Lab Experiment: Magnetic field

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Family Name:	________	________	________	________
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Student Number:	________	________	________	________

Objectives:

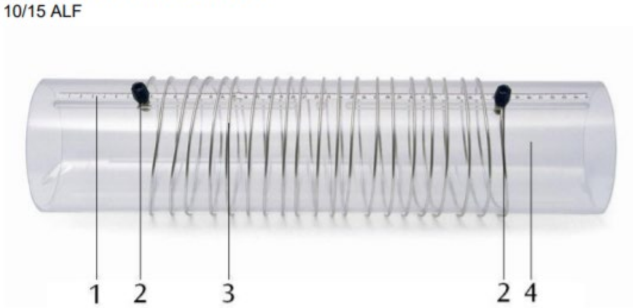
1) Measure the magnetic field in coils with variable number of turns and compare the measured value to the theoretical value.
2) Examine the magnetic field produced by current in a pair of Helmholtz coils.

Part 1: Coils with variable number of turns per unit length U8496175

Coil with Variable Number of Turns per Unit Length 1000965

Instruction Sheet

10/15 ALF



1 Scale
2 4mm safety sockets
3 Coil wire
4 Coil bobbin

1. Safety instructions

- Operation of the coil is only allowed with extra low voltages.
- Do not exceed the maximum current for long-term use.
- Do not touch the coil during the experiment.
- If the coil should become overloaded, they must be allowed to cool before switching on the current again.
- Any modifications to the set-up must be made with the primary voltage switched off.

3. Technical data

Coil diameter:	100 mm
Number of turns:	30
Coil length:	490 mm
Max. Current:	10 A, for short periods 20 A
Anschluss:	4 mm safety sockets

2. Description

The coil of variable number of turns per unit length is used to investigate the magnetic flux density in cylindrical coils as a function of the number of turns per unit length.

The coil has a cylindrical bobbin made from acrylic glass with adjustable 4 mm safety sockets. By means of a clamping device the distance between the ends of the coil windings can be mechanically locked. A cm scale allows easy reading of the coil length. The current may exceed the indicated long-term maximum for short periods.

4. Operating principle

Inside a coil the magnetic flux density *B* depends on the number of turns *n*, the coil length *L* and the coil current *I*. For an air-core coil it is given by the equation:

$$B = \mu_0 \cdot n \cdot I \cdot \frac{1}{L} = \mu_0 \cdot I \cdot \frac{n}{L} \qquad (1)$$

The magnetic field constant is

$\mu_0 = 1{,}256637 \cdot 10^{6}$ Vs/Am.

5.1 Confirmation of equation 1

- Put the coil on the stand and connect it to the power supply unit.
- Switch on the power supply unit and adjust the currentto approx. 10 A.
- Measure the magnetic flux density *B* with the magnetic field sensor.
- Determine the length of the coil and use equation (1) to calculate the theoretical value for *B*.
- Repeat the measurement with different coil lengths.
- Compare the calculated values with the measured ones.

5.2 Determination of the magnetic field constant μ_0

- Measure the magnetic flux density *B* with different coil lengths *l*.
- Record the values in a table and plot *B* as a function of 1/*L* in a coordinate plane.

The slope *m* corresponds to the product $\mu_0 \cdot \frac{n}{L}$.

Hence

$$\mu_0 = \frac{m \cdot L}{n} \qquad (2)$$

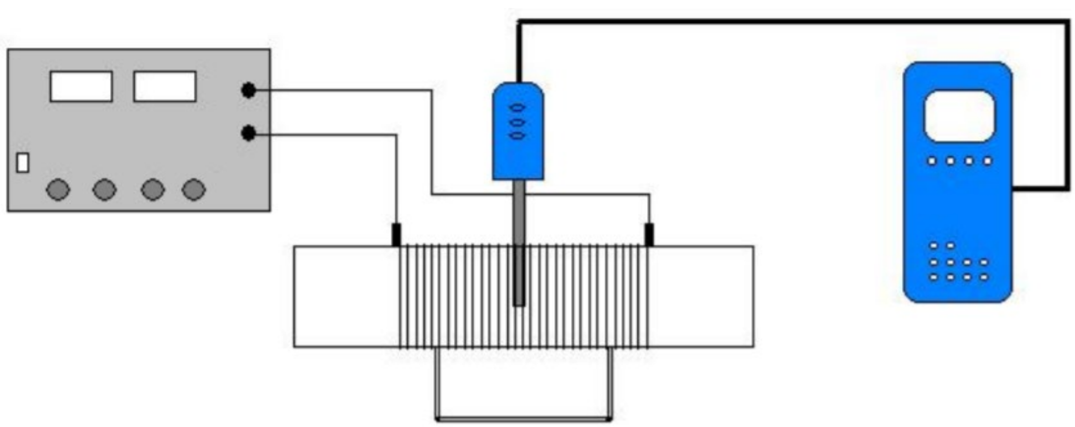


Fig. 1 Experiment set-up

Part 2: Magnetic Field at the Center of a Helmholtz Coil

We can create a stronger and more uniform magnetic field by aligning two identical current loops. A particular configuration that we will be using is known as Helmholtz coil. This consists of two current loops, each with *N* turns and radius R. The two looks are aligned along their axis and are separated by a distance R, identical to the radius, each carrying equal currents in the same direction (see Figure 2). It can be shown that the magnetic field at the center of this configuration (point O) is

$$B(z=0) = \frac{8}{5\sqrt{5}} \frac{\mu_0 I N}{R}$$

where the symbols have the same definitions as before

Procedure:

1. Measure the radius of the Helmholtz coil and record the number of turns.
2. Connect the Helmholtz coil to the DC power supply. You may want to connect an ammeter to the circuit to accurately determine the current.
3. Using the Half probe, measure the field at the center of the Helmholtz coils for current values from 0 A to 1A, in 0.1A increments.
4. Your data should consist of the different values *I* and *B(0)*.

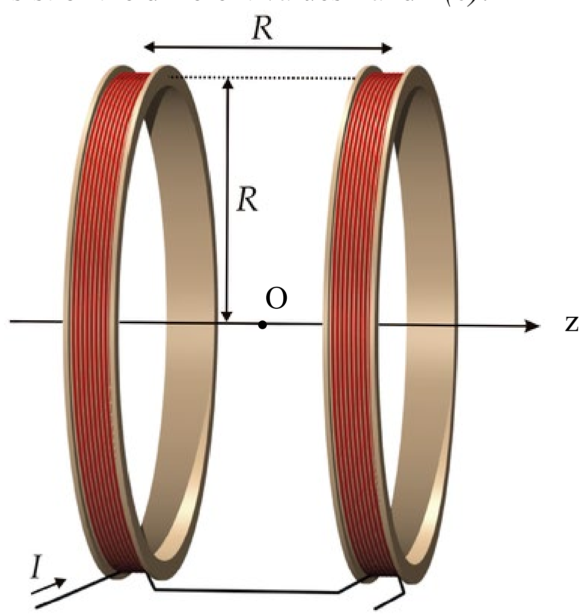


Figure 1: Helmholtz coil

Analysis

1. Plot of a graph of H(0) versus I.
2. Find the slope of the best-fit line.
3. From Equation 2, the slope of this line should correspond to the value of

$$\frac{8}{5\sqrt{5}}\frac{\mu_0 N}{R}$$

Prove this in the theory section of your report. Compare the slope to your graph with this value.