MAGNETIC MOMENT IN THE MAGNETIC FIELD

Equipment

Power supplies (adjustable), pair of Helmholtz coils, digital multimeters, torsion dynamometer, circular conductors.

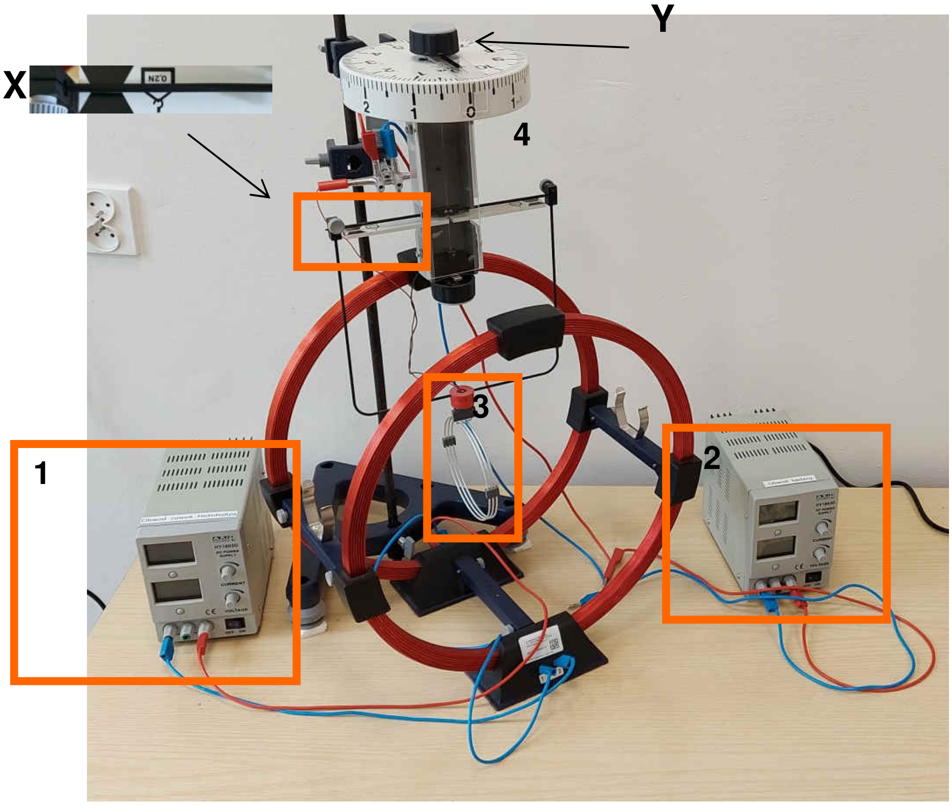

Fig. 1 Experimental setup: (1) power supply for the Helmholtz coils circuit with the digital multimeter, (2) power supply for the circular conductor (3) with the digital multimeter, (4) torsion dynamometer.
3.

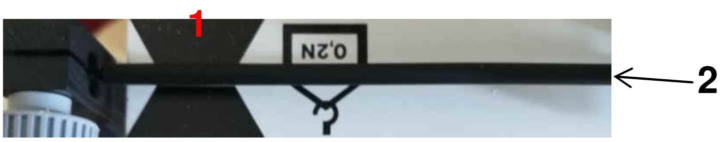

Fig. 2 Upper view on the frame aligned with the dynamometer at zero position (this is the magnified projection from the upper left hand corner of Fig. 1 (marked with X) . 1 – mark on the dynamometer, 2 – arm of the dynamometer

Procedure

A. ***Determination of the torque due to a magnetic moment in a uniform magnetic field, as a function of the strength of the magnetic field.***

1. To zero the experimental setup:
   - Turn off the power supply to Helmholtz coils and the circular conductor.
   - Set „0" using the knob (marked with Y in Fig.1) on top of the dynamometer scale.
   - Align the frame with the mark on the dynamometer, as shown in Fig. 2, using the knob at the bottom of the dynamometer.
2. The circular conductor is already set so that the angle α between the vector $\vec{s}$, perpendicular to the circuit plane, and the induction vector $\vec{B}$, of the magnetic field generated by Helmholtz coils, equals 90^0. Turn the power supply of the circular conductor (3) on, and set the current I_{OB} to 3A.
3. Turn the power supply of the Helmholtz coils. Take eight readings, setting the current in the Helmholtz coils within the range 0 to 3A with the step of about 0,4A. To read the measured value:
   - Align the frame with the mark on the dynamometer, as shown in Fig. 2, using the knob on top (Y) of the dynamometer .
   - The unit on the torsion dynamometer's scale is [mN] (10^{-3} N), hence it is not the direct measure of the moment of twisting force.
     Note the values in table 1.
4. For each current setting calculate the corresponding induction of the magnetic field between Helmholtz coils (B_z)

$$B_z = 0{,}7155\mu_0 \frac{n_H I_H}{R_H}$$

B_z – induction of the magnetic field between Helmholtz coils, $B_Z=B_H$;
μ_0 – magnetic permeability of vacuum;
n_H – number of turns in Helmholtz coil;
I_H - current in Helmholtz coils;
R_H – radius of Helmholtz coil.

5. Plot the graph of the moment of the twisting force as the function of B_z:

$$M(B_z) = \mu \cdot B_z$$

$M(B_z)$ – moment of the twisting force as the function of B_z, μ - magnetic moment;

Determine the magnetic moment based on the graph and note the value in Table 1.

6. Knowing the diameter, the number of coils and the current, calculate the magnetic moment:

$$\mu_T = n \cdot I_{OB} \cdot \pi R^2 = n \cdot \frac{\pi}{4} I_{OB} d^2$$

μ_T – theoretical value of magnetic moment;
n – number of coils in the circular conductor;
R – radius of the circular conductor;
d – diameter of the circular conductor;
I_{OB} – current.

Note the value in Table 1., and compare it with the value determined from the graph above.

B. ***Determination of the diameter of the circular conductor placed in the uniform magnetic field.***

1. To zero the experimental setup repeat steps A1 and A2 from above
2. Turn off the power supply to Helmholtz coils and the circular conductor.
3. Turn the power supply of the Helmholtz coils. Set the current to 3A. Calculate the induction of the uniform magnetic field generated between Helmholtz coils (B_H).

7. Take eight readings, setting the current in the circular conductor within the range 0 to 3A with the step of about 0,4A. To read the measured value:

- Align the frame with the mark on the dynamometer, as shown in Fig. 2, using the knob on top(Y) of the dynamometer .
- The unit on the torsion dynamometer's scale is [mN] (10^{-3} N), hence it is not the direct measure of the moment of twisting force.
  Note the values in table 2.

4. For each current setting calculate the corresponding induction of the magnetic field between Helmholtz coils (B_H).
5. Plot the graph of the moment of the twisting force as the function of current in the circular conductor:

$$M(I_{OB}) = \frac{n\pi B_H d^2}{4} I_{OB}$$

$M(I_{OB})$ – moment of the twisting force as the function of current in the circular conductor.

6. Based on the graph calculate the diameter of the circular conductor and note it at the bottom of Table 2.

Required theoretical knowledge

1. Uniform magnetic field, induction of a magnetic field. Units of measure of the strength and induction of a magnetic field. Magnetic force acting on an electric charge moving in a uniform magnetic field. Magnetic force acting on a wire placed in a uniform magnetic field.
2. Pair of forces acting on a current-carrying rectangular frame placed in a uniform magnetic field.
3. Definition of a torque (moment of force) and of a magnetic moment (units of measure).
4. Calculation of a value of a magnetic moment for a circuit with a circular shape.
5. Calculation of a torque exerted by the magnetic force on a current-carrying circuit placed in a uniform magnetic field.
6. Structure of the setup (Helmholtz coils) used to measure forces acting on a current-carrying circuit placed in a uniform magnetic field.
7. Absorption of electromagnetic waves - transitions between energy levels of paramagnetic nuclei in a constant magnetic field with the induction of B. The phenomenon of a nuclear magnetic resonance (NMR). Resonance frequency.
8. The NMR spectroscopy and its application in chemistry, biology and medicine. Functional NMR and its application in a medical diagnostics.

Recommended literature:

D. Halliday, R. Resnick, J. Walker: „Fundamentals of physics"

Constants

R_H = 0,2 [m]
d = 0,12 [m]
$\mu_0 = 4\pi \cdot 10^{-7} \left[\frac{Vs}{Am}\right]$
l = 0,11[m]
n_H = 154 coils
n = 3 coils

Wrocław Medical University Department of Biophysics and Neuroscience	**Practical No 26** **Magnetic moment in the magnetic field**

………………………………………..…………………… ………………………………….……..………………….. ……………………………………...……………………. Student names	Faculty: …………………………………. Group number: ………………………… Date: ………………..……………………
Grade:	Tutor's signature:

_A._ Determination of the torque due to a magnetic moment in a uniform magnetic field, as a function of the strength of the magnetic field.

Current in the circular conductor [A]

Table 1.

Current in Helmholtz coils [A]	Force measured with torsion dynamometer [N]	Calculated value of the moment of the twisting force [N x m]	Induction of the magnetic field between Helmholtz coils [T]

Magnetic moment determined from the graph	Calculated theoretical value of the magnetic moment

***B*. Determination of the diameter of the circular conductor placed in the uniform magnetic field.**

Current in Helmholtz coils [A]

Table 2.

Current in the circular conductor [A]	Force measured with torsion dynamometer [N]	Calculated value of the moment of the twisting force [N x m]	Induction of the magnetic field between Helmholtz coils [T]

.

Diameter of the circular conductor determined from the graph