Magnetic field inside a coil with Cobra SMARTsense

Physics | Electricity & Magnetism | Electromagnetism & Induction

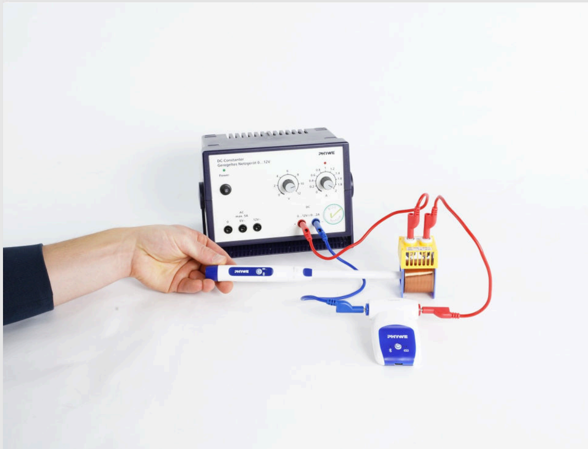
Difficulty level	Group size	Preparation time	Execution time
easy	-	10 minutes	20 minutes

This content can also be found online at:

https://www.curriculab.de/c/67aa7183945666000274bd19

Teacher information

Application



Experimental setup

Coils generate a magnetic field when current flows through them. In this case, we speak of an electromagnet. The higher the current, the stronger the magnetic field and therefore also the magnetic flux density B. The relationship between magnetic flux density and current strength is investigated in this experiment.

Electromagnets are used in numerous applications today, for example in loudspeakers, doorbells, lifting magnets and even in particle accelerators.

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Other teacher information (1/2)

Prior knowledge

Students should be familiar with the basic concepts of magnetic flux density and know that a current-carrying coil generates a magnetic field.

Principle

If current is allowed to flow through a coil, it generates a magnetic field. The strength of the magnetic field depends on both the properties of the coil and the current. The greater the current, the stronger the magnetic flux density. In this experiment, the pupils will work out this relationship independently and calculate the magnetic field constant μ_0 calculate.

Other teacher information (2/2)

Learning objective

In this experiment, the dependence of the magnetic flux density on the current strength is investigated. The pupils also learn how to calculate the magnetic field constant μ_0 can be derived from the measurement data obtained.

Tasks

1. Investigate the relationship between the magnetic flux density B inside a coil and the current.
2. Determine the value for the magnetic field constant μ_0

Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
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info@phywe.de
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Safety instructions

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

Notes

The maximum current of 1 A for the coil should not be exceeded, otherwise the coils may overheat.

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Student information

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

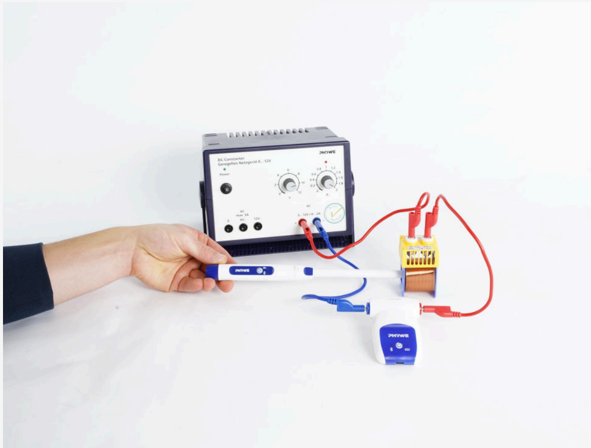
Motivation

Have you ever wondered how excavators can lift and deposit iron without using a grab? This is made possible by magnets - or more precisely, electromagnets. Electromagnets, i.e. coils, generate a magnetic field as soon as current flows through them and can therefore be switched on or off as required. A similar principle can also be found in other applications, such as loudspeakers or doorbells.

How exactly does the magnetic field, i.e. the magnetic flux density $B$is related to the current? We will find out in this experiment!

Electromagnet on an excavator

Tasks



Experimental setup

1. Set up the experiment according to the instructions.
2. Investigate the relationship between the magnetic flux density B inside a coil and the current.
3. Determine the value for the magnetic field constant μ_0.

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37079 Göttingen

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Equipment

Position	Equipment	Item no.	Quantity
1	Cobra SMARTsense 3-Axis Magnetic field - Sensor for measuring the magnetic field in 3 axes ±130mT / ±5 mT (Bluetooth + USB)	12947-00	1
2	Cobra SMARTsense Current - Sensor for measuring electrical current ± 1 A (Bluetooth + USB)	12902-01	1
3	PHYWE power supply unit, RiSU 2023 DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
4	Coil, 1600 windings	07830-01	1
5	Connection cable, 32 A, 50 cm, red Experiment cable, 4 mm plug	07361-01	1
6	Connecting cable, 32 A, 50 cm, blue Experiment cable, 4 mm plug	07361-04	1
7	Connecting cable, 32 A, 25 cm, red Experiment cable, 4 mm plug	07360-01	1
8	measureAPP - the free measurement software for all end devices	14581-61	1

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Structure (1/2)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** 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 whether your device (smartphone, tablet, desktop PC) is running **Bluetooth activated** is.

iOS

Android

Windows

Structure (2/2)

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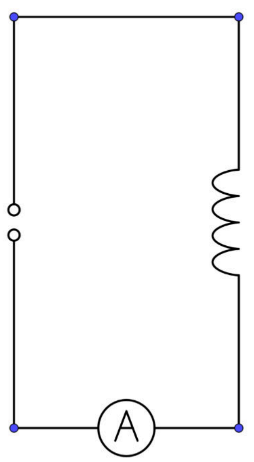

Circuit diagram

- Set up the experiment according to the circuit diagram shown.
- Switch the Cobra SMARTsense Current Sensor to the position where the ammeter is marked.
- Use a coil with 1600 windings.
- Generate a DC voltage of 12 V on the power supply unit. Initially set the current to 0 A. The current will vary in the course of the experiment, but should not exceed a value of 1 A. Switch on the power supply unit.

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Procedure (1/6)

- Switch on your Cobra SMARTsense Current Sensor by pressing and holding the button on the sensor for 3 seconds.
- Open the measureAPP on your tablet or smartphone and make sure that the end device can connect to Bluetooth devices.
- Select the sensor "Cobra SMARTsense Current" and connect it to the app.

Cobra SMARTsense Current

Procedure (2/6)

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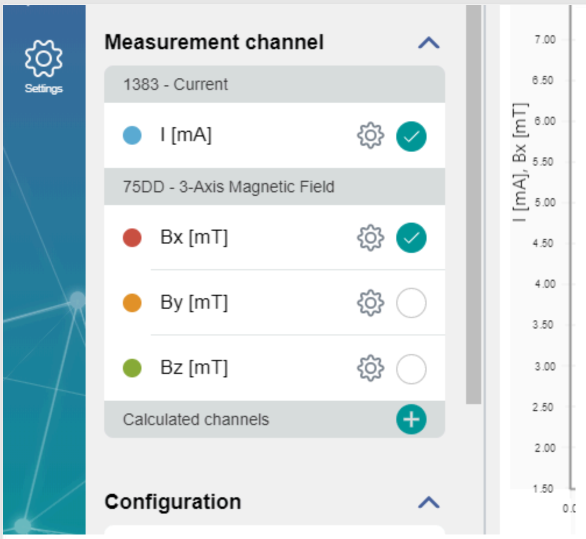

Settings in measureAPP

Now connect the Cobra SMARTsense Magentic Field Sensor to the measureAPP in the same way.

Make the following settings for the sensor in the app:

- 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.
- Set the sampling rate to 500 Hz under Configuration.

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Procedure (3/6)

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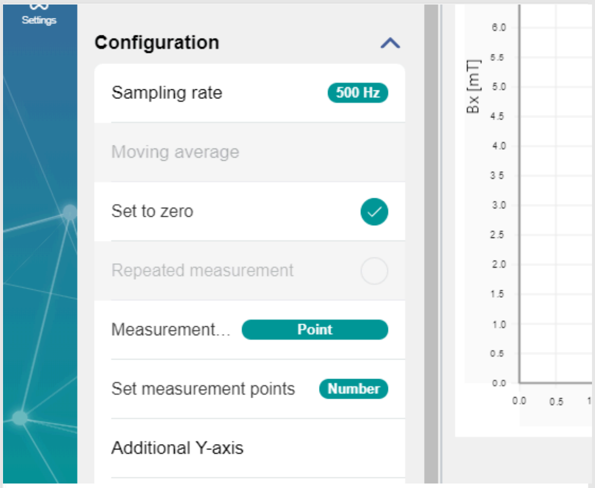

Settings in measureAPP

Carry out the next steps in the measureAPP:

1. Go to the "Configuration" area and click on the "Set to zero" button. Select both the current and the flux density.
2. Under "Configuration", set the measurement value recording to "Point measurement".

Now, after starting a measurement by pressing the red, round button, you can take point measurements for each amperage. I to the resulting graph.

- record another measured value: 

Procedure (4/6)

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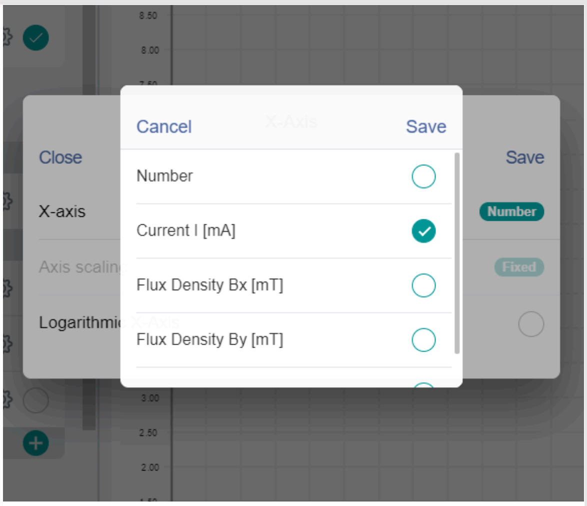

Settings in measureAPP

- Finally, change the X-axis by pressing the cogwheel next to the X-axis.
- Choose the current I from.
- The Y-axis adjusts itself automatically and should reflect the magnetic flux density B show.

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Fax: 0551 604 - 107

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Procedure (5/6)

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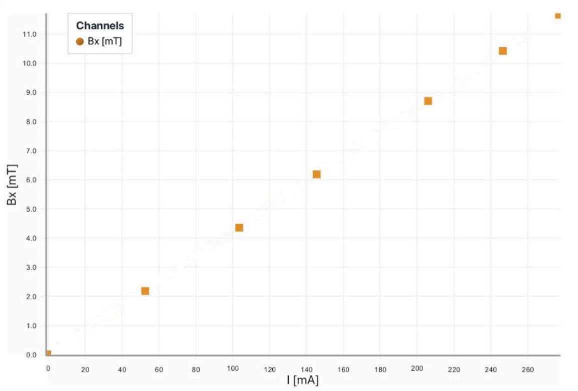

Individual measured values

- Start a measurement.
- Start at 0 A and increase the current in steps of 50 mA to 300 mA.
- Record a value for the magnetic flux density for each current.
- **Make sure that the current never exceeds a value of 1 A!**

Procedure (6/6)

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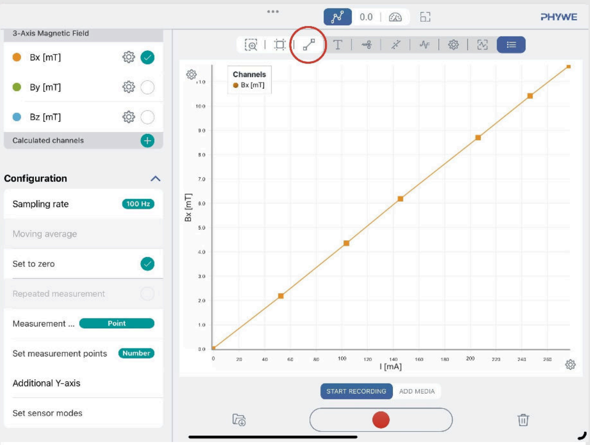

Lay straight through measured values

Now draw a straight line through the measured values. Lay the straight line freehand after pressing the button circled in red. Note the gradient of the tangent.

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Robert-Bosch-Breite 10
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info@phywe.de
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Report

Task 1

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What happens when current flows through a coil?

- [ ] The coil loses its conductivity.
- [ ] The current is stopped immediately.
- [ ] The coil generates a magnetic field.
- [ ] The coil heats up.

Check

Which sensor can be used to determine the current?

- ○ Cobra SMARTsense Voltage
- ○ Cobra SMARTsense Magnetic Field
- ○ Cobra SMARTsense Force & Acceleration
- ○ Cobra SMARTsense Current

Check

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Robert-Bosch-Breite 10
37079 Göttingen
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info@phywe.de
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Task 2

Which of the following statements are correct?

- [ ] The higher the current, the higher the magnetic flux density.
- [ ] The magnetic flux density increases quadratically.
- [ ] The magnetic flux density increases linearly.
- [ ] The higher the current, the lower the magnetic flux density
- [ ] The magnetic flux density increases exponentially.

Check

Task 3

In addition to the current strength, the magnetic field strength also depends on the length l and the number of windings N of the coil. In general, the following equation applies to an air-filled coil $B = \mu_0 \frac{N}{l} I$. The coil has 1600 windings.

Determine the length of the coil and calculate the magnetic field constant from the gradient of the straight line that you calculated in the last step μ_0. Note that the length is given in metres. What value do you get?

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Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
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Slide	Score / Total
Slide 19: Multiple tasks	**0/3**
Slide 20: General consideration of the measured values	**0/2**

Total amount 0/5

Solutions Repeat Export text

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37079 Göttingen
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info@phywe.de
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