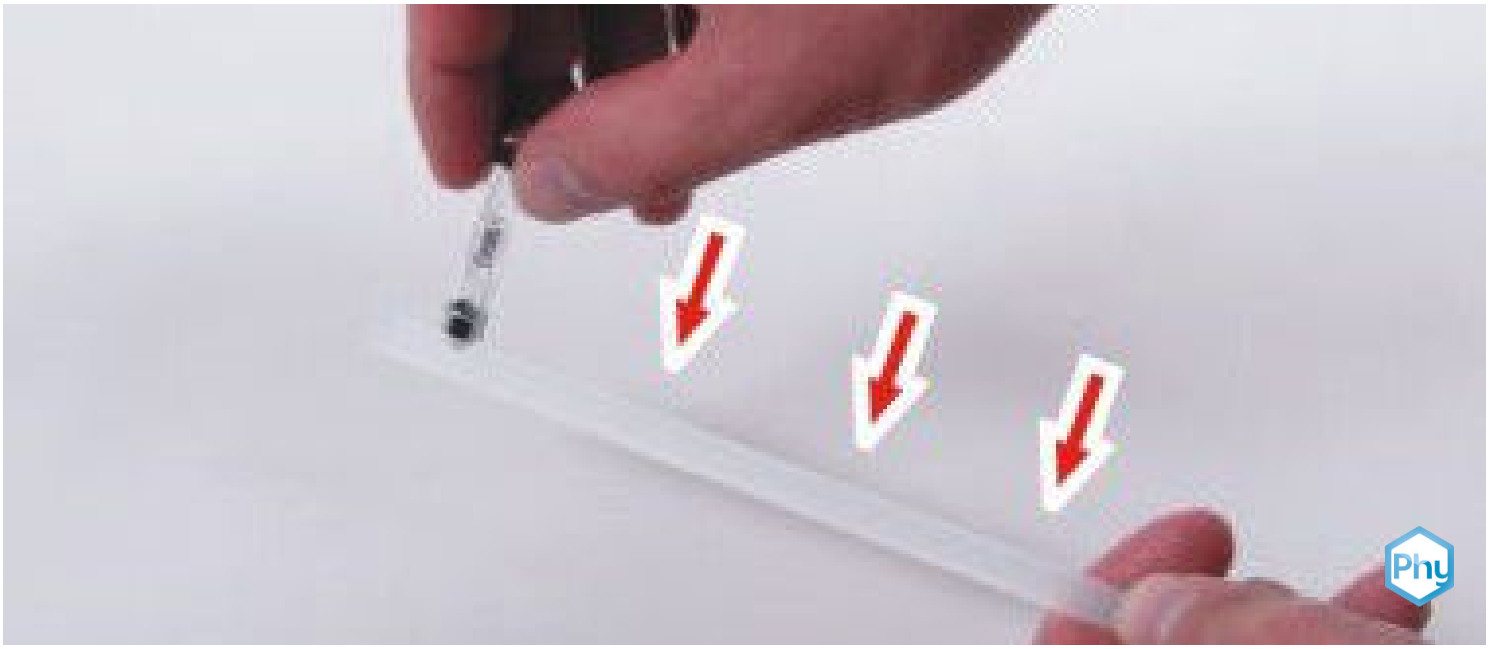
# The mobility of charges in insulators and conductors



Physics | Electricity & Magnetism | Electrostatics & electric field

| Difficulty level | Group size | Preparation time | Execution time |
|---|---|---|---|
| easy | - | 10 minutes | 10 minutes |

This content can also be found online at:

http://localhost:1337/c/642803f85e30a7000275e9c8

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# Teacher information

## Application

Transducer of an electric fence (insulator)

Electrical charge and its transport between different objects have been studied quite thoroughly by the students by now.

What the students have not yet learned, however, is the behaviour of electric charge within a body.

This behaviour depends on whether the respective object is a conductor (metallic object) or an insulator.

Charges within an insulator are therefore always stationary, whereas they can move freely in metals.



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## Other teacher information (1/2)

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### Prior knowledge

The students should have already studied electric charge and its effects in detail. The experiment "Conductors as charge storage" provides a good basis for successfully carrying out this experiment. The knowledge of the type of charge of the rods used and the use of the glow lamp for detection is required for carrying out this experiment.

### Principle

Depending on the material of an object, it has different properties with regard to the electric charge. In conductors (usually metals), for example, the charge moves almost freely throughout the object, whereas in non-conductors (insulators) the electric charge is limited exclusively to the place where it is applied to the object.

## Other teacher information (2/2)

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### Learning objective

The students recognise that in insulators the charges are stationary but can move freely in metals, i.e. conductors.

### Tasks

In this experiment, the students are to investigate the different properties regarding localised electrical charges of different materials.

For this they are to examine a polypropylene rod, a transparent film and a metallic electroscope.



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## Safety instructions

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The general instructions for safe experimentation in science lessons apply to this experiment.

**Notes on set-up and procedure:**

In other experiments, the results of this experiment have already been tacitly assumed. For example, the function of the electroscope requires the charges in it to be movable, while an experiment with a rubbed plastic rod assumes stationary charges, since otherwise a discharge would immediately occur via the hand. In this context, reference can be made to many examples from electrical engineering in which these findings are used (continuous electrically conductive connections as a prerequisite for the current; use of insulators at the points where no current is allowed to flow).

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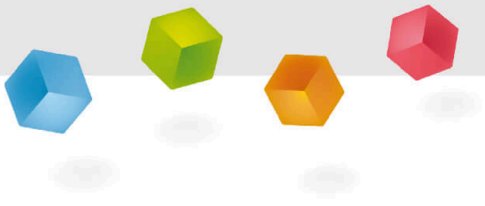

# Student information



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## Motivation

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Transducer of an electric fence (insulator)

You have certainly seen the plastic pick-up shown in the illustration while walking along a pasture. As the name suggests, this has the task of "picking up" and supporting the electric fence of the pasture.

Perhaps you have also had the painful experience of touching the electric fence. This touch is unpleasant, but not life-threatening for humans.

But have you ever touched the insulator while the fence was live? The insulator does not transmit the current to your hand. In this experiment you will learn why this is so.

## Tasks

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In this experiment you will look at the ability of different objects to carry an electric charge.

To do this, first set up an electroscope.

Then examine various electrically charged objects to see whether the charges in them can shift.



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# Equipment

| Position | Material | Item No. | Quantity |
|---|---|---|---|
| 1 | Electroscope w. metal pointer | 13027-01 | 1 |
| 2 | Polypropylene rod, l=175mm, d=10 mm | 13027-09 | 1 |
| 3 | Neon tube | 06656-00 | 1 |
| 4 | Film, transparent, DIN A4, 100 sheets | 08186-10 | 1 |



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## Additional Equipment

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| Position | Equipment | Quantity |
|---|---|---|
| 1 | Dry, rough paper | DIN A4 |

## Set-up

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Structure of the electroscope

First assemble the electroscope. The pointer should hang vertically (one side is slightly longer and therefore minimally heavier) without bumping, the axis is in the notch.



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## Procedure (1/5)

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Experiment 1: Charge the polypropylene rod at one end by rubbing it vigorously with paper. Then test first the unrubbed and then the rubbed end for charges with the glow lamp. Observe the electrodes of the glow lamp carefully!

## Procedure (2/5)

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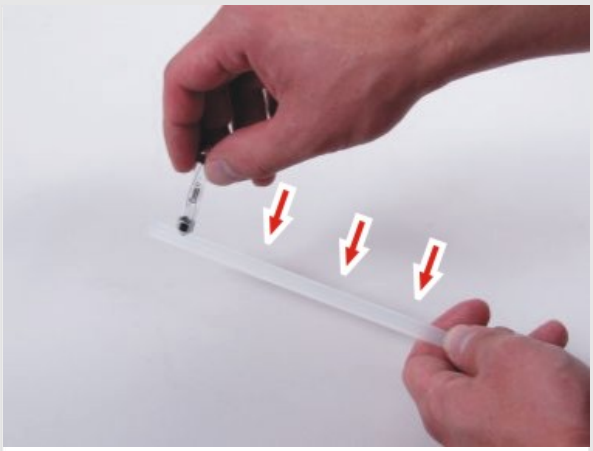

Examine the polypropylene rod with the aid of the glow lamp

Experiment 2:

- Hold the polypropylene rod at one end and rub it with paper along its entire length.
- Then check again for charges at various points with the glow lamp.
- Again, observe the electrodes of the glow lamp carefully.



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## Procedure (3/5)

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Experiment 3: Rub the transparent film lying on the table with paper. Then lift it off the table and check it for the distribution of charges by brushing a metal cap of the glow lamp over it.

## Procedure (4/5)

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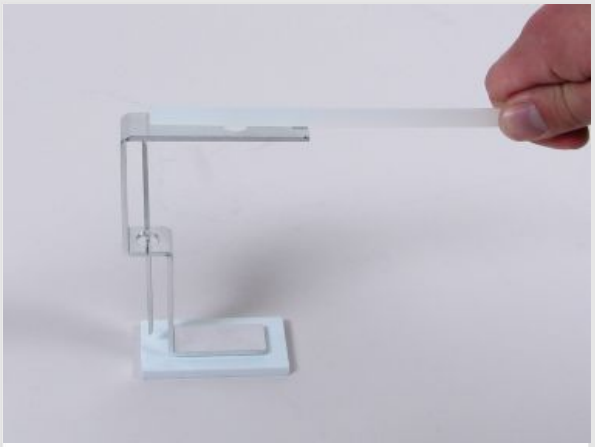

Charge the electroscope using the polypropylene rod

Experiment 4:

- Charge the polypropylene rod again by rubbing it vigorously with paper.
- Then charge the electroscope with the grated polypropylene rod by touching the upper edge.



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# Procedure (5/5)

Examine top end

Examine bottom end

Experiment 4:

- Check for charges with the glow lamp first on the upper edge and then directly afterwards on the lower edge.

Experiment 5:

- Charge the electroscope as before. However, first check the lower edge and then the upper edge for charges.

# Procedure (5/5)

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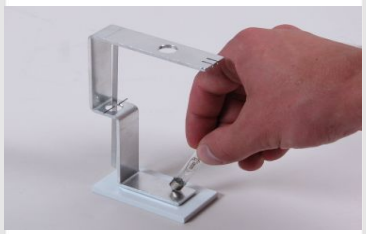
Examine top end



Examine bottom end

Experiment 4:

- Check for charges with the glow lamp first on the upper edge and then directly afterwards on the lower edge.

Experiment 5:

- Charge the electroscope as before. However, first check the lower edge and then the upper edge for charges.



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# Report

## Task 1

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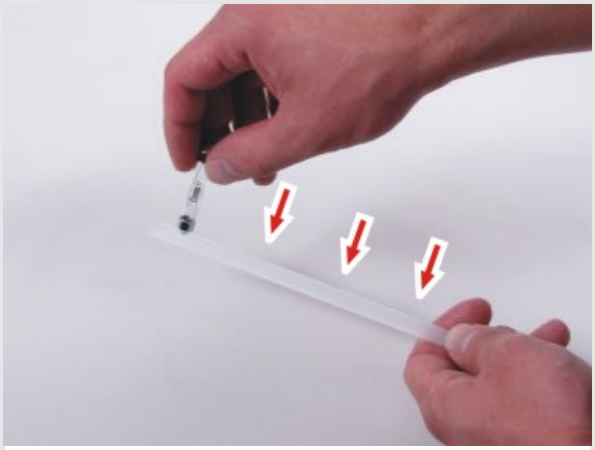

Examine the polypropylene rod with the aid of the glow lamp

On which side does the glow lamp light up in the 1st experiment?

- The lamp lights up at the rubbed end (charged end).
- The lamp lights up at the non-rubbed end (non-charged end).
- The lamp lights up at both ends.



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## Task 2

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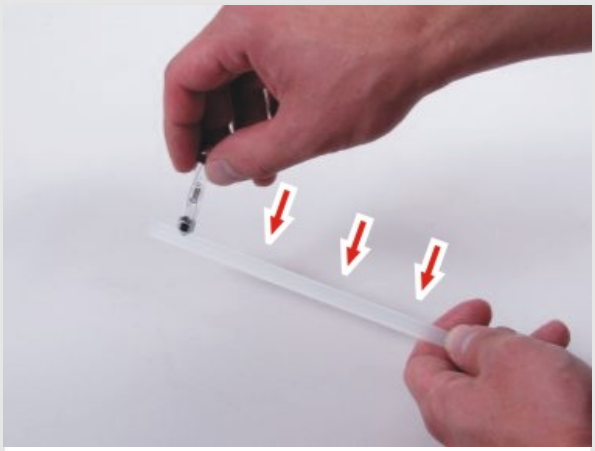

Examine the polypropylene rod with the aid of the glow lamp

On which side does the glow lamp light up in the 2nd experiment?

- The lamp does not light up at any position of the pole.
- The lamp only lights up when touched for the first time.
- The lamp lights up at every position of the pole.

## Task 3

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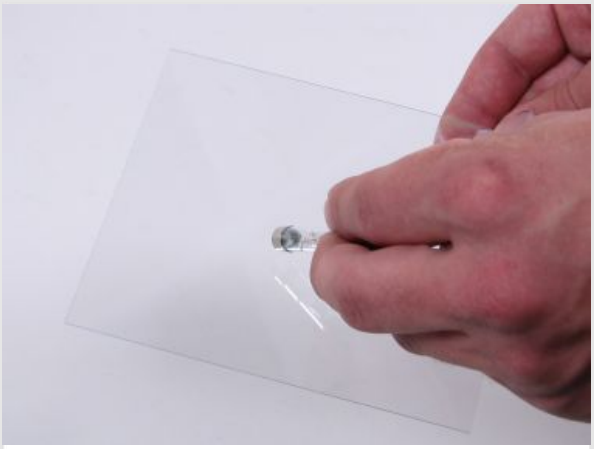

Hold the glow lamp against the transparent film

What do you observe in the third part of the experiment when you brush over it with the glow lamp?

- The glow lamp did not light up at any point on the film.
- The glow lamp lit up once in the first place.
- The glow lamp lights up several times and in different places.



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## Task 4

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Examine electroscope with glow lamp

Where did you detect charges in the 4th experiment?

- At the top of the electroscope.
- At the bottom of the electroscope.
- At every point of the electroscope.
- At no point on the electroscope.

## Task 5

PHYWE

Examine electroscope with glow lamp

Where did you detect charges in the 5th experiment?

- At no point on the electroscope.
- At the top of the electroscope.
- At the bottom of the electroscope.
- At every point of the electroscope.



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## Task 6

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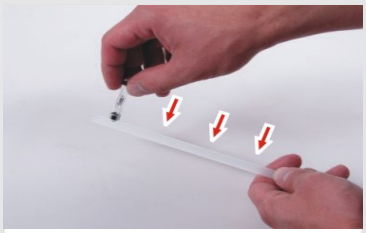

Examine rod

Stripe over foil with glow lamp

What can be learned from experiments 1, 2 and 3 about the displaceability of charges in insulators?

- No correlation can be derived with regard to the displaceability of charges in insulators.
- Charges stay exclusively at the point where they were applied to the insulator.
- No charges can be detected on insulators.
- Charges are freely movable in the insulator and stay at any place.

## Task 7

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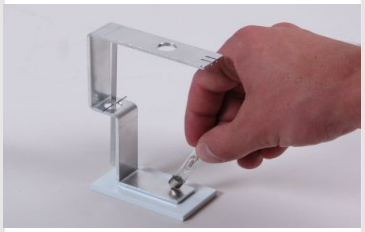
Examine top end



Examine bottom end

What do you conclude from experiments 4 and 5?

- No charges can be detected on conductors.
- No correlation can be derived with regard to the displaceability of charges in conductors.
- Charges stay exclusively at the point where they were applied to the conductor.
- Charges are present at any point in the ladder. They wander in the ladder (they can move freely).



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# Task 8

With the knowledge you have now gained about the mobility or non-mobility of charges, can you justify why you can transport charges to the electroscope with a polypropylene rod held in your hand, but can also discharge an electroscope at any point with your hand?

The electroscope is a _____. Accordingly, its charge _____ be removed at any point with the help of the hand.

The polypropylene rod, on the other hand, is an _____, its charge _____ be removed at any point.

cannot
insulator
conductor
can

Check



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