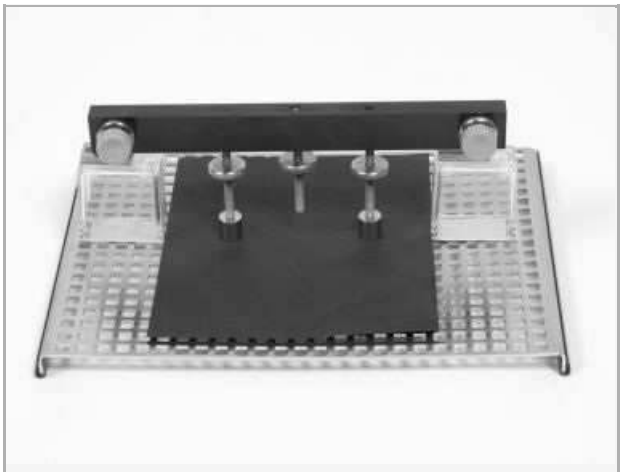

Fig. 7

- Draw the profiles of the electrodes on the carbon paper, loosen the knurled screws slightly and remove the carbon paper again (Fig. 8).
- Accurately fill the marked areas with a soft pencil (Fig. 9). The graphite of the pencil creates better contact between the electrodes and the carbon paper so that, when applying a voltage to the electrodes, an electric field can be measured within the conducting carbon paper.

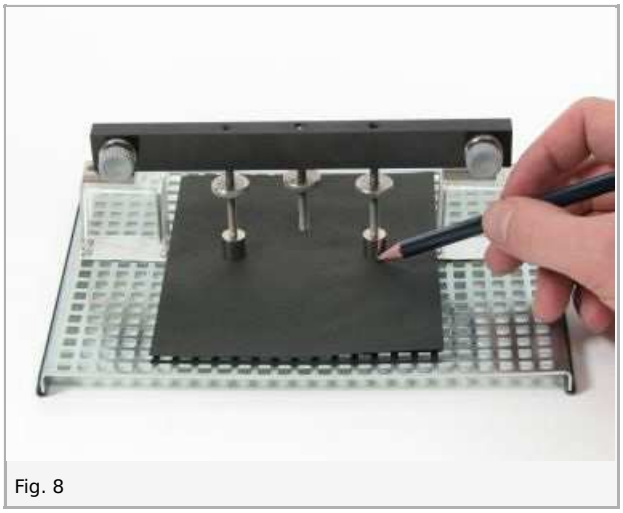

Fig. 8

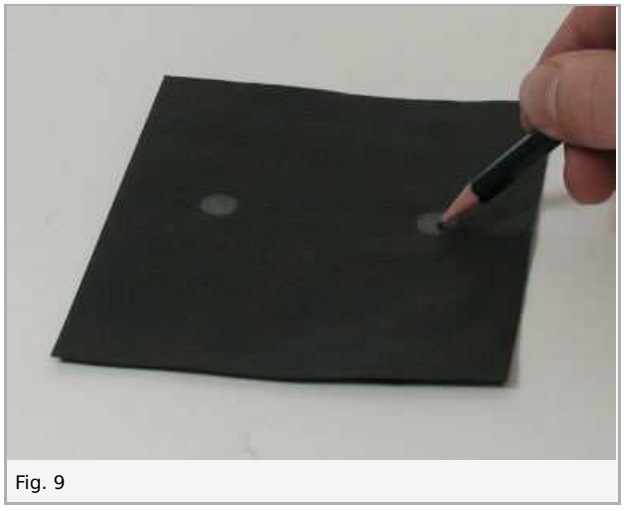

Fig. 9

- Put the carbon paper back into its original position, place the electrodes onto the marked areas and tighten them with the knurled screws on the carbon paper (Fig. 7).
- Connect both electrodes to the outputs of the power supply (Fig. 11).
- Connect the digital multimeter (DMM) to one output (0 V) of the power supply as well as with the knitting needle (Fig. 10-11). If the carbon paper contains an electric field and the knitting needle touches the carbon paper, the DMM will measure the voltage between the point of contact and the connected output of the power supply. If this output has 0 V, the measured voltage will be equivalent to the electric potential in the point of contact. Note: A voltage is always equivalent to a difference of electric potentials between two points.

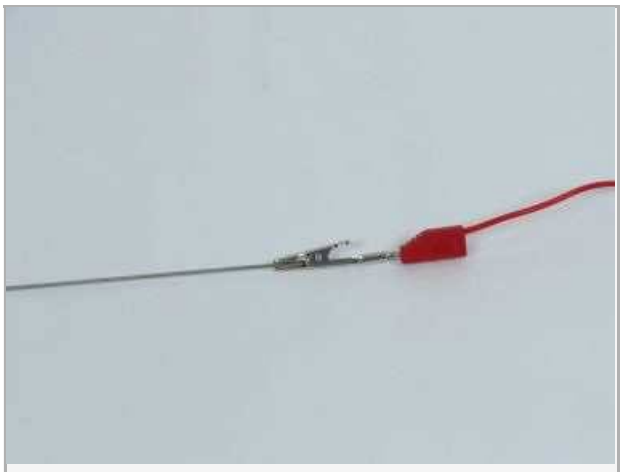

Fig. 10

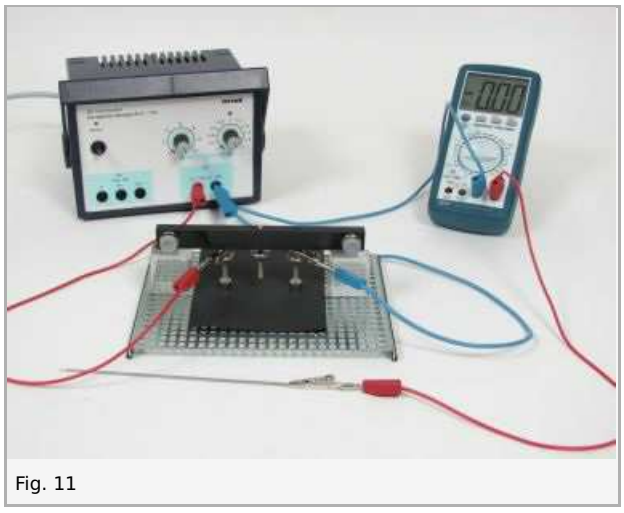

Fig. 11

Procedure

- Switch on the power supply and set its output to 10 V (DC). Attach the tip of the knitting needle to each of the two electrodes and check whether the electrodes have electric potentials of 0 V and 10 V betragen respectively (Fig. 12-13). If necessary, adjust the DC output of the power supply.

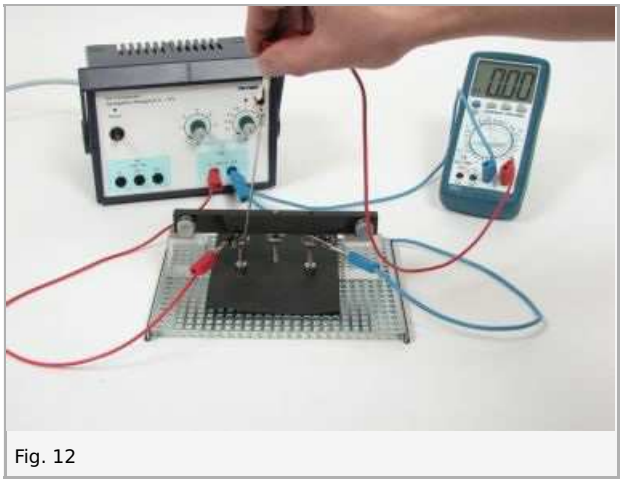

Fig. 12

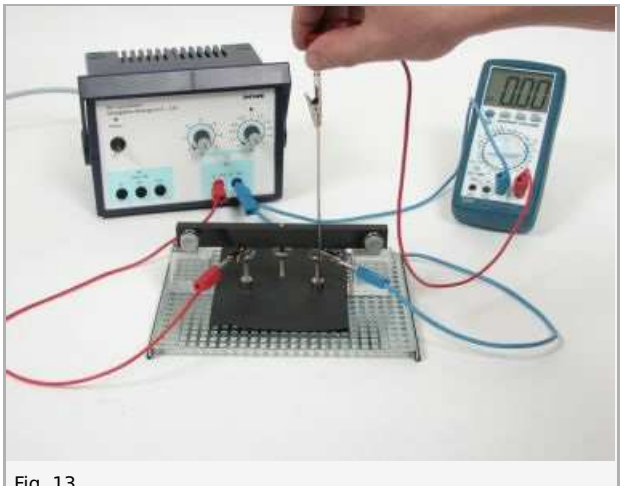

Fig. 13

- Find points on the carbon paper, which have the same electric potential. For this purpose scan the carbon paper with the tip of the knitting needle and mark the points as small circles with a pencil (Fig. 14). Start with a value of 1 V and continue in steps of 2 V. Mark eight points for each value.

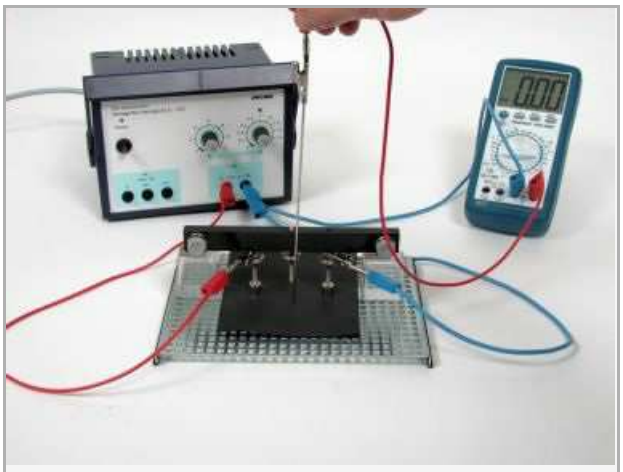

Fig. 14

- After completing the measurement, loosen the screws and remove the carbon paper.

Report: Inhomogenous electric fields (dipole fields)

Result - Sketch

a) Use a pencil and connect the points of equal electric potential as equipotential lines. Label each line by its electric potential.

b) Draw five field lines of the electric field. Think about why these lines should start from the anode (10 V) at equal distance.

Evaluation - Question 1

Examine the electric field pattern and explain why this electric field is inhomogeneous.