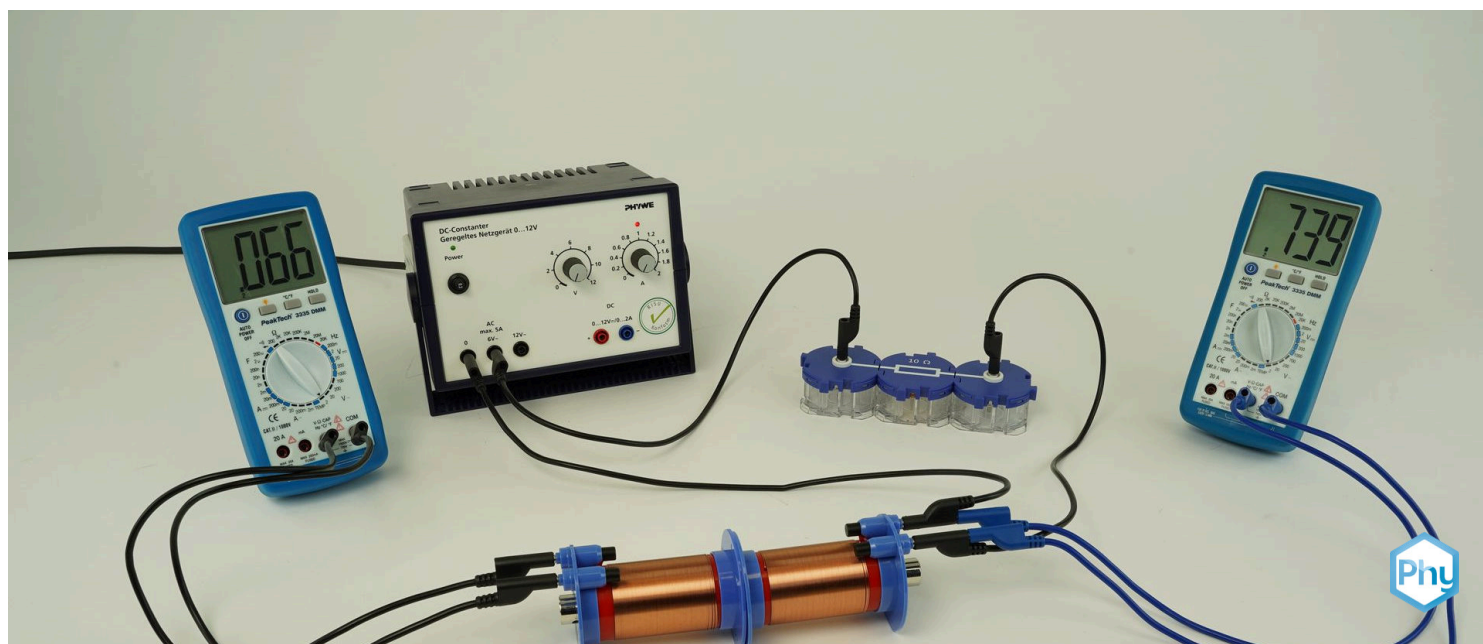


Electromagnetic induction with Cobra SMARTsense



Physics

Electricity & Magnetism

Electromagnetism & Induction



Difficulty level

medium



Group size

2



Preparation time

10 minutes



Execution time

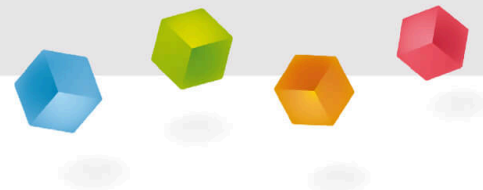
10 minutes

This content can also be found online at:



<http://localhost:1337/c/5f4bbe22c3481500038cb75a>

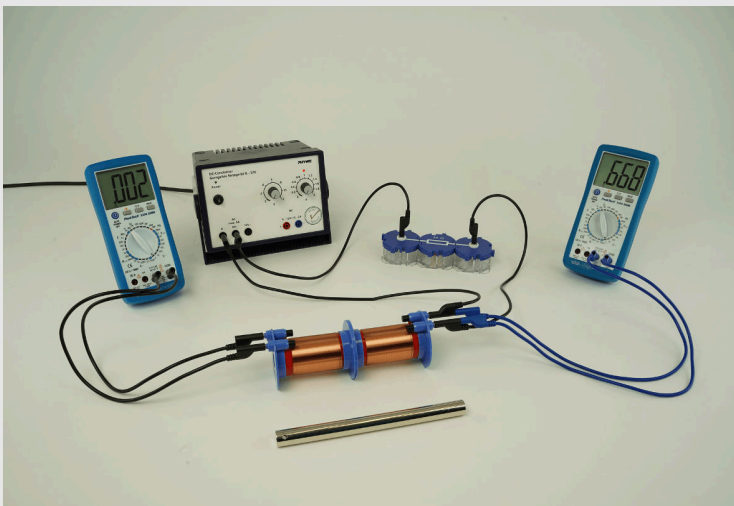
PHYWE



Teacher information

Application

PHYWE



Experiment set-up

Transformers are based on the principle of electromagnetic induction and are a widely used component in electrical engineering.

The main task of a transformer is to convert an input voltage into another output voltage. In addition to the number of windings of the coils used, their design and the magnetic permeability of the material within the coils play a very important role.

Other teacher information (1/2)

PHYWE

Prior knowledge



Students should know the principle of the law of induction and be familiar with the basics of electricity.

Scientific principle



The primary coil, which is connected to an AC voltage, generates a magnetic flux that varies with time. The change in the magnetic flux generates an electric field in the secondary coil and thus a current.

The law of induction states:

$$\nabla \times \vec{E} = \text{rot} \vec{E} = -\frac{\partial B}{\partial t}$$

Other teacher information (2/2)

PHYWE

Learning objective



This experiment is intended to bring the principle of electromagnetic induction closer. A current is induced in a coil by an alternating magnetic flux. The effect of an iron core in the two coils is studied.

Tasks



1. measuring the induced voltage without iron core in the coils
2. measuring the induced voltage with iron core in the coils

In addition, the task can be varied by also measuring the distance between the coils (with and without iron core).

Safety instructions

PHYWE

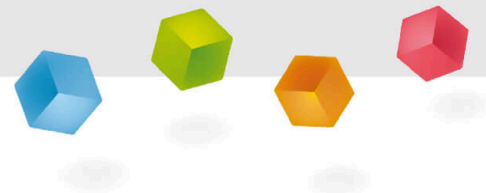


The general instructions for safe experimentation in science lessons apply to this experiment.

Notes

Alternating current, not direct current, is used in this experiment. The resistor is necessary to limit the current so that the coils do not overheat.

PHYWE



Student Information

Motivation

PHYWE



Electric toothbrush

Transformers are based on the principle of electromagnetic induction. Here, an electric field is induced by a magnetic field that changes over time, which in turn generates a current.

Thus, for example, electric toothbrushes or even some smartphones can be charged wirelessly by placing them on a charging station, whereby no metallic contact is made between the charging station and the device.

In this experiment you will learn the interrelationships and the principle of electromagnetic induction.

Tasks

PHYWE



1. measure the electromagnetically induced voltage at the coil, which is not connected to a power source
2. observe the influence of an inserted iron core

Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - 3-Axis Magnetic field	12947-00	1
2	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
3	Resistor module 10 Ohm, SB	05612-10	1
4	Junction module, SB	05601-10	2
5	Induction coil, 100 turns, dia. 40mm	11007-05	2
6	iron core, rod-shaped, d = 16 mm, l = 200 mm	11005-00	1
7	Connecting cord, 32 A, 500 mm, black	07361-05	5
8	Connecting cord, 32 A, 500 mm, blue	07361-04	2
9	Digital multimeter, 600V AC/DC, 10A AC/DC, 20 M Ω , 200 μ F, 20 kHz, -20°C... 760°C	07122-00	2
10	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

Set-up (1/3)

PHYWE

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



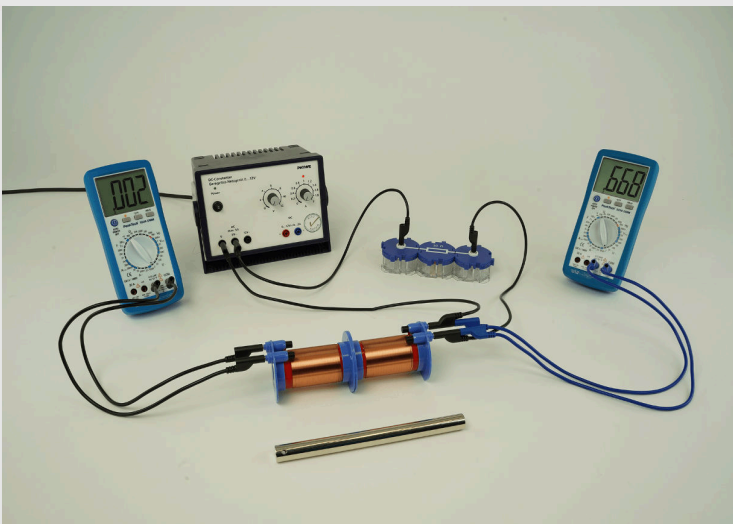
Android



Windows

Set-up (2/3)

PHYWE



Experiment set-up

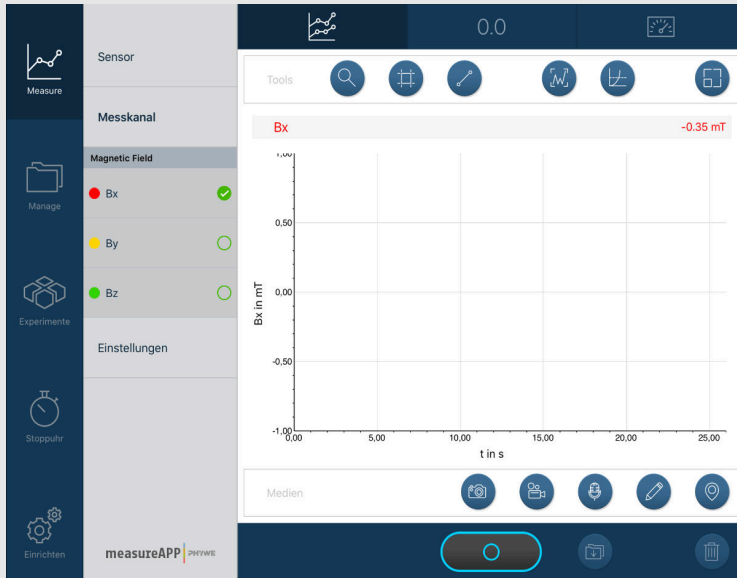
Set up the test according to the adjacent figure.

To do this, switch on the power supply unit (AC voltage with 6 V), the resistor $R = 10 \Omega$ and one of the short coils with $N = 100$ Windings for the primary circuit in series. A voltmeter is connected in parallel with the primary coil to measure the voltage that drops across the primary coil.

The secondary circuit consists of the second short coil with also $N = 100$ turns and a voltmeter which measures the induced voltage on the secondary coil.

Set-up (3/3)

PHYWE



Start measureAPP on the tablet and switch on the Cobra SMARTsense magnetic field sensor (hold down the I/O button for about 3 seconds).

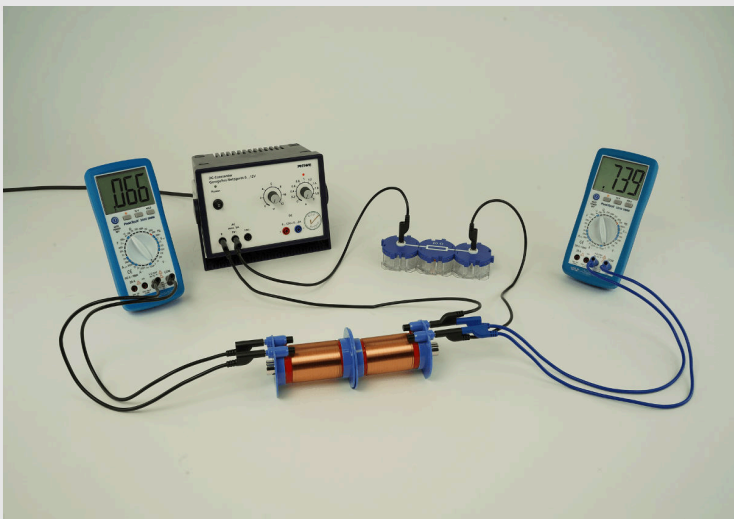
Select the sensor in measureAPP and connect it to the App. The following settings must be made:

- Fine measuring range (- 5 mT ... + 5 mT)
- Measuring frequency: 200 Hz

Also select only the longitudinal direction under Measuring channel B_x of the sensor and set it to zero.

Procedure (1/2)

PHYWE



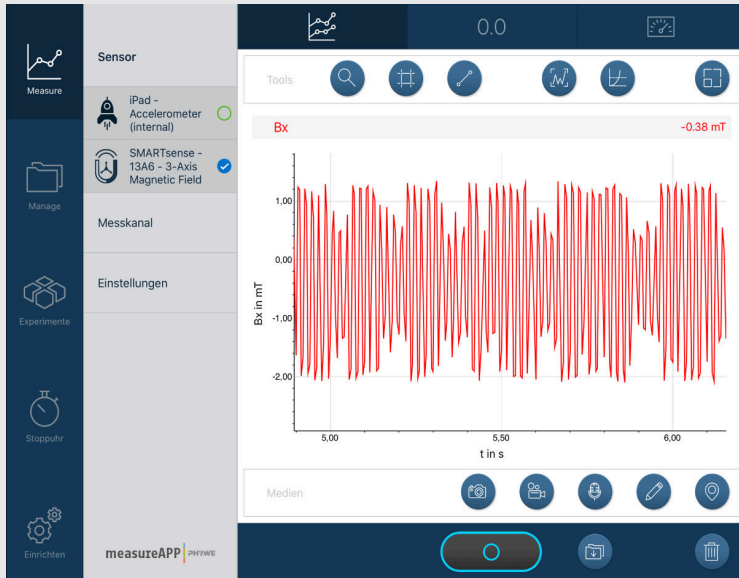
The iron rod is placed in the coils

1. switch on the power supply unit
2. note the primary and secondary voltage in the protocol.
3. hold the magnetic field sensor behind the coil in the secondary circuit and start a measurement of a few seconds duration Save your measurement.
4. switch off the power supply unit

Measuring ranges: primary voltage: 0V-2V AC
secondary voltage: 0V-0.2V AC

Procedure (2/2)

PHYWE



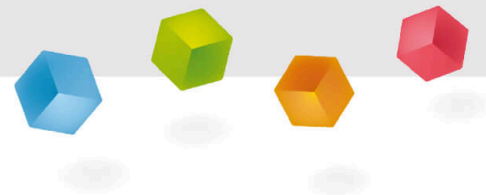
5. push the iron core centrally into both coils and switch the power supply unit on again.

6. write down the primary and secondary voltage in the log again and switch off the power supply unit.

7. now hold the magnetic field sensor again behind the coil in the secondary circuit (directly at the iron core) and start a measurement of a few seconds duration again. Save your measurement.

PHYWE

Report



Table

PHYWE

Enter your readings.

	U_P [V]	U_S [V]	$B_{x,max}$ [mT]
Without iron core			
With iron core			

Task 1

PHYWE

Which of the following statements are correct?

- The voltage is higher in the secondary circuit when the iron core is placed between the coils, as this also increases the magnetic flux density within the coils.
- The voltage is the same in the secondary circuit when the iron core is placed between the coils, since the iron core also keeps the magnetic flux density unchanged.
- The voltage in the secondary circuit is lower when the iron core is placed between the coils, as this reduces the magnetic flux density within the coils.

 Check

Task 2

PHYWE

The change of the magnetic field causes a voltage. Which of the following statements are correct?

- The transformer only works with alternating current.
- The transformer only works with direct current.
- The transformer works with both direct current and alternating current.

✓ Check

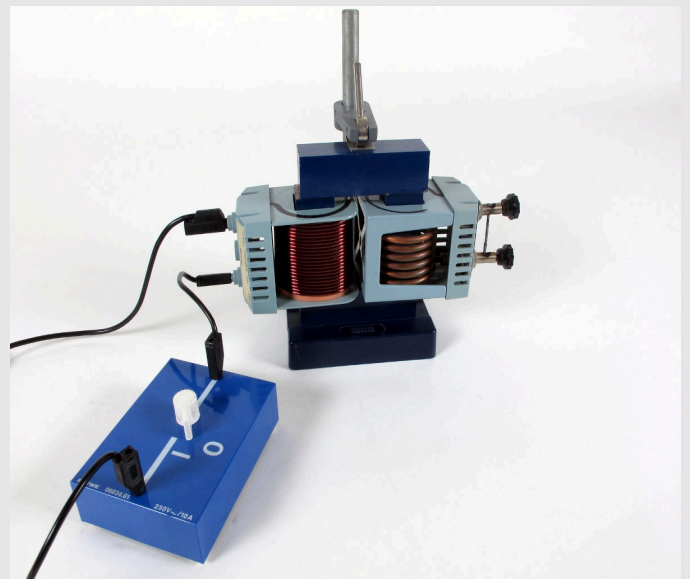
Task 3

PHYWE

A real transformer has a closed iron core. What do you think a sealed iron core does

- This makes the transformer more stable.
- This makes the transformer look better.
- The induced voltage in the secondary coil is even higher.

✓ Check



Task 4

PHYWE


What happens if you increase the distance between the coils?

- The induced voltage remains approximately constant because the coils are approximately long and thin and the magnetic field is therefore directed along the longitudinal axis.
- The induced voltage decreases because the magnetic flux density of the primary coil and thus its change over time becomes smaller with distance.
- The induced voltage increases because more stable and stronger magnetic fields are built up with increasing distance. (Square law of distance)

✓ Check

Slide	Score/Total
Slide 17: With or without iron rod	0/1
Slide 18: electromagnetic induction	0/1
Slide 19: Transformer	0/1
Slide 20: Distance of the coils	0/1

Total amount  0/4

 Solutions

 Repeat

 Exporting text