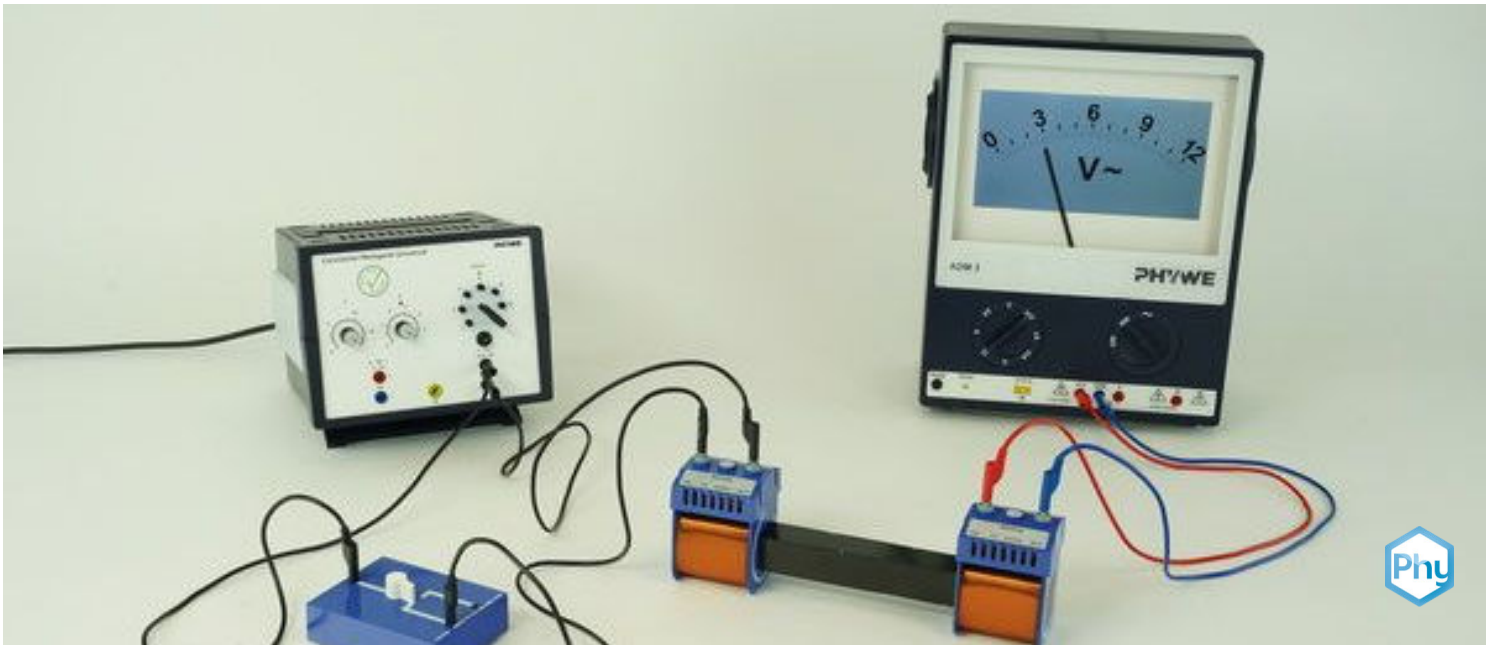
Generation of induced voltage with an electromagnet (DEMO)



Physics | Electricity & Magnetism | Electromagnetism & Induction

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

This content can also be found online at:

http://localhost:1337/c/6478ff59d57c800002376ced

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Teacher information

Application

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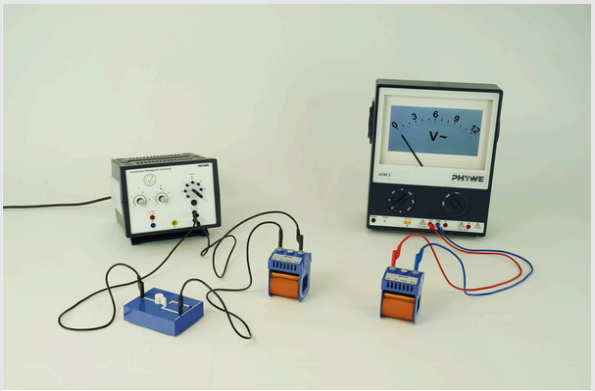

Experimental setup

Transformers are built into many electrical devices. In order to transform current well, the coils must not be too far apart and an iron core is important.

In this experiment, the induced voltage is measured as a function of the distance between the coils and as a function of the iron core.

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Other teacher information (1/2)

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Prior knowledge

No prior knowledge is required.

Principle

When alternating current flows through a coil, it creates a varying magnetic field, which in turn can induce a current in another coil.

Other teacher information (2/2)

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Learning objective

Students should understand how a transformer works.

Tasks

Investigate the functioning of a transformer with and without an iron core.

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Theory

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The magnetic flux density B of a coil is:

$B = \mu_r \cdot \mu_0 \cdot I \cdot \frac{n}{l}$

μ_0 is the magnetic field constant in a vacuum, μ_r is the magnetic permeability, which depends on the material. $\frac{n}{l}$ describes the winding density. With alternating current, the magnetic field also changes, of course. The change in the magnetic field induces a current in the secondary coil.

Lenz's rule:

$\oint_{\delta A} \vec{E} \cdot \mathrm{d}\vec{s} = -\int A \frac{\delta B}{\delta t} \cdot \mathrm{d}\vec{A}$

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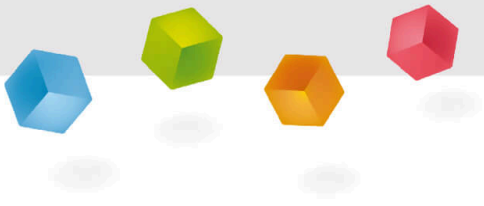

Student information

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Motivation

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Transformers are built into many electrical devices. In order to transform current well, the coils must not be too far apart and an iron core is important.

In this experiment, the induced voltage is measured as a function of the distance between the coils and as a function of the iron core.

A transformer station

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Equipment

Position	Material	Item No.	Quantity
1	PHYWE Power supply, universal, analog display DC: 18 V, 5 A / AC: 15 V, 5 A	13503-93	1
2	PHYWE Demo Multimeter ADM 3: current, voltage, resistance, temperature	13840-00	1
3	Iron core, I-shaped, laminated, L=300mm	06504-01	1
4	Coil, 600 turns	06514-01	2
5	Two-way switch, single pole	06005-00	1
6	Connecting cord, 32 A, 750 mm, red	07362-01	1
7	Connecting cord, 32 A, 750 mm, blue	07362-04	1
8	Connecting cord, 32 A, 750 mm, black	07362-05	3

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Set-up

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- Set up the experiment according to Figure 1.
- In the primary circuit, connect the power supply unit, the changeover switch and the coil (as primary coil) in series.
- The secondary circuit consists only of the secondary coil and the demonstration multimeter.

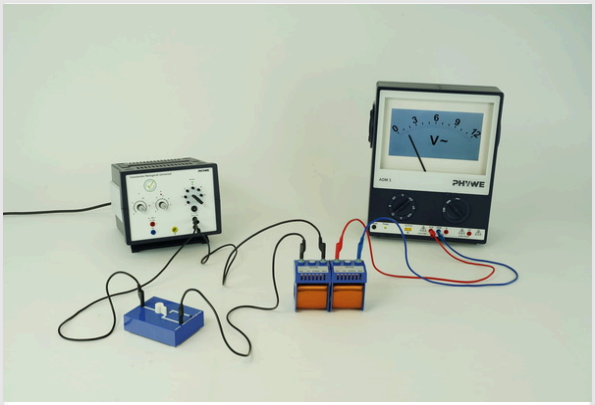

Fig. 1

Procedure (1/2)

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- Set the demonstration multimeter to AC voltage and select a suitable measuring range (e.g. 0...15 V~).
- Switch on the power supply and increase the primary voltage one step at a time (e.g. 6 V, 10 V and 15 V) with the switch closed. Observe the secondary voltage in each case.
- Select the primary voltage from $U_P = 15\mathrm{V}$ and increase the distance between the coils step by step according to figure 2: e.g. in steps of 5 cm to approx. 20 cm. Observe the voltage display on the demonstration multimeter at each step.

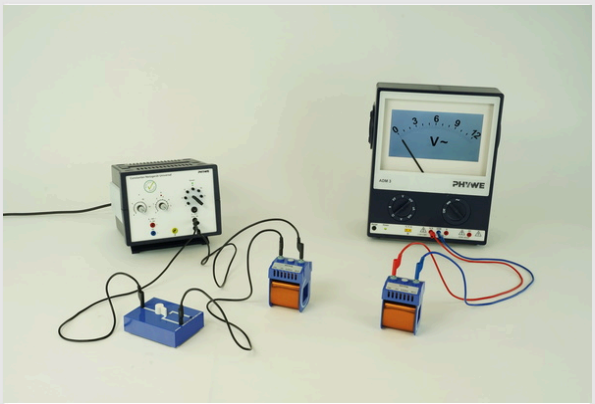

Fig. 2

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Procedure (2/2)

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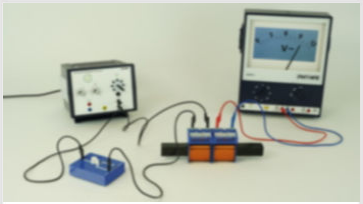

Fig. 3

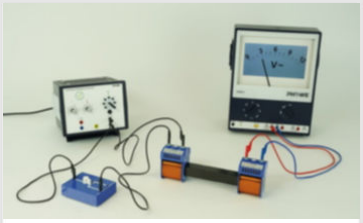

Fig. 4

- Now push the coils together again in contact. Open the switches and push the iron core into the two coils until it is approximately in the middle (see Fig. 3). Close the switches and observe the secondary voltage for different primary voltages.
- Finally, increase again at a primary voltage of $U_P = 15\mathrm{V}$ the distance between the two coils step by step as before (see Fig. 4) and observe the secondary voltage.

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Report

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Task (1/3)

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The secondary voltage without iron core is...

- ... independent of the primary voltage.
- ... anti-proportional to the primary voltage.
- ... proportional to the primary voltage.

Task (2/3)

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Drag the words into the correct boxes!

As shown in the experiment, it is possible to transport _____ without electrical _____ in the form of wires. The magnetic _____ drops rapidly outside the coil.

contact
electrical energy
flux density

Check

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Task (3/3)

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Drag the words into the correct boxes!

However, the _____ used has a much higher magnetic _____ and accordingly a much higher _____, which amplifies the magnetic field and thus leads to a significantly increased induced _____ in the secondary coil, which is still clearly detectable even at a greater _____.

- permeability
- iron core
- voltage
- susceptibility
- distance

Check

Slide	Score / Total
Slide 13: Dependence between secondary and primary voltage	0/4
Slide 14: Functionality of the transformer	0/3
Slide 15: Properties of the iron core	0/5

Total score 0 / 12

Show solutions Repeat

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