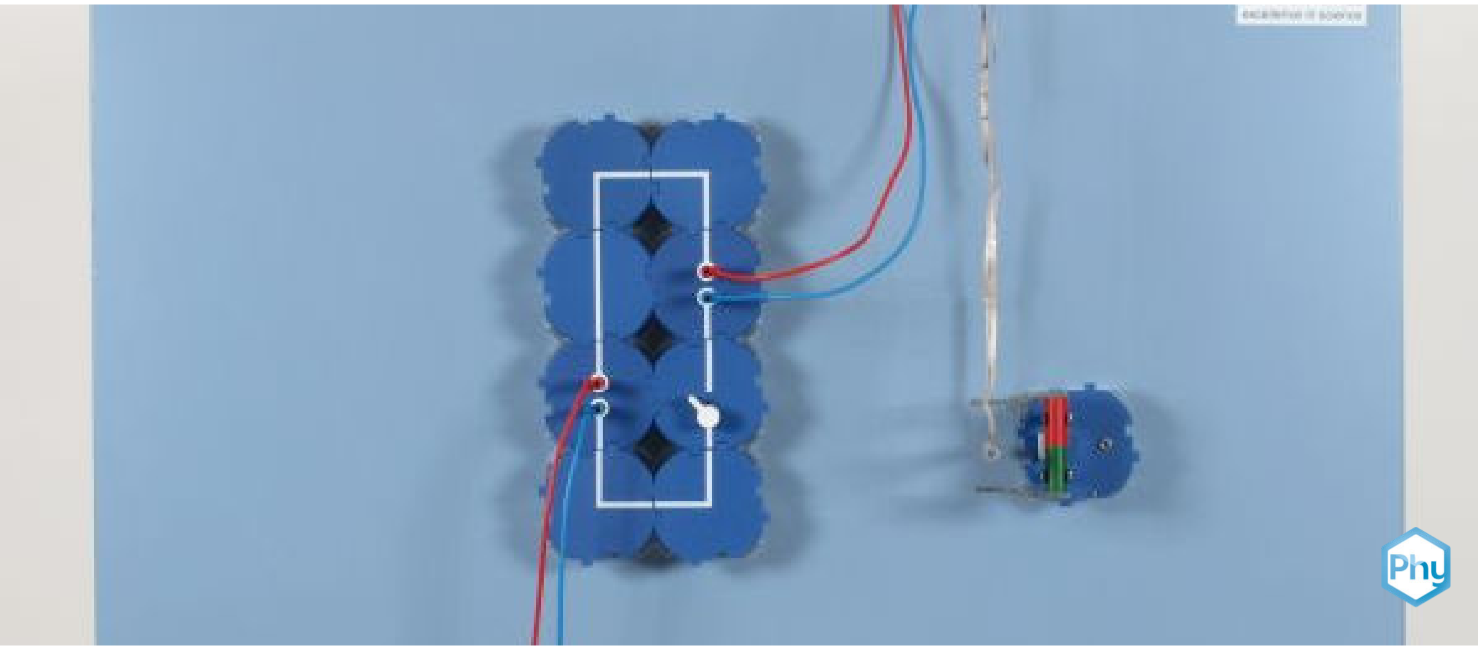
The Lorentz force: current-carrying conductors in a magneticfield



Physics | Electricity & Magnetism | Electromagnetism & Induction

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/619d10177d68a700037e674e

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Teacher information

Application

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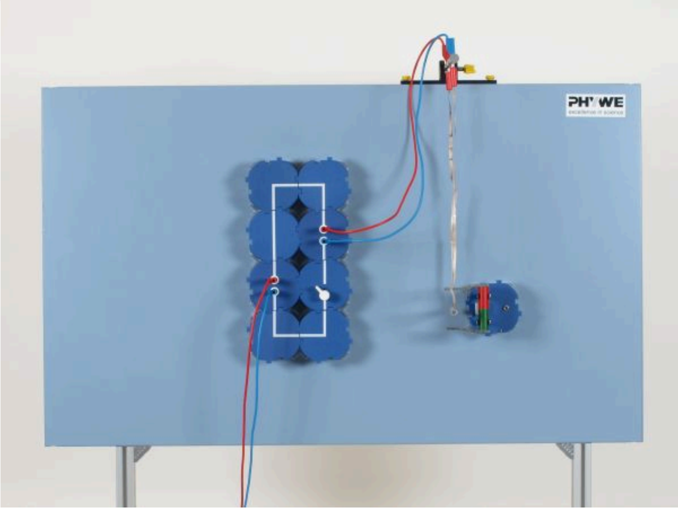

Experimental setup

While the thermal and light effects of electric current are directly accessible to the human senses, this is not true of the chemical and magnetic effects.

The magnetic effect of a current carrying conductor is essential for an electromagnet, electric motors or generators, for example.

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Other teacher information (1/3)

Prior knowledge

Students should have a basic knowledge of simple electrical circuits and of magnetism (forces between magnets, magnetic poles, magnetic fields, etc.).

Scientific principle

The Maxwell equations explain the magnetic vortex field which a current flowing through a conductor causes.

The law of flow is: $\vec{\nabla} \times \vec{B} = \mu_0 \vec{j} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$

The interaction with the magnetic field of the permanent magnetic results in the Lorentz force, which acts vertically on moving electric charges.

Other teacher information (2/3)

Learning objective

The aim of this experiment is to show the students that a permanent magnet exerts a force on a conductor that is carrying current.

Tasks

1. Observe the conductor swing while closing the circuit.
2. Reverse polarity of the applied voltage and observe the conductor swing while closing the circuit.
3. Reverse position of the permanent magnet and observe the conductor swing while closing the circuit.

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Other teacher information (3/3)

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Notes

This experiment is a de facto short circuit. It is permitted because the power supply unit is equipped with electronic current limitation. Students should be made aware of this, otherwise they may underestimate the dangers associated with short circuits.

The circuit should in each case only be briefly opened to avoid overloading the conductor swing. Should no power supply with automatic current limitation be available, then the voltage must be previously so set that the current does not go above 3 A to any great extent.

As the connecting lines are made of copper, they cannot be associated with the magnetic effects, as copper is not magnetic by itself.

Safety instructions

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

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Student Information

Motivation

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Electromagnet on an excavator

Coils are built into electromagnets, as here in the excavator at the scrap yard, but also into transformers or in loud speakers. This makes use of the fact that a current carrying conductor generates a magnetic field.

If a permanent magnet were used in the picture shown, the scrap could be picked up but not thrown off again.

In this experiment you will investigate the magnetic properties of a conductor through which current flows.

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Equipment

Position	Material	Item No.	Quantity
1	PHYWE Demo Physics board with stand	02150-00	1
2	Connector, straight, module DB	09401-01	1
3	Connector, angled, module DB	09401-02	4
4	Connector interrupted, module DB	09401-04	2
5	Switch on/off, module DB	09402-01	1
6	Holder for U-magnet, module DB	09476-00	1
7	Magnet holder,d=18mm	09476-10	1
8	Pole shoes,1 pair (18x4x70)mm	09476-11	1
9	Clamp on holder	02164-00	1
10	Magnet, bar-shaped, d = 18 mm, l = 70mm	06318-00	1
11	Conductor swing	06412-00	1
12	Insulating support, l = 235 mm	07924-00	1
13	Connecting cord, 32 A, 1000 mm, red	07363-01	1
14	Connecting cord, 32 A, 1000 mm, blue	07363-04	1
15	Connecting cord, 32 A, 750 mm, red	07362-01	1
16	Connecting cord, 32 A, 750 mm, blue	07362-04	1
17	PHYWE Power supply, universal DC: 0...18 V, 0...5 A / AC: 2/4/6/8/10/12/15 V, 5 A	13504-93	1

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Setup

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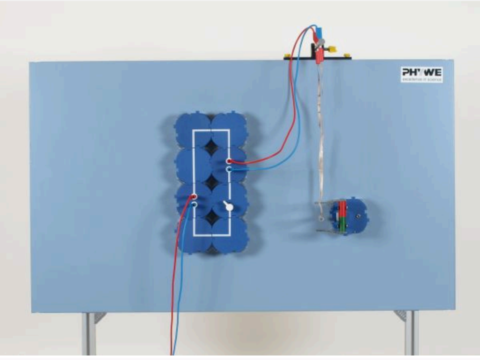
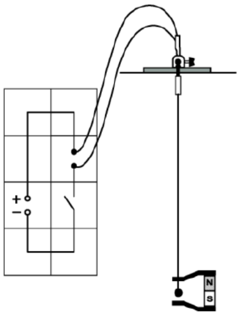
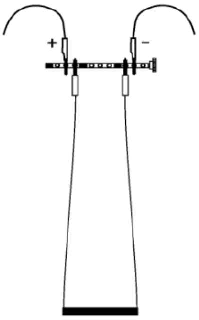
Set up the experiment as shown in the figures, in doing this, screw the clamp on holder tight to the upper edge of the demo board, fix the insulating support with the clamp, hang an the conductor swing and connect the connecting cables (schematic view); attach the magnet holder to the holder for the galvanometer model, press in the magnet and put the pole shoes on such that the middle of the horizontal part of the conductor swing is between the ends of the pole shoes







Procedure

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- Set the power supply to 0 and switch it on; select the 3 A current limit
- Adjust the voltage to 5 V-, briefly close the circuit and observe the conductor swing (1)
- Repeat this procedure several times
- With the switch open, reverse the polarity of the applied voltage and so reverse the direction of the current through the conductor swing
- Repeatedly briefly close the circuit while observing the conductor swing (2)
- Clamp the magnet in the reverse position in the magnet holder, again repeatedly briefly close the circuit while observing the conductor swing (3)

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Report

Task 1

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What happens, when the circuit is closed?

- Nothing
- The swing moves into or out of the magnet
- The swing starts glowing
- The swing moves priodically back and forth

Check

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Task 2

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What does the direction of movement of the conductor swing depend on?

- ☐ The amount of current
- ☐ The direction of the magnetic field of the permanent magnet
- ☐ The absoulte voltage value
- ☐ The polarity of the applied voltage

Check

Task 3

PHYWE

What would happen, if the experiment were repeated with the swing positioned on the backside of the magnet?

- ○ The swing moves in the opposite direction compared to the experiment
- ○ The swing does not move
- ○ The swing moves in the same direction copmared to the experiment

Check

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Slide	Score / Total
Slide 14: Form of the magnetic field	0/1
Slide 15: Coil = Permanent magnet	0/2
Slide 16: Coil = Permanent magnet	0/1

Total amount 0/4

Solutions Repeat

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