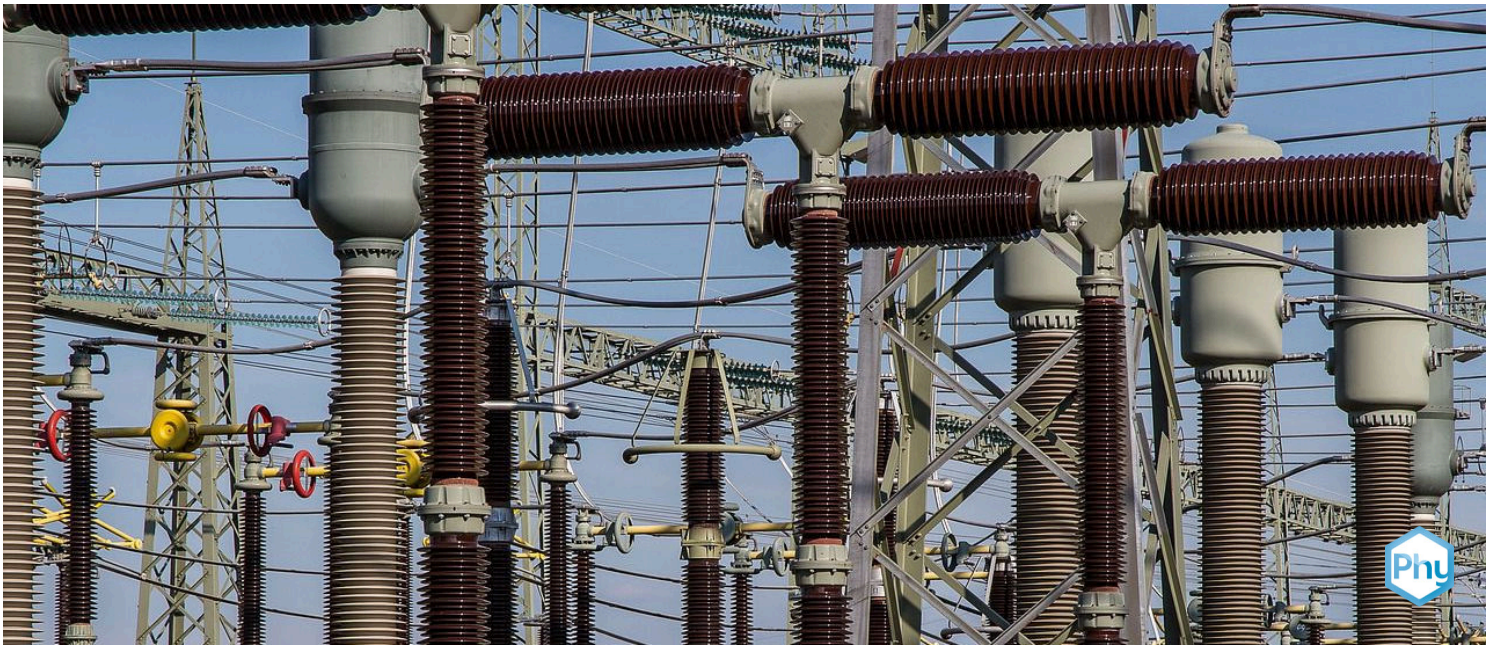
Transformer with Cobra SMARTsense



Physics > Electricity & Magnetism > Electromagnetism & Induction

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

This content can also be found online at:

http://localhost:1337/c/639e6b09772e460003cb6ad1

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Teacher information

Application

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Transformers in a transformer station

The transformer is used in various areas of electrical engineering. For example, in power engineering or in the everyday domestic use of electrical appliances.

In power engineering, transformers connect the different voltage levels of the electricity grid. For high-voltage grids, these are up to $380\,kV$, for medium voltage grids at about $10…36\,kV$ or just under $400\,V$ for domestic use (low-voltage grid).

In electrical appliances, the built-in transformers transform the input voltage further down, provided the appliance cannot work when it is connected to the mains voltage of $230\,V$.

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Other teacher information (1/2)

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Prior knowledge

The students should already have learned and understood the principle of induction. In addition, basic knowledge regarding the electric motor/generator is advantageous for working on this experiment.

Principle

Transformers consist of two or more coils on a common iron core. With its help, an input AC voltage U_1 can be transformed into an output alternating voltage U_2. The ratio between input and output voltage corresponds to the ratio of the number of windings of the input and output coils (N_1 & N_2).

$$\frac{U_1}{U_2} = \frac{N_1}{N_2}$$

Other teacher information (2/2)

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Learning objective

This experiment is intended to demonstrate the principle and one of the advantages of a transformer.

Tasks

In this experiment, the students are to build a transformer from two coils connected with the help of an iron core and investigate and learn about the properties of this transformer.

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Safety instructions

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

Attention!

The maximum voltage of $12\,V$ may be applied for a maximum of **2 minutes** to the coil, otherwise there is a risk of it overheating. Then wait until the coil has cooled down before using it again.

Hint:

The first part of the procedure requires a sufficiently "smoothed" DC voltage. DC voltage. If this is not available, then a flat battery is used for the experiment $4,5\,V$.

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Student information

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Motivation

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Transformers in a transformer station

As you know, normal power sockets in Germany have around $230\,V$ alternating current. However, so that the electricity can be transported from the power plants to the households with as little loss as possible, high voltages of up to $380,000\,V$ are generated and used.

So how is it possible to decrease the voltage from $380,000\,V$ to $230\,V$? Transformers are generally used for this purpose. But what exactly is the operating principle of such a transformer?

You will deal with this question in this experiment.

Tasks

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You have already learned about the principle of electromagnetic induction and examined it in more detail. Based on this, you are to work on the following steps in this experiment:

1. Build a simple transformer and investigate its basic properties.
2. Modify your transformer model and investigate what the transformer can be used for.

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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	Student set Electric motor / Generator, TESS advanced Physics	15221-88	1
3	Cobra SMARTsense Current - Sensor for measuring electrical current ± 1 A (Bluetooth + USB)	12902-01	1
4	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-01	1
5	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up (1/3)

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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 (2/3)

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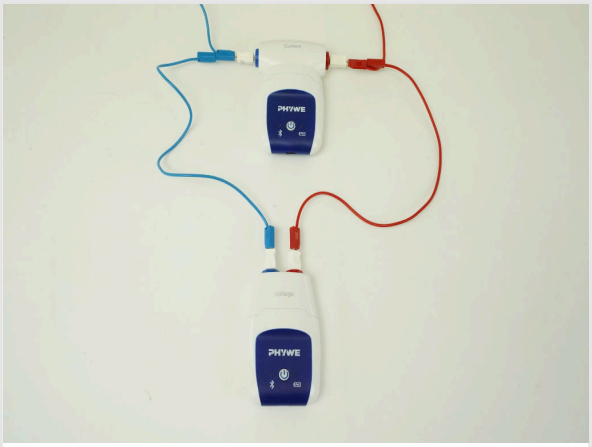

SMARTsense Current & SMARTsense Voltage connected in parallel

Note: You can also connect the SMARTsense Voltage in parallel to the SMARTsense Current in order to measure both the current and the voltage simultaneously during the experiment.

Turn on the SMARTsense(s) by pressing and holding the I/O button for about three seconds. Start the measureAPP and select the sensor(s) to connect.

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Set-up (3/3)

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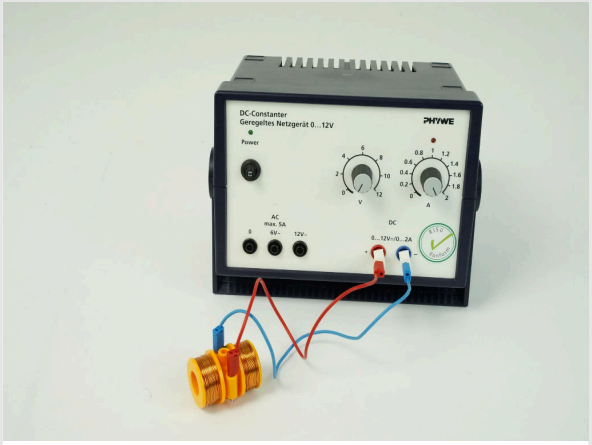

Electromagnet (coil) connected to voltage source

ATTENTION!

Always make sure during this test that the maximum voltage of $12\,V$ is used for a maximum of **2 minutes** with the coil, otherwise it is in danger of overheating. Then wait until the coil has cooled down again.

- Connect the coil as an electromagnet to the voltage source as shown in the illustration.
- Only use the red sockets of the coil.

Procedure (1/4)

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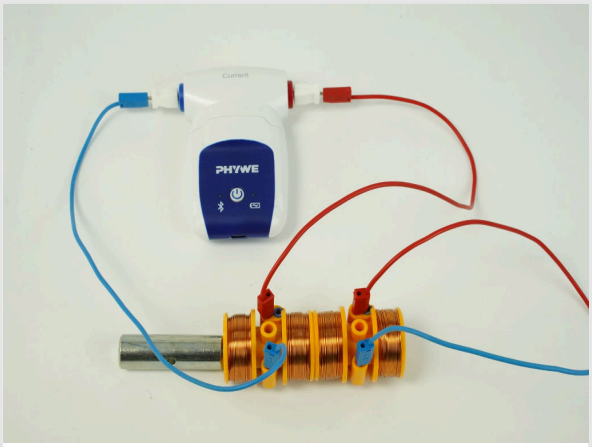

Experiment set-up 1: Simple transformer

Experiment 1: Part 1

- Investigate whether the magnetic field of an electromagnet can also induce a voltage.
- Set up the experiment according to the illustration.
- Both coils contain an iron core.
- Start a measurement, apply a DC voltage of $5\,V$ to the first coil and move them back and forth quickly. What are you observing?
- Then observe what happens when the two coils are at rest? Finish the measurement and save it if necessary.

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Procedure (2/4)

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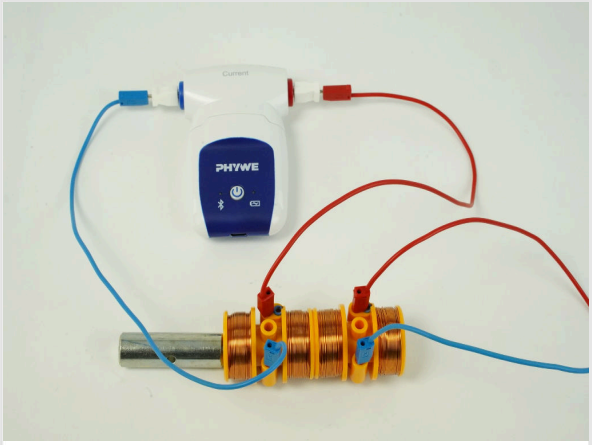

Experiment set-up 1: Simple transformer

Experiment 1: Part 2

- Now place the coils as shown in the picture and push an iron core into both coils.
- What do you observe if you now apply an alternating voltage of about $6\ V$ to the first coil? (Maximum 2 minutes!)

Procedure (3/4)

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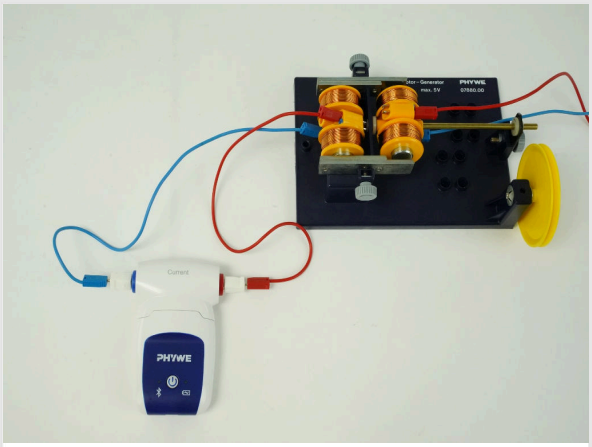

Experimental setup 2: Extended transformer

Experiment 2: Part 1

- Now investigate the properties of a so-called transformer.
- Set up the experiment as shown in the illustration. The iron cores of the two coils are assembled via the pole shoes to form a so-called toroidal core.
- The connection lines of both coils are first connected to the **red** terminals of the coil (full number of turns). An alternating voltage of $6\ V$ is set.
- Start a measurement. What current/voltage are you measuring?

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Procedure (4/4)

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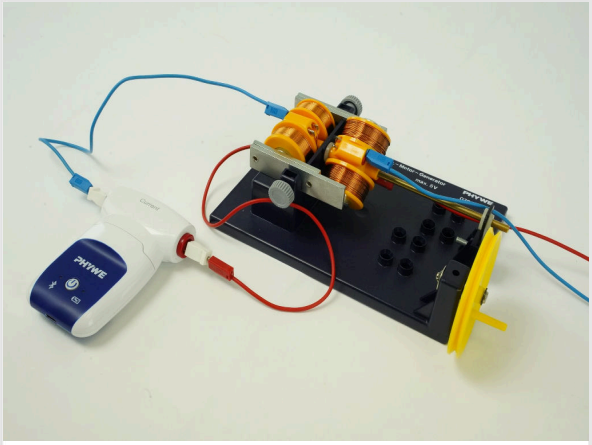

Experimental setup 2: Extended transformer

Experiment 2: Part 2 & 3

- Now halve the number of turns of the coil connected directly to the current source (connection to the **blue** socket). Start a measurement again. What changes in the measured values?
- Now take for the coil connected to the current source the full (**red** socket) and for the other half the number of turns (**blue** socket).
- Start another measurement. What values are you measuring this time?

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Report

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Task 1

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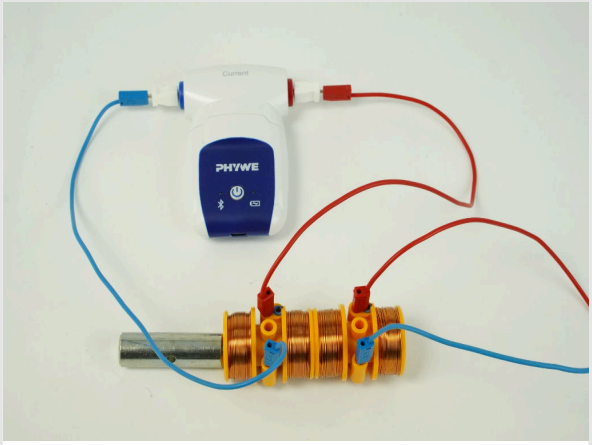

Experiment set-up 1: Simple transformer

What was your observation during part 1 of the 1st experiment (in motion)?

- When moving one coil, the measureAPP shows a small measurement deflection.
- When moving one coil, the measureAPP does not show a measurement deflection.

Task 2

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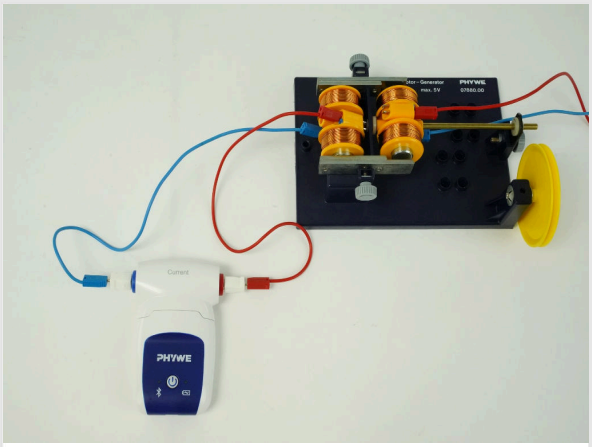

Experimental setup 2: Extended transformer

What was your observation during part 1 of the 2nd experiment?

- The measureAPP shows an approximate value of $6 - 12\,V$.
- The measureAPP does not display a measured value (such as $0\,V$).
- The measureAPP shows an approximate value of $3 - 6\,V$.

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Task 3

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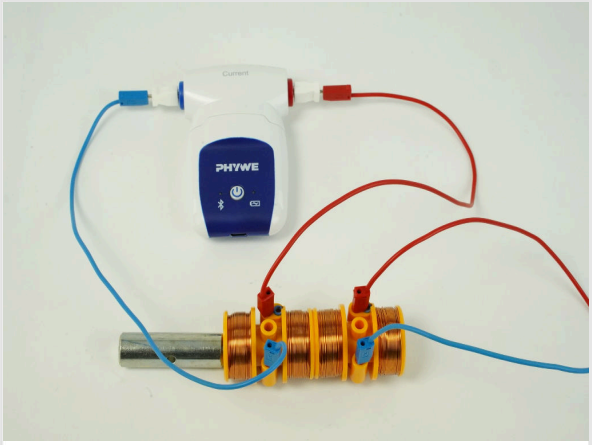

Experiment set-up 1: Simple transformer

The two coils of the transformer are called primary and consumer coil. Think about which coil has which name.

In this case, the coil connected to the voltage source is the _____ and the coil connected to the meter is the _____.

primary coil | consumer coil

Check

Task 4

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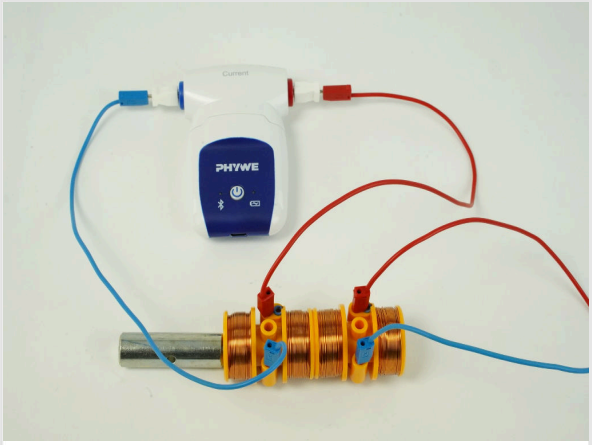

Experiment set-up 1: Simple transformer

Think about which equation represents the principle of the transformer.

$\frac{U_2}{U_1} = \frac{1}{2} \cdot N_1$

$\frac{U_2}{U_1} = \frac{N_1}{N_2}$

$\frac{U_2}{U_1} = \frac{N_2}{N_1}$

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Task 5

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Think about what you could use a transformer for.

- [ ] To store electrical charge, similar to a battery for example.
- [ ] For converting the voltage between the so-called grid levels. For example, from the high-voltage grid to the medium-voltage grid.
- [ ] For converting the voltage from the socket to charge the mobile phone.

Check

Slide	Score / Total
Slide 18: Observation: Experiment 1	0/3
Slide 19: Observation: Experiment 2	0/3
Slide 20: Coil designations	0/2
Slide 21: Transformer equation	0/1
Slide 22: Application examples	0/2
Total	**0/11**

Solutions Repeat

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