

T.C.

GEBZE TECHNICAL UNIVERSITY

PHYSICS DEPARTMENT

PHYSICS LABORATORY II

EXPERIMENT REPORT

THE NAME OF THE EXPERIMENT

Current Balance / Force acting on a current-carrying conductor

GEBZE
TEKNİK ÜNİVERSİTESİ

PREPARED BY

NAME AND SURNAME :

STUDENT NUMBER :

DEPARTMENT :

GROUP NO :

TEACHING ASSISTANT :

DATE OF THE EXPERIMENT :

DATE :

Signature:

Experimental Procedure:

The current balance enables the force exerted by a homogenous magnetic field on a conductor through current flows to be determined as a function of the current through the conductor, the length of the conductor and the magnetic field.

The force F_B acting on a current-carrying conducting loop in a uniform magnetic field (Lorentz force) is measured with a balance. Conducting loops of various sizes are suspended in turn from the balance, and the Lorentz force is determined as a function of the current, the length and magnetic field. The uniform magnetic field is generated by an electromagnet. The magnetic induction can be varied with the coil current. The experimental set-up for current-balance is shown in Figure 6.1.

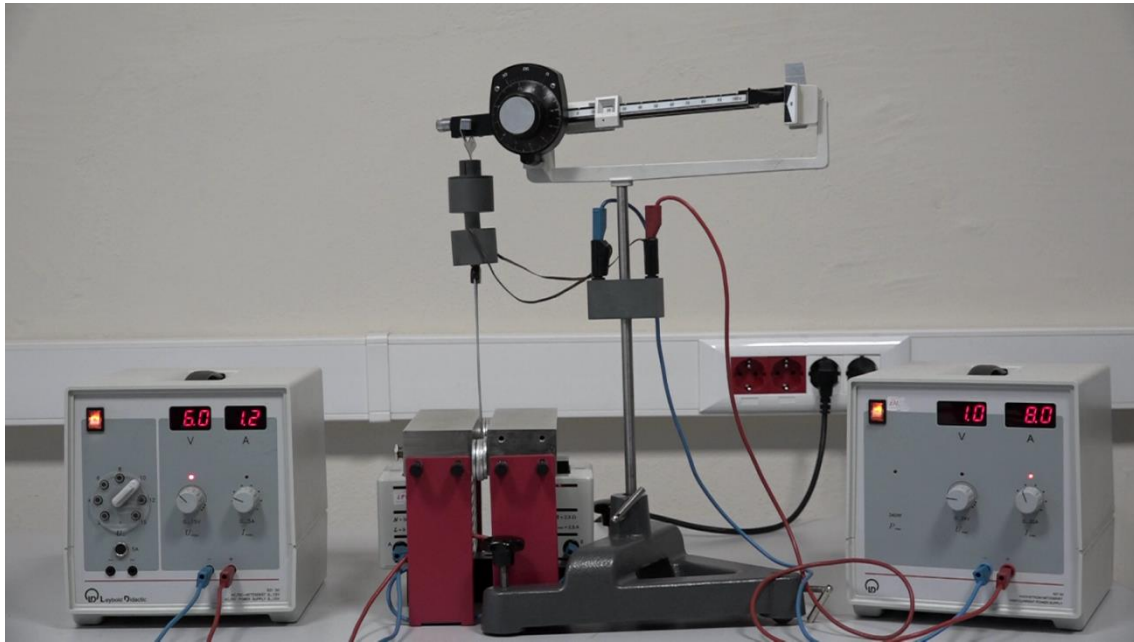


Figure 6.1: Current balance experimental set-up

Warning: *During the experiment, conducting loops could be hot because of high current. Do not touch or interfere with the loops when power supply is on. Please turn off the power supply when making changes to the experimental set-up.*

1. Be sure that power supplies are closed.
2. Connect coils of the electromagnet in series and connected to the power supply.
3. Connect the conducting loop with width $L = 10 \text{ mm}$ to the balance.
4. Adjust the balance, read the mass m_0 , and record the value.
5. Turn on both power supplies that drive current to the coils and conducting loop.
6. Apply 1.2 A steady current to the coils to create a magnetic field.
7. Set the current flowing through the conductive loop to 2 A.
8. Bring the balance back into balance by turning the scale knob and read the value m_I from the scale.
9. Repeat the measurement by increasing the current I from 2 to 8A in steps of 2 A. Each time measure m_I and fill in the table.
10. Follow the same procedure for each conductive loop and fill in the tables below.

Table 6.1: Current vs. mass for 10 mm width loop $m_0 = \underline{\hspace{2cm}}$ (gr)


I (mA)	m_I (gr)	$m = m_I - m_0$ (gr)	F_B (mN)	$L = 10$ (mm)
2000				
4000				
6000				
8000				

Table 6.2: Current vs. mass for 20 mm width loop $m_0 = \underline{\hspace{2cm}}$ (gr)

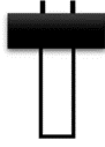
I (mA)	m_I (gr)	$m = m_I - m_0$ (gr)	F_B (mN)	$L = 20$ (mm)
2000				
4000				
6000				
8000				

Table 6.3: Current vs. mass for 40 mm width loop $m_0 = \underline{\hspace{2cm}}$ (gr)


I (mA)	m_I (gr)	$m = m_I - m_0$ (gr)	F_B (mN)	$L = 40$ (mm)
2000				
4000				
6000				
8000				

Table 6.4: Current vs. mass for 80 mm width loop $m_0 = \underline{\hspace{2cm}}$ (gr)


I (mA)	m_I (gr)	$m = m_I - m_0$ (gr)	F_B (mN)	$L = 80$ (mm)
2000				
4000				
6000				
8000				

Table 6.5: Current vs. mass for 40 mm width semi-closed loop $m_0 = \underline{\hspace{2cm}}$ (gr)

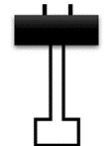
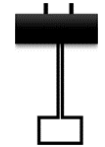
I (mA)	m_I (gr)	$m = m_I - m_0$ (gr)	F_B (mN)	$L = 40$ (mm)
2000				
4000				
6000				
8000				

Table 6.6: Current vs. mass for 40 mm width closed loop $m_0 = \underline{\hspace{2cm}}$ (gr)

I (mA)	m_I (gr)	$m = m_I - m_0$ (gr)	F (mN)	$L = 40$ (mm)
2000				
4000				
6000				
8000				

Calculations and Analysis:

Two weighings of the conducting loop are necessary for each determination of the force exerted, either upwards or downwards, according to the current direction. The loop must be weighed when not carrying m_0 and when carrying m_I , current. The difference in the two weighings $m = m_I - m_0$ gives the mass for the force conversion into the unit *Newton* with $F = mg$. ($g = 9.81 \text{ m/s}^2$). Calculate the forces F_B and fill the Tables 6.1–6

I. Lorentz force as a function of the current in the conducting loop:

According to equation $\vec{F}_B = I\vec{L} \times \vec{B}$, Lorentz force is directly proportional to the current on the conducting loop $F_B \propto I$. We expect a line in the form of $y = ax$, where a is the slope of the line, passing through those points and the origin. Use I and F_B columns of Tables 6.1–4 and calculate the slopes of the lines by means of the statistical linear fitting method called “*least squares method*” its formulae are given below.

i) $L = 10 \text{ mm}$

$$\sum_{i=1}^k I_i F_i =$$
$$\sum_{i=1}^k I_i^2 =$$

$$a_1 = \frac{\sum_{i=1}^k I_i F_i}{\sum_{i=1}^k I_i^2} =$$

ii) $L = 20 \text{ mm}$

$$\sum_{i=1}^k I_i F_i =$$
$$\sum_{i=1}^k I_i^2 =$$

$$a_2 = \frac{\sum_{i=1}^k I_i F_i}{\sum_{i=1}^k I_i^2} =$$

iii) $L = 40 \text{ mm}$

$$\sum_{i=1}^k I_i F_i =$$
$$\sum_{i=1}^k I_i^2 =$$

$$a_4 = \frac{\sum_{i=1}^k I_i F_i}{\sum_{i=1}^k I_i^2} =$$

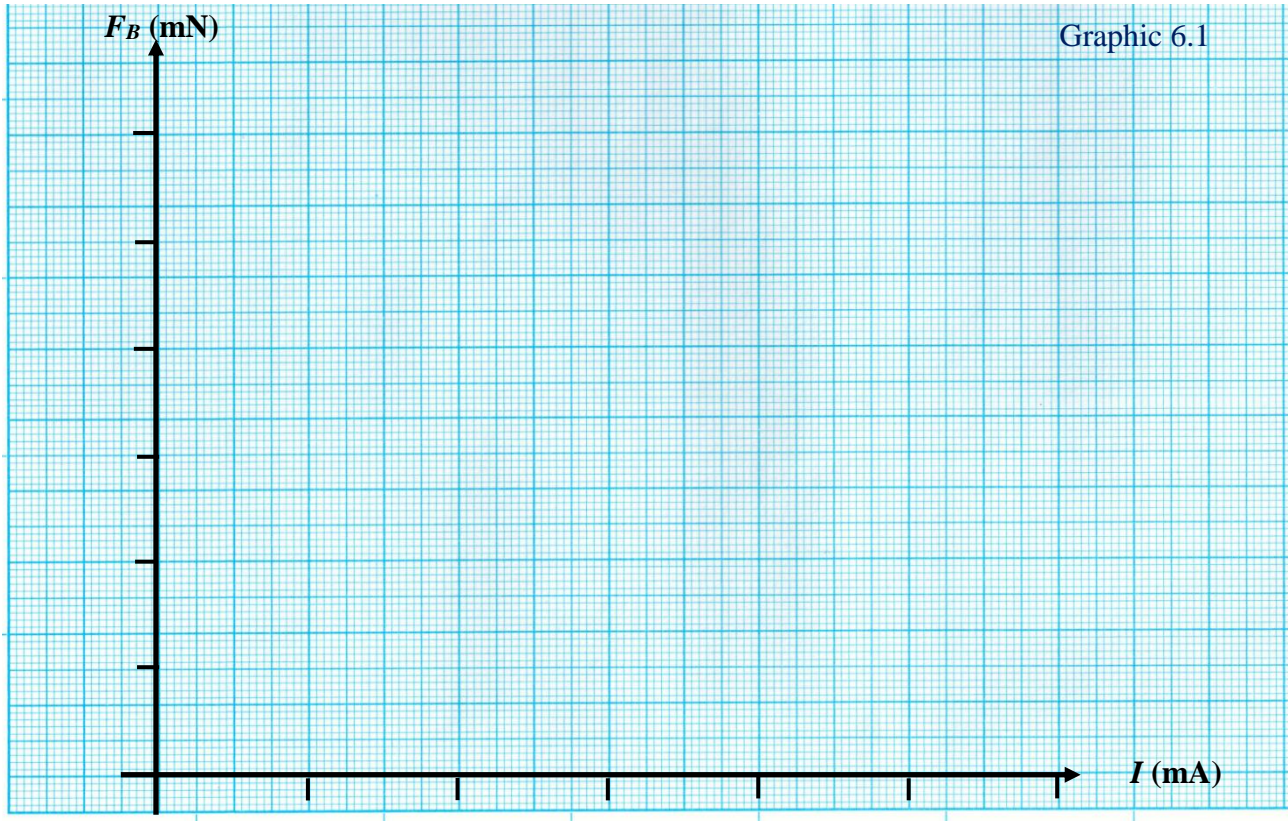
iv) $L = 80 \text{ mm}$

$$\sum_{i=1}^k I_i F_i =$$
$$\sum_{i=1}^k I_i^2 =$$

$$a_8 = \frac{\sum_{i=1}^k I_i F_i}{\sum_{i=1}^k I_i^2} =$$

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Plot $I - F_B$ graph for each conducting loop using data sets from Tables 6.1–4. Represent the I values on the x -axis, while the F_B values on the y -axis of your graphs. Mark the data points on your graph and draw the straight lines $y = ax$, where the slopes a 's are calculated for each *conductive loop* in the previous step. Use those a values to plot the lines that are passing from the origin on your graph and observe how they fit with your experimental data points.



What can you say about the relationship between the magnetic force applied to and the current through the loops?

As we know from the Biot-Savart law, the steady current flows ($I_C = 1.2A$) through the coils; therefore, the induced magnetic field B is also constant. Calculate and compare the magnetic fields B induced by the coils. Write the unit of the magnetic field B in terms of Tesla. Are the values different?

Discuss possible reasons. $\left[F_B = ILB \Rightarrow \frac{F_B}{I} = a = LB \Rightarrow B = \frac{a}{L} \right]$

i) $(L = 10 \text{ mm}) \Rightarrow B_1 = \frac{a_1}{L} =$

iii) $(L = 40 \text{ mm}) \Rightarrow B_4 = \frac{a_4}{L} =$

ii) $(L = 20 \text{ mm}) \Rightarrow B_2 = \frac{a_2}{L} =$

iv) $(L = 80 \text{ mm}) \Rightarrow B_8 = \frac{a_8}{L} =$

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II. Lorentz force as a function of length of the conducting loop:

In order to examine the relationship between the Lorentz force (F_B) and the length of the conducting loop (L), fill in Table 6.7 using only the data in rows $I = 8000$ mA of Tables 6.1-4.

Table 6.7: Lorents force F_B as a function of the conductor loop width L

L (mm)	F_B (mN)
10	
20	
40	
80	

According to equation $\vec{F}_B = I\vec{L} \times \vec{B}$, Lorentz force is directly proportional to the width of the conducting loop $F_B \propto L$. We expect a line in the form of $y = ax$, where a is the slope of the line, passing through those points and the origin. Use L and F_B columns of Table 6.7 and calculate the slope of the line means of the statistical linear fitting method called “least squares method” its formulae are given below.

$$\sum_{i=1}^k L_i F_i =$$

$$\sum_{i=1}^k L_i^2 =$$

$$a = \frac{\sum_{i=1}^k L_i F_i}{\sum_{i=1}^k L_i^2} =$$

Calculate the induced magnetic field by using the slope of line a that fits data points in the $L - F_B$ graph. Write the unit of the magnetic field B in terms of Tesla. $[F_B = ILB \Rightarrow \frac{F_B}{L} = a = IB \Rightarrow B = \frac{a}{I}]$.

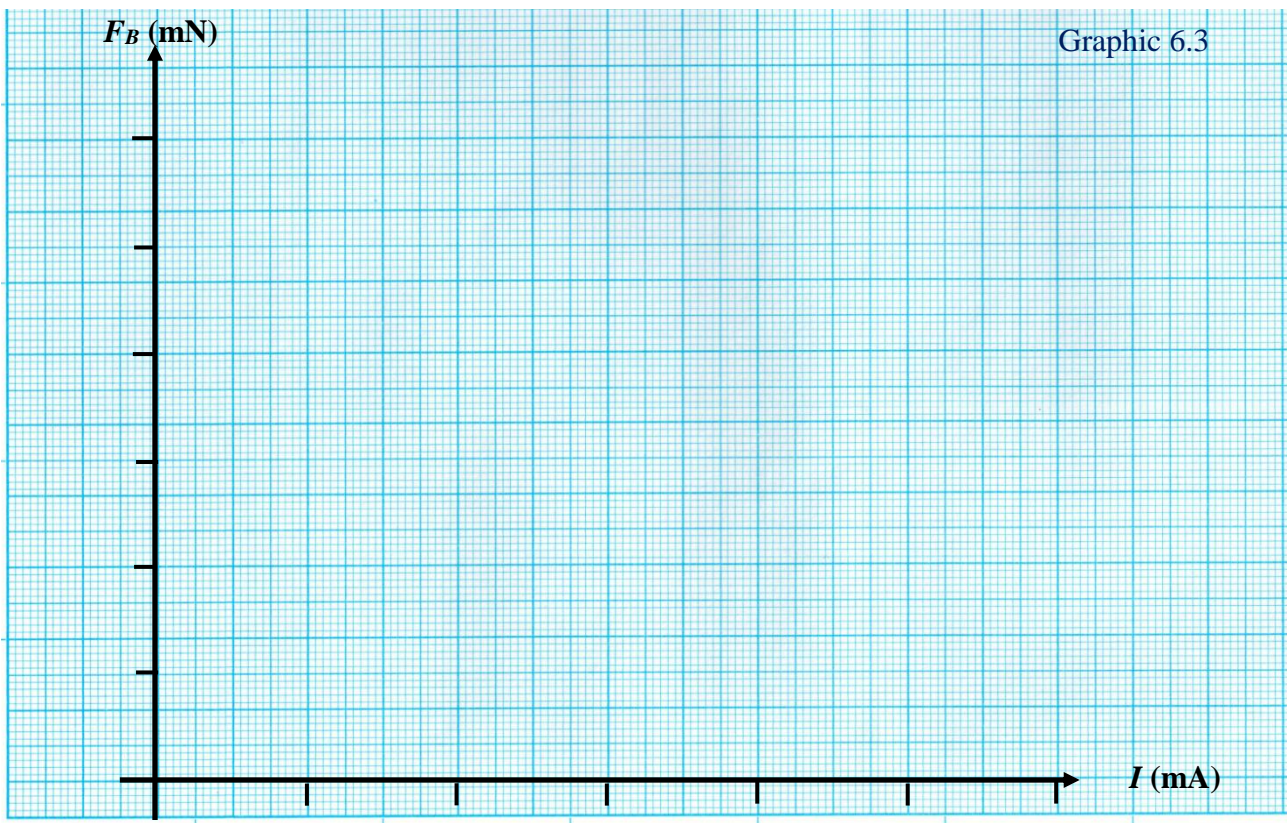
$$(I = 8 A) \Rightarrow B = \frac{a}{I} =$$

Compare the calculated B with those calculated in the previous section. Are the values different? Discuss possible reasons.

III. The effect of the conducting loop shape on the Lorentz force:

One can see that if the right-hand rule is applied with the equation $\vec{F}_B = I\vec{L} \times \vec{B}$, the Lorentz force acting on parallel wires, which have countercurrent, is opposing each other.

In order to examine the effect of the conducting loop shape on the magnetic force, plot I vs. F_B graphs using data sets from Tables 6.3, 6.5, and 6.6 for *open*, *semi-closed*, and *closed* conducting loops with lengths ($L = 40\text{ mm}$). Represent the current I values on the x -axis, while the Lorentz force F_B values on the y -axis of your graphs. Mark the data points on your graphs and draw the most suitable straight lines passing through the origin and your data points without making any fitting, only with crude eye estimation.



Although the widths of the loops used in the graphic are equal, are the slopes of the lines and forces exerted on the wires different? Please explain why?

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