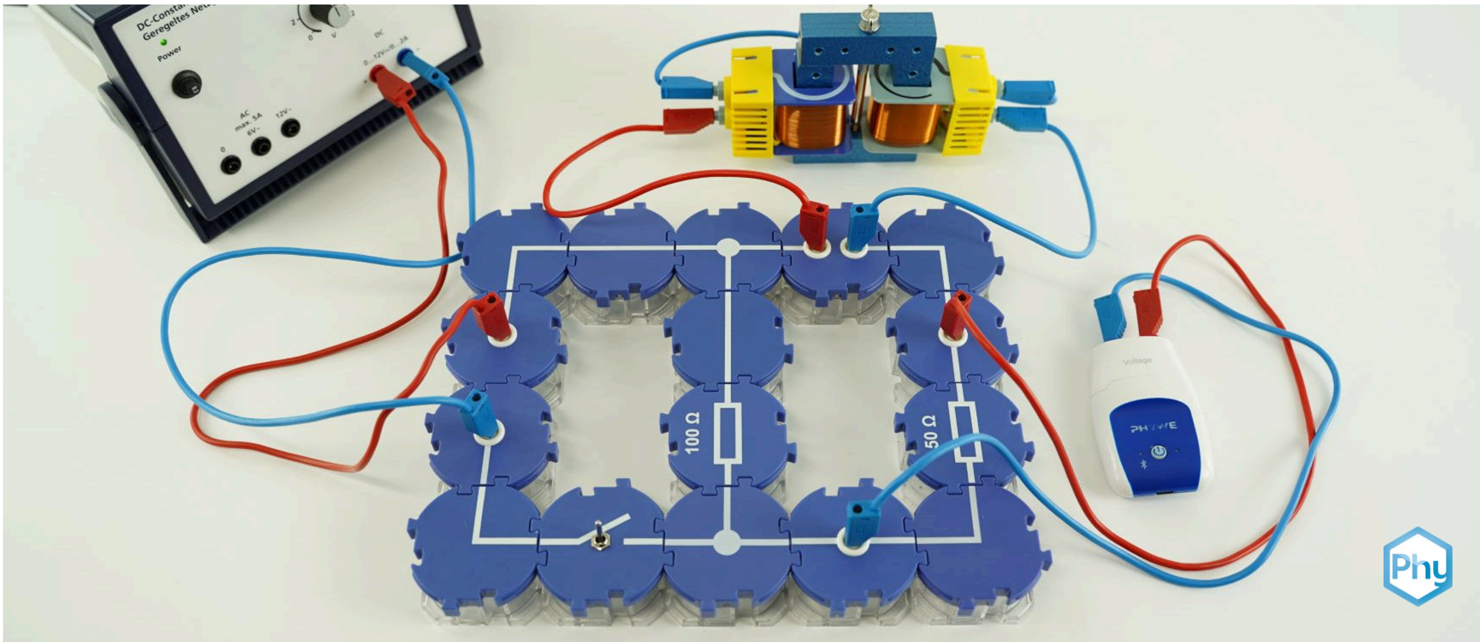
The self-induction during the switch-on process with Cobra SMARTsense



Physics | Electricity & Magnetism | Electromagnetism & Induction

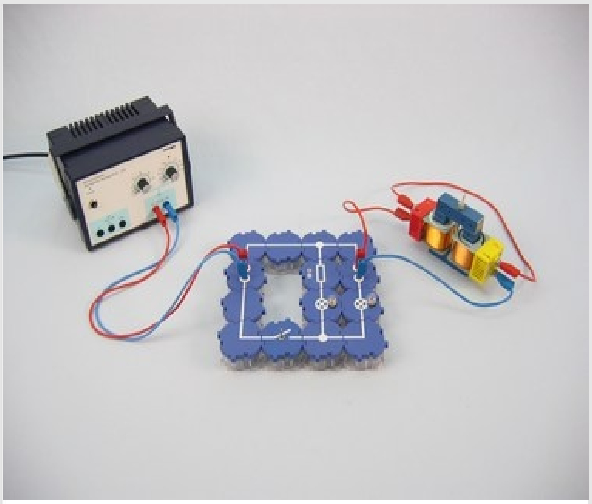
Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	20 minutes

This content can also be found online at:

http://localhost:1337/c/638c80620783cf00038d1565

Teacher information

Application



Experimental setup

Current-carrying coils have a magnetic field that must first be built up after the DC circuit is closed and must be reduced after the circuit is opened. This results in a self-induction voltage.

According to Lenz's law, the self-induction voltage always counteracts its cause. The following applies: $U_i = -L \cdot (\mathrm{d}I/\mathrm{d}t)$ with self-inductance L, with the unit Henry $(1\,H = 1\,\Omega s)$.

This principle is used, for example, as a damper in electrical measurement technology. Other examples of induction applications include charging stations or induction cookers.

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Other teacher information (1/3)

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Prior knowledge

The students should be able to construct and understand a simple electric circuit. They should know that a voltage is induced in a coil as long as the magnetic field encompassed by the coil changes. They should be familiar with electromagnets and therefore also know that a current-carrying coil has a magnetic field and what the strength of the magnetic field depends on.

Principle

Self-inductance is a property of electrical circuits or components, especially coils. The self-inductance of a circuit relates the time rate of change of the electric current to the electric voltage. Both switching on and switching off counteracts the change and thus causes a delay in the change.

Other teacher information (2/3)

PHYWE

Learning objective

With the experiment provided, the students are to recognise that when switched on, a self-induction voltage is created which counteracts the increase in current.

Tasks

The experiment is first carried out with two coils connected by an iron core. When the coils are switched on and off again, it should be recognised that the bulb on the coil lights up later, while the other one lights up immediately.

In the second section, the iron core is removed and it is recognised that the previously observed effect no longer occurs when switching on.

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Other teacher information (3/3)

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Notes on set-up and procedure

Since the inductance is relatively low, the students have to trigger the switch-on process repeatedly in order to prepare their eyes for the subsequent lighting up of the bulb L_2 to train them. They may recognise this better if they also carry out the experiment with a low operating voltage.

The available coils without iron core have the inductances $50\,mH$ and $3\,mH$. With a closed core, the coil with 400 turns has an inductance in the order of magnitude of about $100\,mH$, the coil with 1600 turns has one of approx. $700\,mH$.

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

Induction cooker

Induction is a principle that is used in many ways in electrical devices. Therefore, one often encounters this phenomenon in everyday life without being aware of it.

The most obvious example of induction is the induction cooker. Here, eddy currents are used to heat the bottom of the pot on the cooker. Another example where induction plays a role is wireless charging, where a time-varying magnetic field induces an electric field, which in turn generates a current.

In this experiment, you will learn about the self-induction of a coil and what effect this has on an electric circuit.

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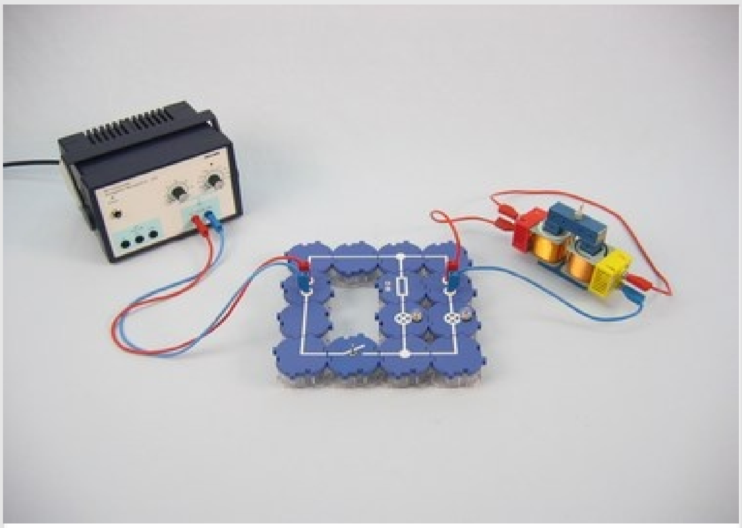
Tasks



Experimental setup

What effect does a coil have when closing a DC circuit?

Investigate the effect of a coil built into one of the branches on a parallel circuit of two incandescent lamps.

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Equipment

Position	Material	Item No.	Quantity
1	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
2	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-01	1
3	Straight connector module, SB	05601-01	2
4	Straight connector module with socket, SB	05601-11	2
5	Angled connector module, SB	05601-02	4
6	T-shaped connector module, SB	05601-03	2
7	Interrupted connector module with sockets, SB	05601-04	2
8	On-off switch module, SB	05602-01	1
9	Socket module for incandescent lamp E10, SB	05604-00	2
10	Filament lamps 4V/0.04A, E10, 10	06154-03	2
11	Resistor module 50 Ohm, SB	05612-50	1
12	Resistor module 100 Ohm, SB	05613-10	1
13	Junction module, SB	05601-10	2
14	Coil, 400 turns	07829-01	2
15	Coil, 1600 turns	07830-01	1
16	Iron core, U-shaped, laminated	07832-00	1
17	Iron core, I-shaped, laminated	07833-00	1
18	Tightening screw	07834-00	1
19	Connecting cord, 32 A, 250 mm, red	07360-01	1
20	Connecting cord, 32 A, 250 mm, blue	07360-04	2
21	Connecting cord, 32 A, 500 mm, red	07361-01	2
22	Connecting cord, 32 A, 500 mm, blue	07361-04	2
23	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up (1/2)

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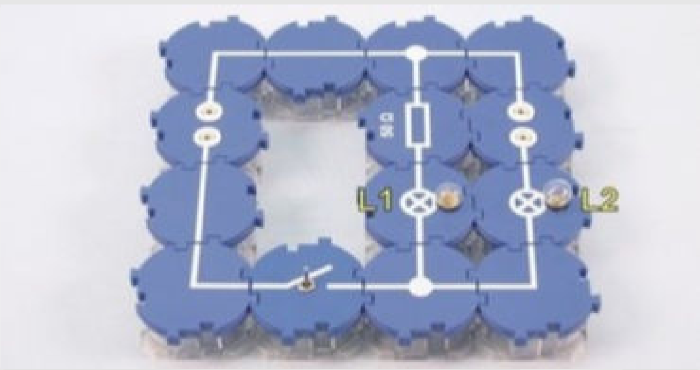
For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check that on your device (smartphone, tablet, desktop PC) **Bluetooth** is **activated**.

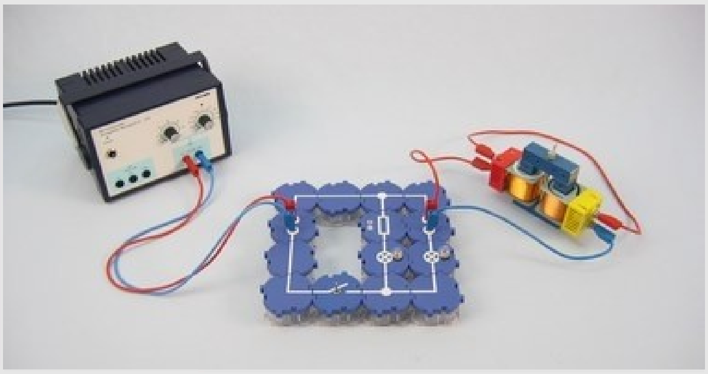
iOS	Android	Windows

Set-up (2/2)

PHYWE

Place the coils on the U-core. Press the U-core and the coils firmly together with the clamping screw. Set up the experiment according to the illustrations. The switch is open at first.





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Procedure (1/3)

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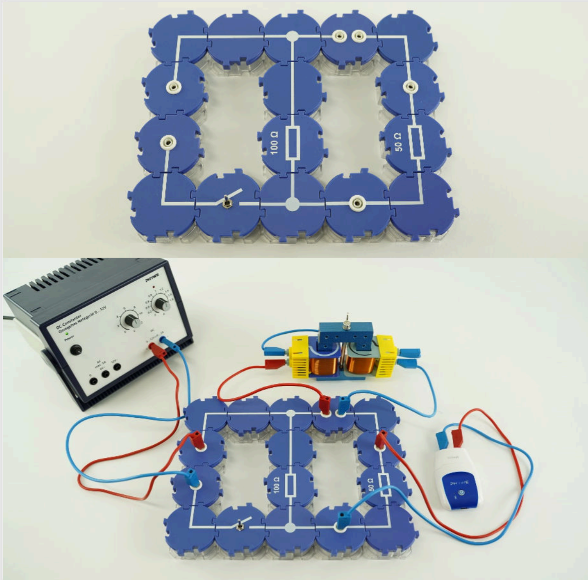

- Switch on the power supply and set the DC voltage to 6V.
- Close and open the switch repeatedly.
- Observe the bulbs L1and L2 simultaneously.
- Repeat this with a lower voltage and observe the bulbs again.
- Switch off the power supply unit.
- Set up the circuit according to the illustrations. The switch remains open again for the time being.

Procedure (2/3)

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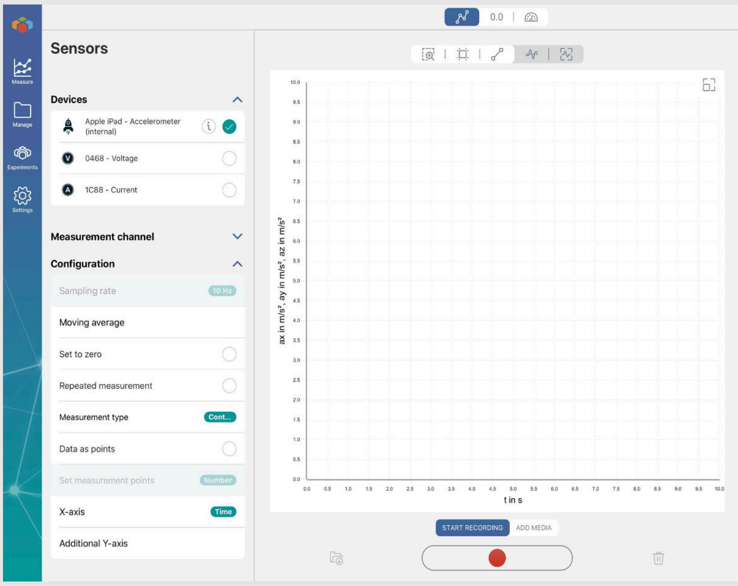

- Turn on the SMARTsense sensor by pressing and holding the power button and make sure the tablet can connect to Bluetooth devices.
- Open the PHYWE measure app and connect the sensor under "Measure" > "Sensor". > "Sensor" and then select the sensor "Voltage" (top left).
- After each of the following measurements, the measurement can be saved. For further analysis, the measurement can be opened again at any time under "My measurements".

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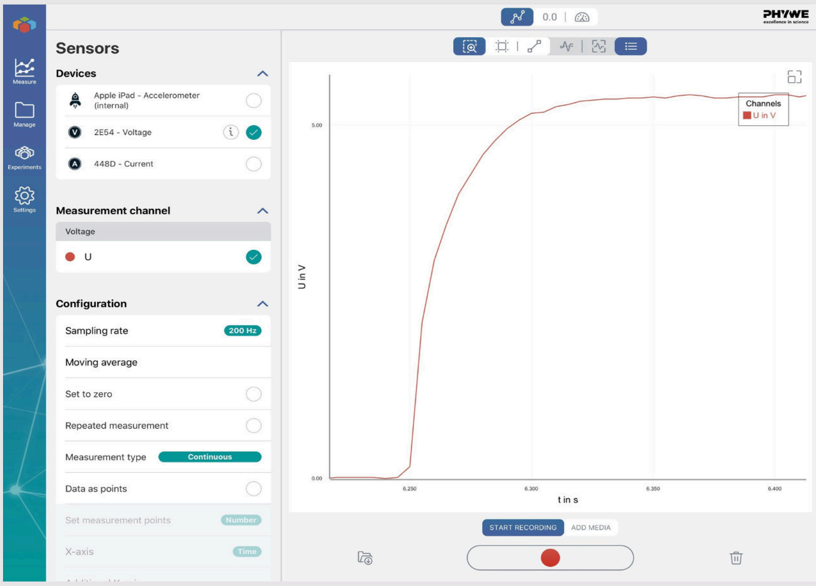
Procedure (3/3)



- Position on the power supply unit $6\ V$ and a current limitation of $1\ A$.
- Start a measurement and now repeatedly switch the circuit on and off at the switch and record the measured values.
- When zooming in on a switch-on operation with the zoom button, the measurement line should look similar to the illustration on the left.
- Repeat the measurements, but remove the iron core from the coils!

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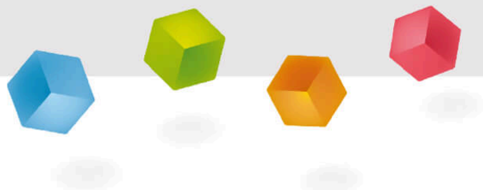

Report

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Task 1

PHYWE

When closing the circuit...

- no bulb lights up.
- a light bulb lights up first.
- both bulbs light up at the same time.

The bulb in the branch with the coil lights up later than the bulb next to the resistor.

- ○ True
- ○ False

Check

Task 2

PHYWE

What can be observed when opening the circuit.

- ☐ The bulbs go out at the same time.
- ☐ The bulb next to the coils goes out immediately when switched off.
- ☐ The bulb next to the coils stays lit longer.
- ☐ The bulb next to the resistor stays on longer.

Check

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Task 3

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How can the behaviour of the coil during the switch-on process be explained?

After the circuit is closed, the current begins to flow and builds up a variable (increasing) ______ in the coils. This causes an ______ in the coils which ______ the applied operating voltage and delays the ______ of the current until its maximum value is reached.

Not needed: ______ (adjective), ______ (noun).

- induction voltage
- same-sense
- magnetic field
- growth
- opposes
- decline

Check

Task 4

PHYWE

Drag the words into the correct boxes!

When the circuit is opened, both bulbs go out ______. This is because the ______ at the bulb in the branch of the coils also drops very quickly to a level at which the bulb no longer lights. After removing the iron core, the phenomenon is no longer observed during the switch-on process. This is because the iron core enormously ______ the ______ effect of the coils. If it is removed, the ______ is not strong enough to cause a noticeable time difference in the illumination of the bulbs.

- inductive
- at the same time
- amplifies
- voltage
- self-induction

Check

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Slide	Score / Total
Slide 17: Multiple tasks	**0/2**
Slide 18: Observation opening the circuit	**0/2**
Slide 19: Explanation switch-on procedure	**0/6**
Slide 20: Explanation opening and without iron core	**0/5**

Total **0/15**

Solutions Repeat

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