Charge distribution in a Faraday cup

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/6426c878ab58420002f62a76

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Teacher information

Application

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Faraday cup

A Faraday cup is - according to its name - a cup-shaped object with the help of which one can determine electric charge (especially ion beams).

The inside of the metal cup is basically field-free and electrical charges can only be taken out via the outer wall of the cup. However, the electric charge can also be supplied to the cup via the inner wall.

This therefore means that no charge can migrate from the inner wall of the Faraday cup to an influence plate, but it is possible from the outer wall of the cup.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Other teacher information (1/2)

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Prior knowledge

The students should already have studied electric charge and its effects in detail. The previous experiments, in which the electric charge is examined using a simple electroscope, provide basic knowledge for this. In addition, the experiment "Conductors as charge storage" provides a good basis for successfully carrying out this experiment.

Principle

The inside of the Faraday cup is basically field-free. Thus, no electrical charges can migrate from the inner wall of the cup to other objects. The outer wall of the cup, on the other hand, is able to transfer charges to other bodies.

Other teacher information (2/2)

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Learning objective

The students realise that in a charged Faraday cup, the charges are on the outside of the cup and can only be removed from there. However, charges can be applied to both the outside and the inside of the cup.

Tasks

In this experiment, the students are to investigate the properties of the Faraday cup in detail. To do this, they have to determine the charge distribution on the Faraday cup.

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Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

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:

Experimentelly critical is the proof that there are no charges on the inside of the Faraday cup. When using the influence plate, this can only be proven if the influence plate is safely inserted into the beaker without contact. Charge transfer can already occur when approaching the upper rim. Therefore, the plate must be handled with care.

Since the Faraday cup, in addition to its function as a charge storage device, also plays a major role in a modified form as a Faraday cage, the shielding of electrostatic fields can be investigated in the additional task. The protective effect of a car body during a thunderstorm can be pointed out.

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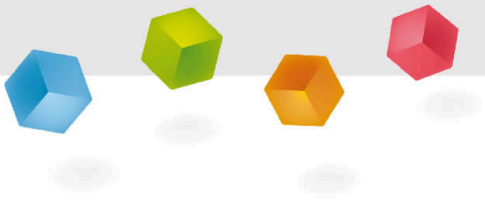

Student information

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Motivation

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Faraday cup

A Faraday cup is - according to its name - a cup-shaped object with the help of which one can determine electric charge (especially ion beams).

Due to the special geometry of the Faraday cup, the inside of the metal cup is basically field-free, which has special effects on the charge distribution in relation to the cup.

This experiment shows you exactly how the charges are distributed on the Faraday cup and what properties result from this.

Tasks

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In this experiment, you will take a close look at the so-called Faraday cup and its properties.

First set up an electroscope and make sure that the Faraday cup is insulated as well as possible.

Then investigate the distribution of the electrical charge on a metal cup.

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Robert-Bosch-Breite 10
37079 Göttingen

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Equipment

Position	Material	Item No.	Quantity
1	Electroscope w. metal pointer	13027-01	1
2	Faraday pail, d. 40mm, h. 75mm	13027-03	1
3	Polypropylene rod, l=175mm, d=10 mm	13027-09	1
4	Acrylic resin rod, l=175 mm, d=8 mm	13027-08	1
5	Electrostatic influence plate, 30 x 60 mm	13027-12	1
6	Film, transparent, DIN A4, 100 sheets	08186-10	1
7	Rubber stopper,d=49/41mm, 1 hole	39263-01	1

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Robert-Bosch-Breite 10
37079 Göttingen
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Additional Equipment

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Position	Equipment	Quantity
1	Dry, rough paper	DIN A4
1	Adhesive tape	

Set-up

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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.

Then attach the influence plate to the polypropylene rod and the Faraday cup to the acrylic rod. Then insert the acrylic rod into the rubber stopper as shown in the illustration opposite.

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Robert-Bosch-Breite 10
37079 Göttingen

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Procedure (1/6)

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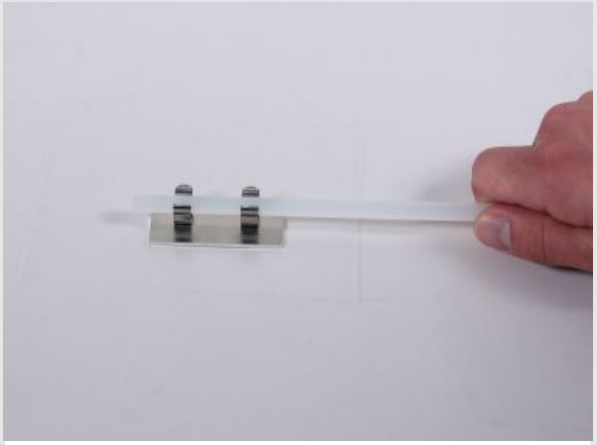

Charging the Influence Plate

Experiment 1:

- Rub the influence plate over the transparent film lying on the table.

Procedure (2/6)

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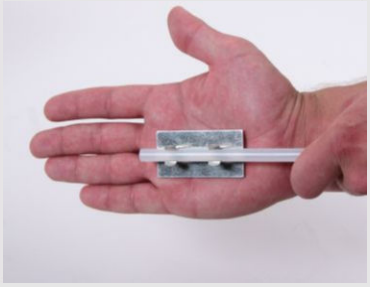
Experiment 1:

- Then touch the outside of the Faraday cup with the Influence Plate.
- Repeat this process several times so that the Faraday cup is well charged.
- Now unload the influence plate and the electroscope by touching them with your hand.



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Procedure (3/6)

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Alternately touching the Faraday cup and the electroscope

Experiment 1:

- Now alternately touch the outside of the Faraday cup and the electroscope with the Influence Plate
- Keep a close eye on the pointer.

Procedure (4/6)

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Examine the inside of the cup

Experiment 2:

- Check whether charges can also be transferred to the electroscope from the inside of the Faraday cup.
- As in the first part of the experiment, charge the Faraday beaker well and discharge the electroscope.
- Touch the bottom or the inner wall of the beaker (but not the upper rim) with the influence plate and then the electroscope.
- Finally, touch the outside of the cup again and then touch the electroscope to check.

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Robert-Bosch-Breite 10
37079 Göttingen

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info@phywe.de
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Procedure (5/6)

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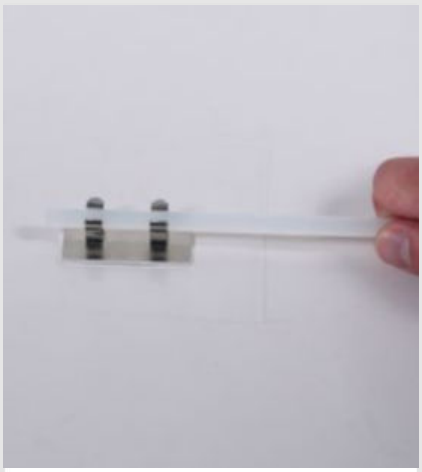
Discharge Faraday Cup

Electroscope discharged

Experiment 3:

- Now check whether charges can be transferred to the inside of the Faraday cup.
- First discharge the Faraday beaker and the electroscope.
- Then charge the Influence Plate by rubbing it on the transparent film.



Charging the Influence Plate on Transparent Film

Procedure (6/6)

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Examine the inside of the cup

Experiment 3:

- Touch the inside of the cup with the charged Influence Plate.
- Be careful not to touch the edge or the outside.
- Then check with the influence plate and the electroscope whether charges can be picked up from the inside of the cup.
- Then also check whether charges can be taken from the outside.

Examine the outside of the cup

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
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info@phywe.de
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Report

Task 1

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Alternately touching the Faraday cup and the electroscope

How does the position of the pointer change with the individual touches of the electroscope in the first partial experiment?

With each further movement, the pointer deflected further. Strongly at first, then less and less.

With each movement, the pointer moved briefly and then returned to its original position.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
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info@phywe.de
www.phywe.de

Task 2

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Alternately touching the Faraday cup and the electroscope

What does the changing pointer deflection in the first partial experiment tell us about the size of the charges on the Faraday cup and the electroscope?

The _____ the increase in the pointer deflection, the more electrical charge was removed from the cup.

The _____ the increase in the pointer deflection, the less residual charge was in the cup.

larger | smaller

Check

Task 3

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Examine the inside of the cup

When did a pointer deflection occur in the second part of the experiment with the electroscope?

- Both after touching the inside and the outside of the cup, a deflection occurred on the electroscope.
- While no pointer deflection occurs after previous contact with the inside, the pointer deflects after contact with the outside wall.

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Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 4

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Examine the inside of the cup

Where on the Faraday cup were the transferred charges located during the second partial experiment?

The charge in the Faraday cup was on the _____ of the cup, so it _____ cause the electroscope to move.

The _____ of the cup was free of charge, so it _____ cause the electroscope to move.

inside | outside | did not | did

Check

Task 5

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Examine the inside of the cup

Where could charges be taken from in the third partial experiment?

- Only on the outside of the cup.
- Only on the inside of the cup.

Examine the outside of the cup

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Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
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Task 6

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What is the difference between the possibilities of applying and removing charges on the Faraday cup?

The Faraday cup is made of metal and is therefore electrically _____. Therefore, it can be charged at _____ point during contact, especially on the _____. Due to the _____ force effect of charges of the same name, the charges are distributed at the _____ distance from each other, i.e. especially on the _____. Accordingly, the charges can only be reduced there.

inside
outside
conductive
any
repelling
largest possible

Check

Slide	Score / Total
Slide 19: Observation: Experiment 1	0/1
Slide 20: Conclusion: Experiment 1	0/2
Slide 21: Explanation: Experiment 2	0/1
Slide 22: Explanation: Experiment 2	0/4
Slide 23: Observation: Experiment 3	0/1
Slide 24: Conclusion	0/6

Total 0 / 15

Solutions Repeat

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de