Current-carrying conductors in magnetic fields

(Item No.: P1375600)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physik	Klasse 7-10	Elektrizitätslehre	Elektromagnetismus	Stromdurchflossener Leiter im Magnetfeld

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional information

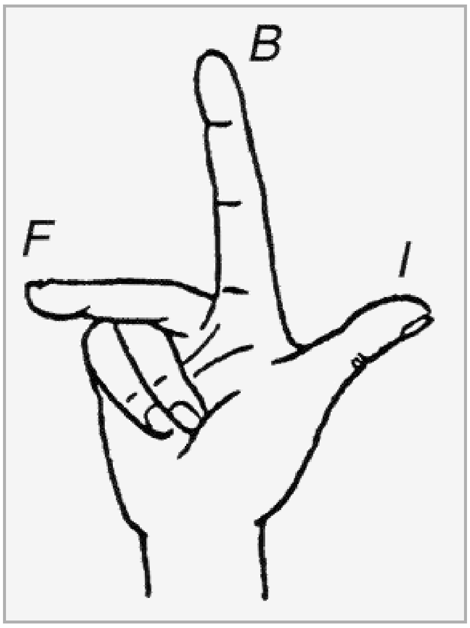
The students should know, that a current-carrying conductor is surrounded by a magnetic field whose field lines are concentric circles, and how one can determine the direction of the field lines. They should also know the conventions, that the field lines external to a permanent magnet or an electromagnet run from the North pole to the South pole, and electric current flows from the positive pole to the negative pole.
The students should find out that a force acts on a current-carrying conductor in a magnetic field and how one can determine its direction.

Notes on setup and procedure

The power supply is electronically protected against overload, the maximum current strength is 2 A.
In the second experiment, a battery is required as the source of current; the duration of the short-circuit should be kept as brief as possible.
The conception of the experiment results in the findings strived for, even when only the first experiment is actually carried out.

Remarks

With this experiment, only a qualitative statement on the Lorentz force which acts on a current-carrying conductor is intended. The students should – even when the Lorentz force is not taken as a theme – be aware that a force acts on the current-carrying conductor because a deflecting force acts on each electron of the current in a magnetic field. The deflected electrons take the conductor altogether with them.
When the thumb of the right hand points in the direction of the current, and the forefinger in the direction of the field lines, then the horizontally-stretched middle finger shows the direction of the force which acts on the conductor.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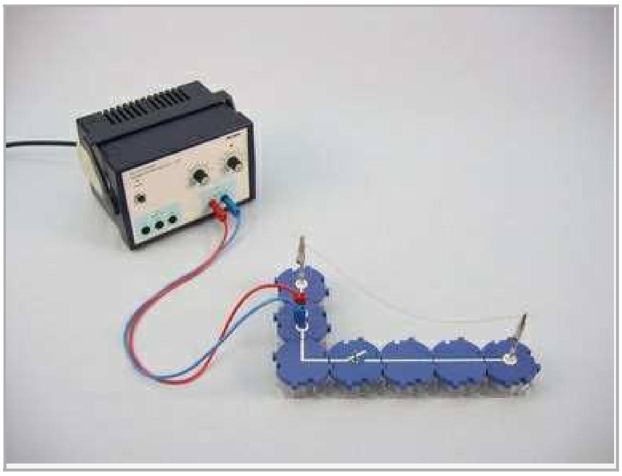
Task and equipment

Task

How can electric current generate mechanical movement?

Let current flow through a conductor which is in a magnetic field, and investigate whether forces act on the conductor and which direction these forces have.



Equipment

Position No.	Material	Order No.	Quantity
1	Straight connector module, SB	05601-01	2
2	Angled connector module, SB	05601-02	1
3	Interrupted connector module, SB	05601-04	1
4	Junction module, SB	05601-10	2
5	On-off switch module, SB	05602-01	1
6	Alligator clips, bare, 10 pcs	07274-03	2 pieces
7	Coil, 400 turns	07829-01	1
8	U-core	07832-00	1
9	Bar magnet, l = 72mm	07823-00	1
10	Connecting cord, 32 A, 500 mm, red	07361-01	1
11	Connecting cord, 32 A, 500 mm, blue	07361-04	1
12	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
13	Battery cell, 1.5 V, baby size, type C	07922-01	1
14	Copper wire, d = 0.2 mm, l = 100 m	06106-00	350 mm
15	Battery holder module (C type), SB	05605-00	1
16	Connecting plug, 2 pcs.	07278-05	2 pieces

Set-up and procedure

Set-up

First experiment

Set up the circuit as shown in Fig. 1 and Fig. 2 with the switch open; use two crocodile clips (on connecting plugs) to fit in an approx. 30 cm length of copper wire in such a way that it hangs loosely.

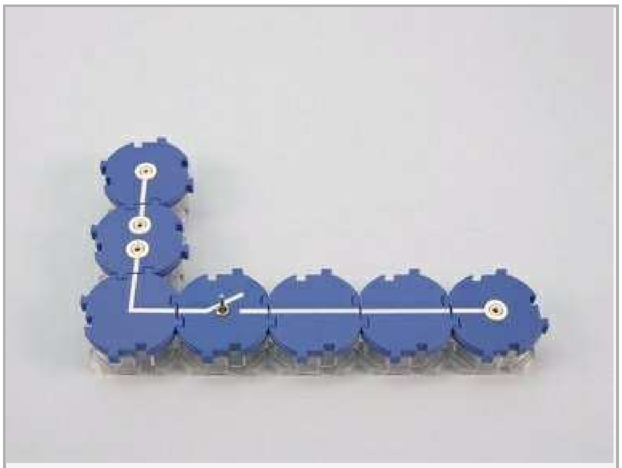


Fig. 1

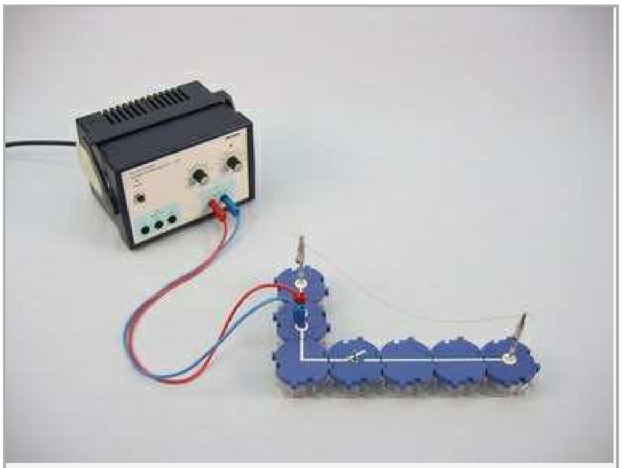


Fig. 2

Second experiment

Change the connections in the circuit to those shown in Fig. 3 and Fig. 4, with the switch again first open; position the coil with 400 turns and the U-core so on the table that the suitably hanging wire passes through the arms of the U-core without touching them, or the coil.

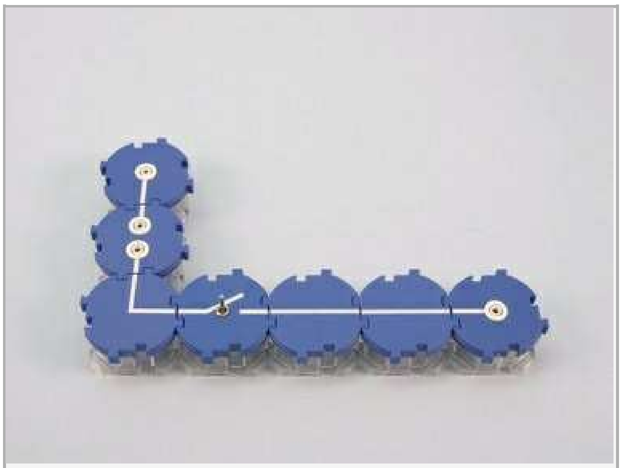


Fig. 3

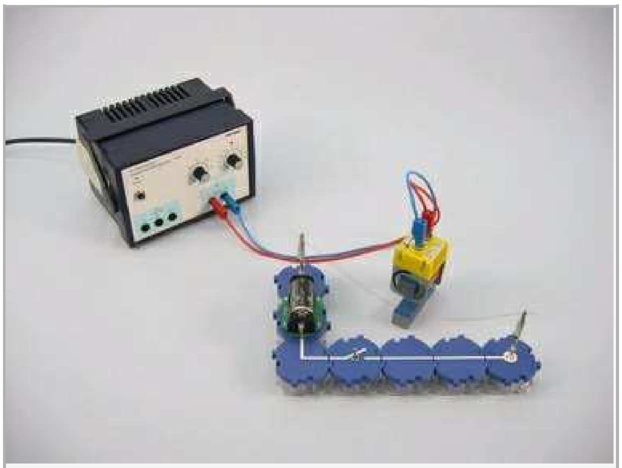


Fig. 4

Procedure

First experiment

- Switch on the power supply, set it to 0 V and set the current limitation to 2 A.
- Close the switch and carefully increase the voltage until the control lamp on the power supply lights up; open the switch.
- Hold the magnet vertically above the lowest part of the wire, so that the gap between them is only a few millimetres, and first with the North pole down, as shown in Fig. 5.
- Briefly close the switch, observe the behaviour of the wire and immediately open the switch again.

Note: Because we are short-circuiting here, the circuit can only be briefly closed (for 1 to 2 seconds). Should it not have been possible to exactly observe the behaviour of the wire, again briefly close the circuit.

- Note your observation in Table 1 under experimental step 1 in the report.
- Now hold the magnet with the South pole down, repeat the upper procedure and note what you observe (step 2).
- Reverse the polarity of the power supply and repeat the upper procedure, first with the South pole down towards the wire, and then with the North pole; note what you observe (steps 3 and 4).
- Set the power supply to 0 V and switch it off.

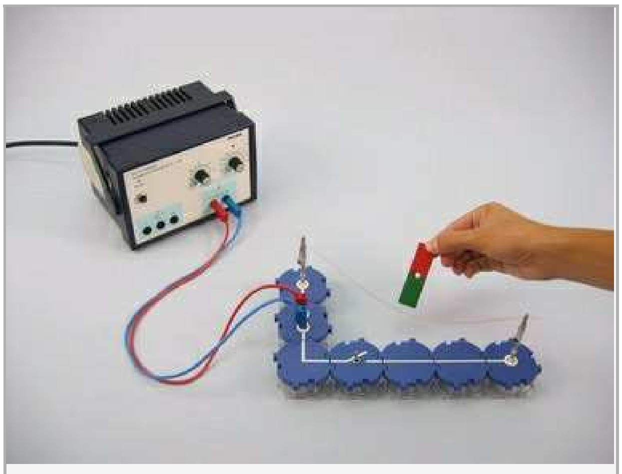


Fig. 5

Second experiment

- Set the power supply to approx. 3.5 V and 1 A and switch it on.
- Test with the bar magnet, if the upper pole of the electromagnet is a North pole, if not, reverse the connections to the power supply.
- Carry out the experiment in 4 steps, analogous to the first experiment:
  North pole up, current direction from back left to front right.
  South pole up (after reversing the connections to the power supply), current direction unchanged.
  South pole up, current direction (after replugging the battery holder) reversed.
  North pole up (after reversing the connections to the power supply), current direction unchanged.
- In each case, observe the deflection of the wire on briefly (!) closing the switch, and compare these deflections with those observed in the 4 steps of the first experiment (Table 1).
- Note the results of your comparison under Result - Observation.
- Set the power supply to 0 V and switch it off.

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Result - Table 1

Note your observations.

Experimental step	Direction of the current in the conductor	Direction of the field lines of the magnet	Direction of t
1	From back left to front right	Vertically down	
2	1	1	
3	1	1	
4	1	1	

Result - Observations

Compare the observations for the different steps from Table 1.

Evaluation - Question 1

Formulate an assertion on the direction of the force in relation to the direction of the current and the field lines (refer to Table 1).

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Evaluation - Question 2

Which conclusion can be drawn from the comparison of the experiment 1 (magnetic field of a permanent magnet) and experiment 2 (magnetic field of an electromagnet) noted under Result - Observation?

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