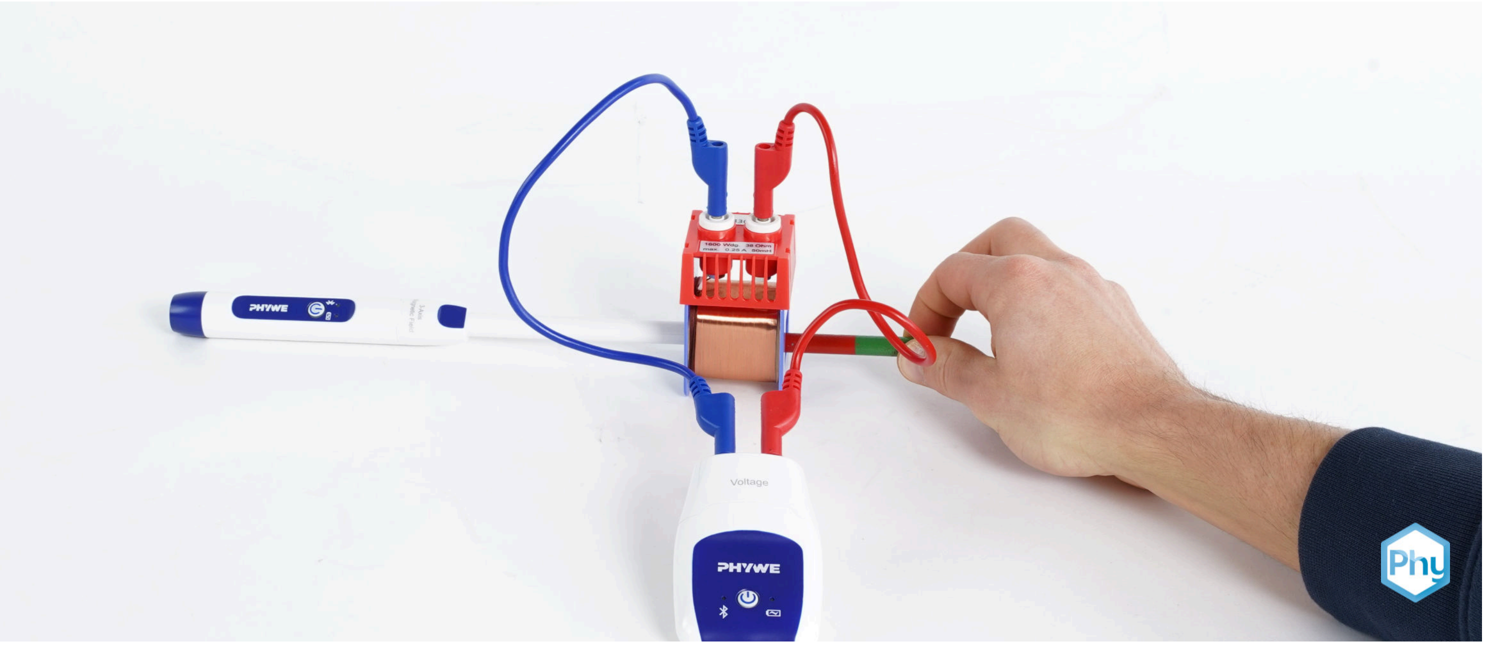
Induced voltage and magnetic flux density with Cobra SMARTsense



Physics | Electricity & Magnetism | Electromagnetism & Induction

Difficulty level	Group size	Preparation time	Execution time
easy	-	10 minutes	20 minutes

This content can also be found online at:

https://www.curriculab.de/c/67b448a9b9a8b10002bcc476

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Teacher Information

Application

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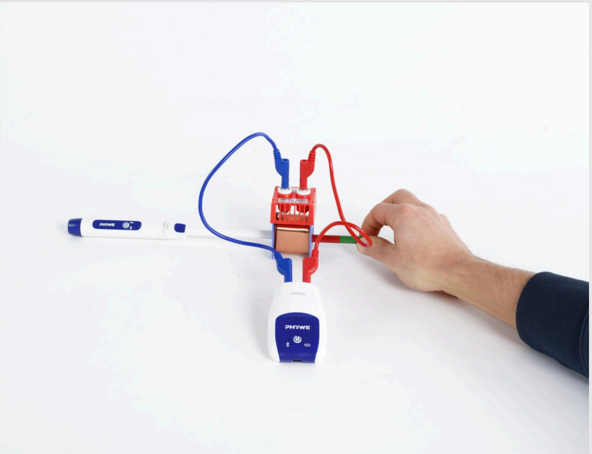

Experimental setup

Electromagnetic induction describes the generation of an electric voltage when the magnetic flux through a coil changes. This induced voltage can be measured directly and detected as an electric field.

A practical example is the bicycle dynamo: here, the rotation of the wheel moves a magnet past a coil. The changing magnetic field induces a voltage, which supplies the bicycle lamp with energy.

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Other teacher information (1/2)

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Prior

No prior knowledge is required.

Principle

If a magnet is moved in a certain way within a coil, this leads to a change in the magnetic flux within the electrical conductor. This change induces an electrical voltage and thus an electrical current flow in the coil.

Other teacher information (2/2)

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Learning

Pupils should understand the principle of electromagnetic induction and independently determine the proportionality between the induced voltage and the rate of change of flux density. This serves as preparatory work for introducing the law of induction.

Tasks

1. Set up the experiment according to the specifications.
2. Movement of the magnet with simultaneous detection of magnetic flux density and induced voltage.
3. Derivation of the relationships between the detected variables.

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Safety instructions

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

Student Information

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Motivation

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Bicycle light powered by electromagnetic induction

Have you ever wondered why your bike light turns on as soon as you start riding—without a battery or a switch? The answer lies in electromagnetic induction: movement changes a magnetic field, inducing a voltage in the coil.

This principle is not only used in bicycle dynamos but everywhere electricity is generated through motion. In this experiment, you will explore how changes in the magnetic field generate electrical energy and what role the direction and speed of movement play.

Tasks

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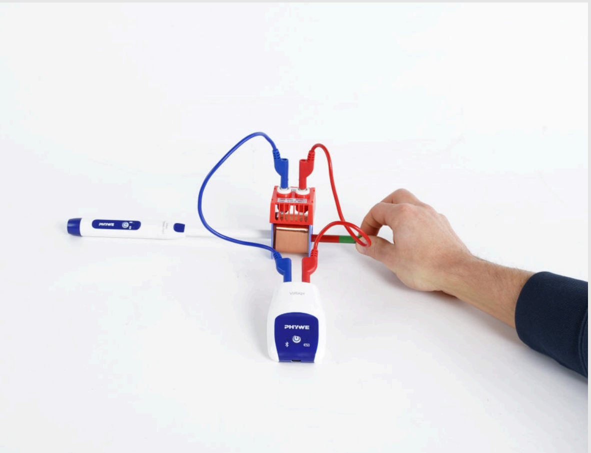

Experimental setup

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Equipment

Position	Material	Item No.	Quantity
1	Plug-in board, for 4 mm plugs	06033-00	1
2	Connecting cord,19 A,25cm, blue	07313-04	1
3	Connecting cord,19 A,25cm, red	07313-01	1
4	Coil, 1600 turns	07830-01	1
5	Magnet, d=8 mm, l=60 mm	06317-00	1
6	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-01	1
7	Cobra SMARTsense 3-Axis Magnetic field - Sensor for measuring the magnetic field in 3 axes ±130mT / ±5 mT (Bluetooth + USB)	12947-00	1
8	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Structure (1/2)

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For measurements 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 **Bluetooth** is **activated** on your device (smartphone, tablet, desktop PC).

iOS

Android

Windows

Structure (2/2)

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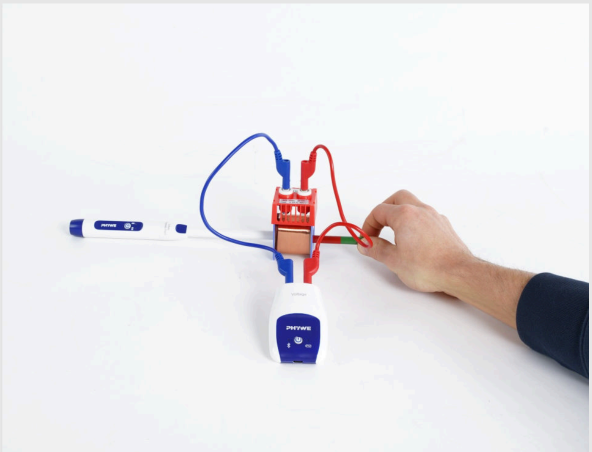
- Set up the experiment as shown in the figure on the right.
- Use a coil with the following specifications
  - $N = 1600$



Experimental setup

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Procedure (1/2)

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Cobra SMARTsense Voltage & Magnetic Field

- Switch on the Cobra SMARTsense Voltage and Cobra SMARTsense magnetic field sensors by pressing and holding the button on both sensors for approx. 3 seconds.
- Make sure that your end device can connect to Bluetooth.
- Open the PHYWE measureAPP and select the sensors "Voltage" and "Magnetic Field".

Procedure (2/2)

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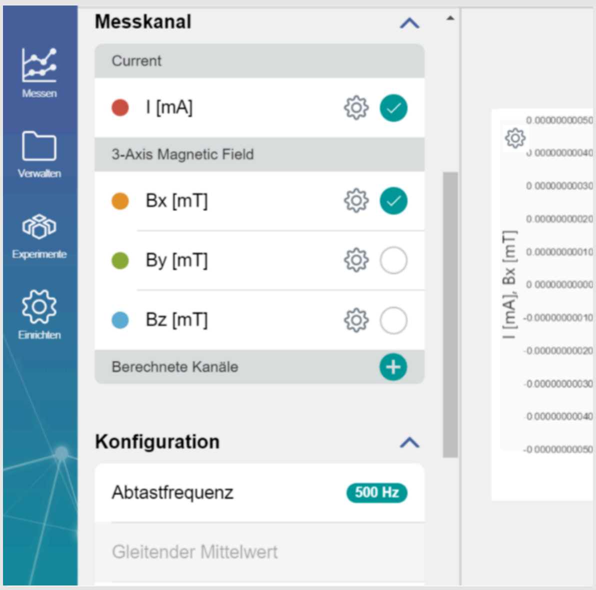

After you have connected the Cobra SMARTsense Magnetic Field Sensor, apply the following settings in the measureAPP:

- After the connection, select the fine measuring range (-5 mT... + 5 mT) for the sensor.
- Select only the longitudinal direction under Measuring channel B_x of the sensor, so that only the magnetic flux density in the direction of the longitudinal axis of the sensor is measured.
- Select the sampling frequency for the sensors under Configuration. The higher this is, the more accurate the measurements will be.

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Procedure (3/3)

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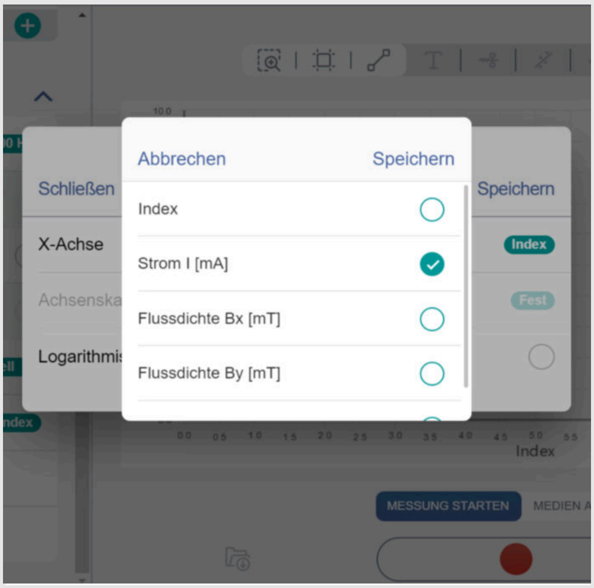

Carry out the next steps in the measureAPP:

- Go to the "Configuration" area and click on the "Set to zero" button. Select both the current and the flux density.

Finally, change the X-axis by pressing the cogwheel next to the X-axis.

- Choose the current I.
- The Y-axis should adjust itself automatically and should reflect the magnetic flux density B.

Realisation (4/3)

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Start a measurement.

Move the magnet in different patterns in front of or inside the coil. Do not make the movements too quickly and save your measurements for comparison in between.

Here are some examples of what you can do. Enter your observations in the log area:

1. Move the magnet into the coil with the north pole first, wait briefly and move the magnet back again
2. Repeat the process with the south pole side.
3. Move the magnet faster in and out of the coil.
4. Let the magnet rest in the coil.
5. Rotate the magnet in the coil around the longitudinal axis.

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Report

Evaluation (1/2)

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Movement	Observation	Movement	Observation
North pole into coil		Faster movement of the magnet	
North pole out of coil		Magnet rests in the coil	
South pole into coil		Rotation of the magnet around the longitudinal axis	
South pole out of coil		(In the section "Evaluation (2/2)" you can enter the movements you have devised and the corresponding observations).	

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Evaluation (2/2)

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Movement	Observation	Movement	Observation

Task 1

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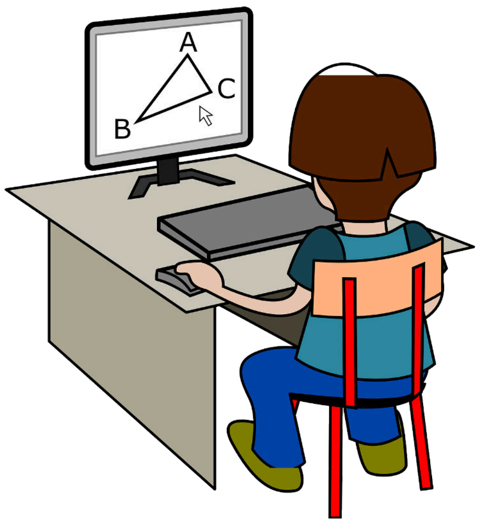
How is the rate of change of the magnetic flux density related to the induced voltage?

- $U_{ind}(t) = dB(t)/dt$
- $U_{ind}(t) \sim (dB(t)/dt)^2$
- $U_{ind}(t) \sim log(dB(t)/dt)$
- $U_{ind}(t) \sim dB(t)/dt$



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Task 2

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Drag the words into the correct boxes!

The ______ of a magnet within a coil affects the ______. When the magnet moves ______, the gradual change in the magnetic field produces a ______. If it moves ______, the rate of change of magnetic flux increases, generating a ______. However, if the magnet remains stationary, the magnetic field stays constant, and ______ is induced. The ______ only changes again when the magnet is moved or its direction is reversed, allowing a voltage to be measured.

- movement
- faster
- no voltage
- slowly
- higher voltage
- low voltage
- magnetic flux
- induced voltage

Task 3

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Fill in the gaps.

Electromagnetic induction describes the generation of an ______ when the ______ through a ______ changes. When a magnet moves into or out of the coil, the magnetic flux changes, inducing a ______. The ______ the movement, the greater the induced voltage. However, if the magnet remains ______, the magnetic field stays ______ and no voltage is generated. This relationship follows the principle that the induced voltage is ______ to the rate of change of the magnetic flux.

Check

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Slide	Score / Total
Slide 19: Relationship between rate of change of magnetic flux dens...	0/2
Slide 20: Movement of the magnet	0/8
Slide 21: Summary of electromagnetic induction	0/8

Total amount 0/18

Solutions Repeat Export text

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