TED ANKARA COLLEGE FOUNDATION PRIVATE HIGH SCHOOL

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PHYSICS EXTENDED ESSAY

Effect of Salt Concentration of Medium on Magnetic Field Strength

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1 Abstract

This experiment is settled in order to see if there is a relation between medium conditions and magnetic field strength created in this medium.

The aim of this study is to investigate the effects of salt concentration in salty water on the magnetic field strength created by long bar magnets in this medium. During the experiment volume of water that different concentrations of salt is dissolved, temperature of water, resistance of conducting wires, number of turns in coil, internal resistance of power supply, magnets used to create magnetic field are controlled. As a result of the investigation, it is expected to found out that as salt concentration in salty water increases, magnetic field strength created in the water decreases.

Word Count:119

Content

2 Introduction

2.1 Background

Magnetism was known by early Greeks as early as 800 B.C. They discovered that certain stones now called magnetite(Fe_3O_4) attract pieces of iron.[1] It is known that a simple compass uses this property to show the directions. In order to learn about design and principle of how these compasses work, the term magnetic field should be defined. A magnetised material has areas of concentrated magnetism called poles. All magnets have at least two poles, north and south. Magnetic field lines connect the north and south poles of a magnet. They always go from north to south and they never cross. The more field lines there are in a particular area, the stronger the magnetic field.[2] Magnetic field strength in the interior of the solenoid can be calculated by using the formula given below;

$$B = \mu_0 \times \frac{NI}{L}$$

where N is number of turns, L is the length of solenoid, I is the current through it and μ_0 is the magnetic permeability. Magnetic permeability is a physical constant which shows the relation between the medium conditions and magnetic field strength.[3]

The answer of the question, how magnetic field strength is affected from medium conditions, is searched during this investigation.

2.2 Objective

The objective of this study is to investigate the effect of salt concentration in salty water on magnetic field strength of the system (through giving different current values to the experimental setup) which is shown in *Figure 1* and *Figure 2* in *Section 4* and calculating magnetic force. Considering the aim of the study the answer of the question that is given below as a research question is searched during the investigation;

[1] Serway, 4th Edition, Physics For Scientists&Engineers
[2] http://www.acecrc.sipex.aq/access/page/?page=75ee44de-b881-102a-8ea7-0019b9ea7c60
[3] K.A. Tsokos, 5th Edition, Cambridge, Physics for the IB Diploma

Research Question: How does different salt concentrations affect the magnetic field strength of the system which is constructed in salty water with a coil and two magnets on both sides of the coil?

According to the information given above in *Section 2.1 Background,* an hypothesis is stated as below to specify the expected results of the investigation;

Hypothesis: As the salt concentration of salty tap water is increased, magnetic field strength around the coil which is placed in the solution decreases.

3 Equipment Description& Experimental Setup

3.1 General Description of Equipments

The basic equipments which are used to perform the experiment are described as given below;

- An electronic scale (±0.1g) is used in the experimental setup to analyse the magnetic force due to the current given to the system and the effect of different salt concentrations on magnetic force. Change in magnetic force is being read on electronic scale and it gives us the magnetic force exerted on the coil.
- In the shape of rectangular prism, four identical magnets($20.0 \times 3.0 \times 4.0$cm^3) which have enough length to create a uniform magnetic field are used.
- Power supply (0-25V) is used in order to give different current values to the coil to obtain magnetic force that is observable on electronic scale.
- Two wood sticks (1.0± 0.1m) are used to hang the coil over the electronic scale to prevent the coil to be in touch with the surface of the electronic scale.
- Two conducting wires with same properties are used to connect the power supply to the coil.
- Coil(2A, 3Ω, 600 turns) is used to observe the magnetic force exerted on it.
- Salt ($Total\ amount = 400.0 \pm 0.1g$) is used to prepare salty water at different concentrations to observe the effect of salt on magnetic field strength.
- Tap water(1.0 ±0.1L) is used to dissolve different concentrations of salt in it and change medium conditions in this way.

- Cylindrical shaped container($r = 9.0cm$)($h = 20.0cm$) is used to put salty water in it, place the coil in it and put it on the electronic scale.
- Spoon is used to stir up the mixture of salt and water to dissolve different concentrations of salt in water.
- Thermometer(±0.1℃) is used to measure the temperature of the system.
- Graduated cylinder(10±1 ml) is used to measure the amount of salt that is planned to be dissolved in tap water.

3.2 Key Variables

3.2.1 Dependent Variables

- Magnetic force exerted on the coil
- Magnetic field strength created in the coil

3.2.2 Independent Variables

- Salt concentration in salty water
- Current passing through the coil

3.2.3 Controlled Variables

The variables which are not tested in the experiment but might have an effect on the results are controlled during the experiment. These variables are stated below;

Volume of water that different concentrations of salt is dissolved in it is kept constant at 1.0±0.1L. Since using different volumes of water may change the solubility of salt and affects the magnetic field strength of the system, it is kept constant at a fixed value.

Tap water is used in each trial due to the fact that different ingredients in water may affect the magnetic field permeability(μ_0), it is controlled by using water from the same source in each setup.

Temperature of water is kept constant at $23.5 \pm 0.1\ ^0C$. Since temperature of water may affect the conductivity of conducting wire and in this way the current given to the system may be affected. Another reason is that different temperatures may also affect the solubility of salt in tap water and change the magnetic field strength of the system indirectly. In addition, the temperature of water is kept constant at a fixed value which is equal to room temperature in order to prevent any error which may occur due to exchange of heat between materials.

The resistance of conducting wires is controlled by using the same wires in each trial. Otherwise change in resistance of wires causes a variation in the current passing through the circuit.

The length, number of turns, material that the coil is made up of and the resistance of coil are other important factors that are controlled in the experiment. Since magnetic field strength may change due to the coil, same coil (2A, 3Ω, 600 turns) is used in each trial.

Internal resistance of the power supply has also an effect on the current produced in the circuit. Therefore the same power supply with 0-25V is used in each trial of the experiment.

Shape and volume of container is another important factor. Since different shaped containers may affect the distance between the coil and the magnets and it may also affect the magnetic effects on the coil, the same cylindrical shaped container with radius of 9.0cm and height of 20.0cm is used in each setup.

Magnets used in the experiment are the sources of magnetic effects. Since attraction between different magnets may change and affect the magnetic force attracted to the system, same magnets with same size($5.0 \times 3.0 \times 4.0cm$) are used in each setup.

So distance between magnets and coil can be kept constant at $10.0 \pm 0.1cm$. By this way the uncertainty of the measurement devices are kept constant.

4 Procedure

4.1 Preparation

Before performing the experiment, setup is constructed carefully. The experimental procedure includes two main parts. One is the experimental procedure which is carried out in air and the second one is the procedure which is performed in tap water with different concentrations of salt.

First of all to begin with the first part of the experiment the coil is hung over the electronic scale with the help of wood sticks as it is shown in *Figure 1 and Figure 2* in *Section 4.3 Schematic Setup*. It is made sure that the coil is not in touch with the surface of the electronic scale. However, it should be close to the surface of the electronic scale to make the change in the value read on the scale(caused by magnetic effects) depending on the current passing through the coil more observable.

After that two of four magnets are put on the left side of the coil 10.0cm away and the other two are put on the right side 10.0 cm away from the coil. In this part it is important to make sure that the opposite poles of magnets are facing each other to provide attraction caused by magnetic effects. Then power supply is connected to coil by the help of conducting wires to observe magnetic effects. As a result, the setup of first part of the experiment is completed.

In the second part of the experiment the setup is constructed in tap water with different concentrations of salt. To begin with 1.0L of tap water, that it is prepared before and made it wait at least 2 hours in room temperature(23.5 ºC), is put into the cylindrical container. Its temperature is measured by the help of thermometer to be sure that it is equal to room temperature. Then the container full of tap water is put on electronic scale and the coil is placed in this container. The coil is hung which is in the container by the help of wood sticks, making sure that it is not in touch with the surface of the container but still close to the surface due to the reasons that are mentioned above. After that magnets are placed on the electronic scale. One of them is put 10.0cm away from the right side of the coil in the container and one is put right side of the coil out of the container. So one magnet is put in the container and one is put out of the container in right side and the same process is repeated for the left side of the coil as it is shown in *Figure 1* and *Figure 2*. By using two coils on one side and two coils on other side, magnets are placed 10.0cm away from the coil.

The preparation of the second part of the experiment is repeated for different concentrations of salt. This time after the container full of tap water is prepared certain amount of salt is added to the container. For example, if 4.0g of salt is considered, while measuring the salt, first the mass of empty graduated cyclinder is measured with electronic scale. Then zero set button pressed and while the graduated cyclinder is still on the scale salt is started to be added into the graduating cyclinder until the value read on the scale shows 4.0g. After 4.0g of salt is added to 1.0L of tap water and the mixture is stirred up with the help of a spoon, the container and the magnets are placed on the electronic scale as explained above. This preparation process is repeated for each trial with different concentrations of salt.

Warning: When each preparation process is done, zero set button of electronic scale is pressed to ignore the change in value read on scale during preparation process. Moreover, it is important to state that the same magnets, conducting wires, power supply and electronic scale are used to keep irrelevant variables constant and prevent unexpected results.

4.2 Conducting the Experiment

Firstly, power supply is activated and it begins to give current to the coil from 0.2A to 3.0A increasing the current value by 0.2A in each trial. Change in value read on electronic scale for different current values is observed and data is recorded carefully. This process is repeated for each setup, the setup in air, the setup in salty water with different concentrations of same brand of salt.

4.3 Schematic Setup

Schematic setup of this experiment is presented below in *Figure 1* and *Figure 2*.

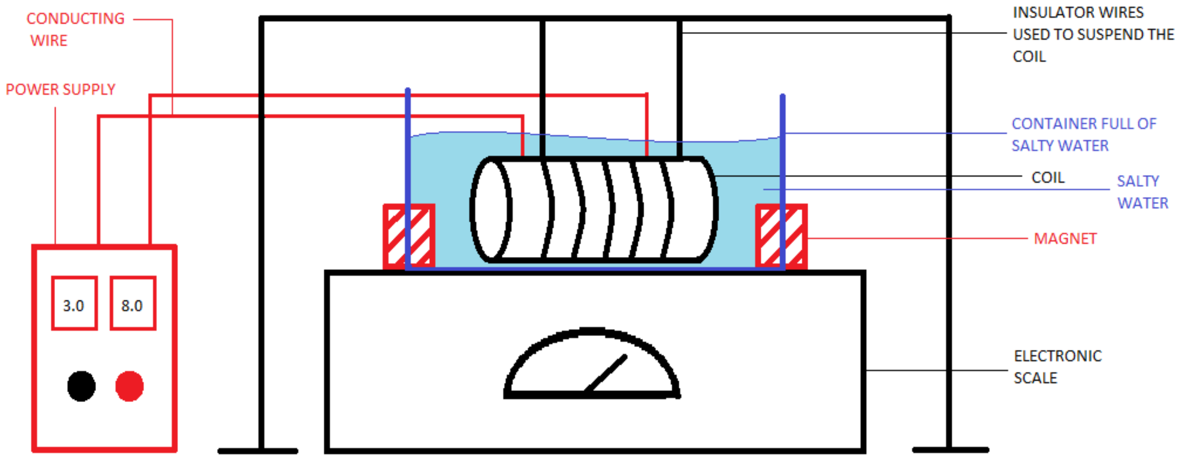


Figure 1: Sample diagram of the setup in a container full of salty water showing how power supply, coil, magnets and electronic scale are conneted together in the experiment

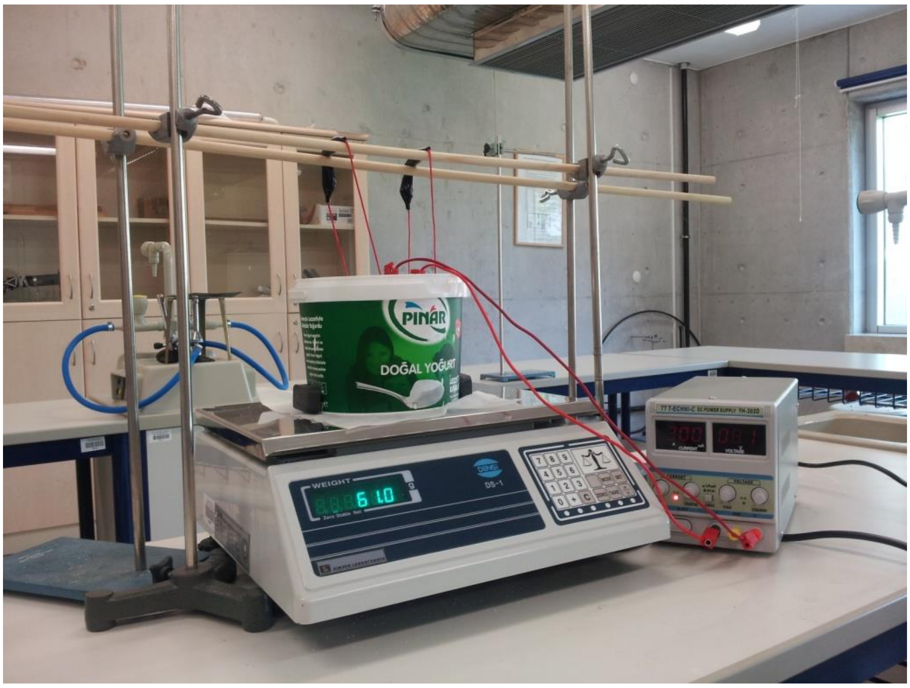


Figure 2: Photograph showing the setup in tap water including each material used in the experiment(power supply, coil, electronic scale, magnets, conducting wire, etc)

5 Data Collection & Processing

5.1 Trials in air

This section includes the data obtained during the experiment which was carried out in air are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current (±0.01)(Ampers)	Change in Mass Read on Electronic Scale (±0.1)(grams)	Average Change in Mass (±0.1g)
1	0.00	0.0	0.0
2		0.0	
3		0.0	
1	0.20	5.0	4.7
2		4.5	
3		4.5	
1	0.40	9.5	9.2
2		9.0	
3		9.0	
1	0.60	14.0	13.7
2		13.5	
3		13.5	
1	0.80	18.5	18.2
2		18.0	
3		18.0	
1	1.00	23.0	22.7
2		22.5	
3		22.5	
1	1.20	27.5	27.0
2		27.0	

3		26.5	
1	1.40	32.0	31.5
2		31.5	
3		31.0	
1	1.60	36.5	35.8
2		35.5	
3		35.5	
1	1.80	41.0	40.2
2		40.0	
3		39.5	
1	2.00	45.5	44.7
2		44.5	
3		44.0	
1	2.20	49.5	48.8
2		48.5	
3		48.5	
1	2.40	54.0	53.2
2		53.0	
3		52.5	
1	2.60	58.0	57.2
2		57.0	
3		56.5	
1	2.80	62.0	61.2
2		61.0	
3		60.5	
1	3.00	76.5	75.3
2		75.5	
3		74.0	

Table 1: Change in the value read on electronic scale(caused by magnetic effects) depending on the current passing through coil

Measurements of change in mass of the system are made in unit of gram. However, to use them in the equation which is going to be used to calculate the magnetic field strength, mass values are going to be converted into unit of kilogram and then multiplied by gravitational acceleration constant which is equal to 9.8m/s^2 to obtain the force in unit of Newton.[4] In this way change in mass values are going to be used in the equation as an applied force. Since the increase in force exerted on the scale is caused by magnetic effects, we can conclude that the change in force is equal to the magnetic force applied on the coil.

$$F_{magnetic} = m.g$$

Average of Change in Mass (±0.1g)	**Change in Mass (±0.0001kg)**	**Force (±0.0001N)**
0.0	0.0000	0.000
4.7	0.0050	0.046
9.2	0.0090	0.090
13.7	0.0140	0.134
18.2	0.0180	0.178
22.7	0.0230	0.222
27.0	0.0270	0.265
31.5	0.0320	0.309
35.8	0.0360	0.351
40.2	0.0400	0.394
44.7	0.045	0.438
48.8	0.049	0.478
53.2	0.053	0.521
57.2	0.057	0.561
61.2	0.061	0.600
75.3	0.075	0.738

Table 2: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to 9.8m/s^2

[4] http://www.phy-astr.gsu.edu/dhamala/Physics2211/Chapter13.pdf

Magnitude of the magnetic force applied on the coil is directly proportional to the current(I) passing through the coil, magnetic field strength(B) around the coil and the length of the conducting wire which stays in magnetic field.[5]

Magnetic force of the system is going to be calculated by the help of formula given below;

$$F = B.I.L.N$$[6]

where;

$$F: force\ applied\ on\ the\ system(N)$$

$$B: magnetic\ field\ strength(T)\left(\frac{N}{A.m}\right)$$

$$I: current\ given\ to\ conducting\ wire(A)$$

$$L: length\ of\ the\ conducting\ wire\ that\ stays\ in\ magnetic\ field(m)$$

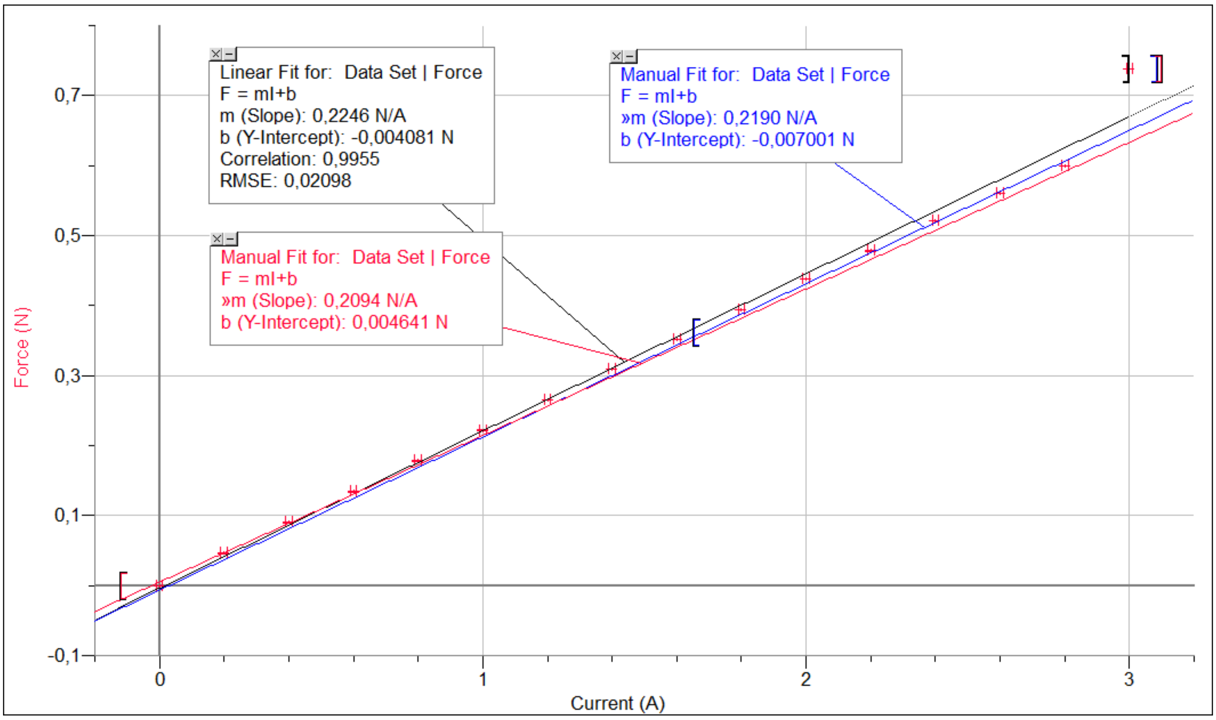
$$N: number\ of\ turns\ in\ coil(which\ is\ equal\ to\ 600\ in\ this\ experiment)$$

The subject of the equation is changed as below in order to calculate magnitude of the magnetic field strength of the system;

$$B = \frac{F}{ILN}$$

A graph of force to current is going to be drawn. Slope of the best fit line of this graph gives the multiply of magnitude of the magnetic field strength, length of the conducting wire and number of turns. Since number of turns and length of conducting wire that is in magnetic field are kept constant in the experiment, magnetic fields strength is going to be found by dividing the slope of the best fit line by length of the wire and number of turns in the coil. According to the information above, graph of magnetic force versus current is plotted for the setup in air and necessary calculations are carried out as following:

[5] K.A. Tsokos, 5th Edition, Cambridge, Physics for the IB Diploma
[6] K.A. Tsokos, 5th Edition, Cambridge, Physics for the IB Diploma



Graph 1: The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = BLN$$

$$\frac{Slope}{LN} = B$$

$$Slope\ of\ the\ best\ fit\ line = 0.2246\ N/A$$

$$Magnetic\ field\ strength\ of\ the\ setup\ in\ air = \frac{0.2246}{600 \times 0.06} = 6.2 \times 10^{-3}\ \frac{N}{A.m}$$

Magnetic field strength around the coil is found by the formula of $B = \frac{F}{ILN}$. $\frac{F}{I}$ value in this formula is the slope of the best fit line of the graph of force versus current. That's why during error calculations of magnetic field strength uncertainty of $\frac{F}{I}$ value is calculated by using the worst lines of the graph;

$$Uncertainty\ of\ \frac{F}{I}\ value = \frac{|\max slope - \min slope|}{2}$$

$$\frac{|0.2190 - 0.2094|}{2} = 0.0048N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I}Ratio = \frac{0.0048}{0.2246} \times 100 = 2.14\%$$

$$Percentage\ Uncertainty\ of\ Length\ of\ Wire = \frac{0.001}{0.060} \times 100 = 1.67\%$$

Since the number of turns on the coil is a standart value, its uncertainty is zero. The uncertainty of the magnetic field strength around the coil is calculated below;

$$Percentage\ Uncertainty\ of\ Magnetic\ Field\ Strength\ = 2.14 + 1.67 = 3.81\%$$

$$0.0062 \times \frac{3.81}{100} \cong 0.0002T$$

As a result the magnetic field strength around the coil in air is found to be:

$$= 0.0062 \pm 0.0002T$$

See Appendix for further information of other trials which includes tap water and salts with different concentrations in it.

6 Data Presentation& Analysis

6.1 Presentation

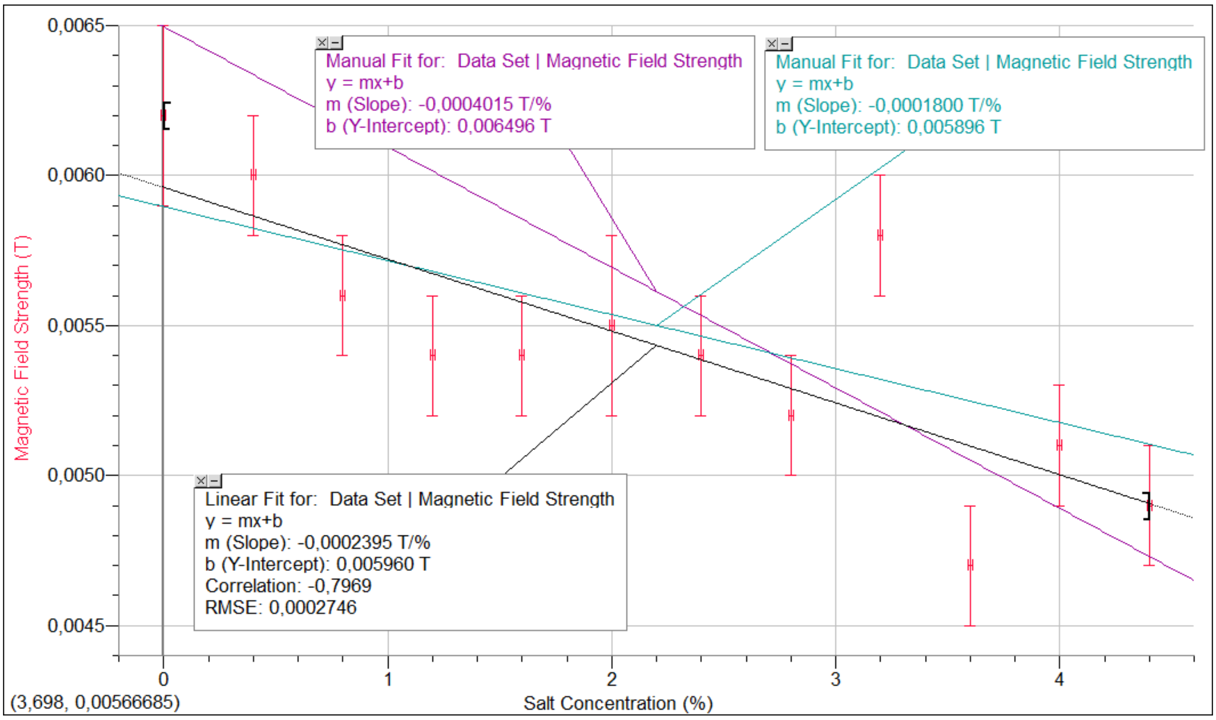
The magnetic field strength created by four long bar magnets around a current carrying coil and the salt concentration in the salty water where the magnets and coil are placed are represented in *Table 3.*

Mass of Salt (±0.1g)	Salt Concentration (%)	Magnetic Field Strength(T)	Uncertainties of Magnetic Field Strength
0,0	0,0	0,0062	0,0003
4,0	0,4	0,006	0,0002
8,0	0,8	0,0056	0,0002
12,0	1,2	0,0054	0,0002
16,0	1,6	0,0054	0,0002
20,0	2,0	0,0055	0,0003

24,0	2,4	0,0054	0,0002
28,0	2,8	0,0052	0,0002
32,0	3,2	0,0058	0,0002
36,0	3,6	0,0047	0,0002
40,0	4,0	0,0051	0,0002
44,0	4,4	0,0049	0,0002

Table 3: Mass of salt(g) dissolved in 1L of tap water, salt concentration and magnetic field strength(T) of the system

To put the relation between concentration of salt in water and the magnetic field created in this medium, a graph of magnetic field strength versus salt concentration is plotted.



Graph 2: Salt concentration(%) in 1.0L of tap water to magnetic field strength(T) of the system

6.2 Experimental Error Calculation

The error calculations were carried out regarding the slopes of the worst lines in *Graph 2.*

$$Absolute\ Error\ of\ the\ Investigation = \frac{|Slope_{max} - Slope_{min}|}{2}$$

$$= \frac{|-0.00018 - (-0.0004015)|}{2} = 0.00011T$$

$$Percentage\ Error = \frac{Absolute\ Error}{Slope\ of\ Best\ Fit} \times 100 = \frac{0.00011}{0.0002395} \times 100 = 45.92\%$$

6.3 Analysis

As it is shown in *Table 3*, as salt concentration in tap water is increased in each trial, magnetic field strength of the system slightly decreases. According to *Graph 2* the magnetic field strength decreases where salt concentration increases, this specifies that the function is linearly decreasing.

7 Conclusion& Evaluation

This study is carried out to investigate the medium effects on magnetic field strength created by two long bar magnets. More specifically, the relation between the salt concentration in salty water and magnetic fields strength created by the magnets in this medium is attempted to be put forward.

Firstly the experiment is constructed in air conditions to have a reference of magnetic field strength of the system. When the experiment is constructed in tap water, it is observed that magnetic field strength is nearly same with the setup in air. The reason of that is magnetic field permeability(μ_0) of water and air is close to each other. Magnetic permeability of air is 1.00000037 and magnetic permeability of water is 0.999992[7]. According to this information magnetic field strength of setup in water should be almost same with the setup in air.

The magnetic field strength created by bar magnets is calculated by using the magnetic force exerted on the current carrying coil placed in this magnetic field. The current

[7] http://info.ee.surrey.ac.uk/Workshop/advice/coils/mu/

passing through the coil is increased regularly and the variation in the magnetic force exerted on the coil is measured by the setup mentioned in *Section 4.2.* The magnetic field strength created by long bar magnets around the coil is calculated by using the slope of the graph of magnetic force versus current passing through the coil. The same procedure is followed by placing the setup into salty water with different salt concentrations. At the end the variation of magnetic field strength created by the same system in salty water with varying salt concentrations is analyzed.

Moreover, considering *Graph 2* which shows the relation between salt concentration and magnetic field strength, it can be stated that there is a relation between magnetic field strength and salt concentration. The graph shows a linearly decreasing function. As salt concentration of salty water is increased, magnetic field strength of the system decreases linearly, which means that the hypothesis of the investigation is confirmed.

As a result, it is concluded that increasing amount of salt concentration decreases the effect of magnetic field strength. This conclusion may be an effective solution for undesired effects of magnetic field. For example, it is known that strong magnetic field may give harm to some devices which includes magnetic field also or it can even effect the credit cards which are commonly used in daily life in negative ways. Furthermore, it is obviously clear that strong magnetic field is also harmful for human body. Bluetooth, wireless network connection or devices like mobiles, televisions, computers, microwave ovens etc are the most common ones which are used in daily life. However, the strong magnetic field is found out to be very harmful for humans. It may increase the risc of cancer or damage to brain cells. There are some methods to decrease the effect of magnetic field created by these devices. Another method could be related with the results of this investigation. By using the decreasing effect of salt concentration on magnetic field strength, the undesired effects of magnetic field can be reduced.

Although the result of the investigation is as it is expected and stated in hypothesis, there is a huge percentage error that cannot be ignored. As it is presented in *Section 6.2* percentage error of the experiment is 45.92%. Obvious error source for such a great percentage error could be the reconstructing of experimental setup for each trial. When

Graph 2 is assessed, it is seen that some points are out of the best fit line of the graph. The reason of that random error could be the reconstruction of experiment.

Moreover, the other error source can be resistance of power supply. During the experiment power supply is used to give current to the coil. After that magnetic field strength is calculated by the help of magnetic force which is caused by current given to the system. However, power supply that is used in the experiment has internal resistance which affects the current given to the coil. This means that current values that are desired to be given to the coil may have not been given due to that internal resistance. To prevent this error source and minimize its effects a different power supply with less internal resistance can be used to get better results.

During the second part of the experiment tap water which is used to dissolve salt is put into thick and plastic cylindrical shaped container and two of four magnets are placed inside the container, but the other two are placed outside of the container. Since the container is made up of plastic, it can have the property of being insulator and prevent effects of magnets on the system. Thickness and the material of the container may cause a systematic error. In order to prevent this error source, another container which does not have the property of being insulator and also a thin one can be used.

Another limitation is the measurement devices that are used. The most significant measurement device used is electronic scale. Calculations of magnetic force and magnetic field strength are carried out through values read on electronic scale. However, the device that is used could not make precise measurements enough. Using a different electronic scale which can make more precise measurements can make the results of the investigation more observable.

Moreover, to improve the results of the investigation making the whole experiment can be increase accuracy of data taken during the experiment. Since each time the experimental setup is established, the conditions may differ and it may cause errors in the experiment. Therefore, making each trial at the same time with the same setup could make results more accurate.

8 Appendix

8.1 Trials in Tap Water

In this section data obtained during the experiment which was performed in tap water is presented.

Trials	Current(±0.01A)	Change in Mass(±0.1g)	Average Change in Mass(±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	4,1	4,1
2		4,0	
3		4,2	
1	0,40	8,7	8,6
2		8,7	
3		8,4	
1	0,60	12,6	13,3
2		14.3	
3		13,0	
1	0,80	17,5	17,4
2		16,3	
3		18,4	
1	1,00	22.1	21,2
2		20,3	
3		21,2	
1	1,20	24,5	24,4
2		24,0	
3		24,7	
1	1,40	30,1	29,9
2		30,1	

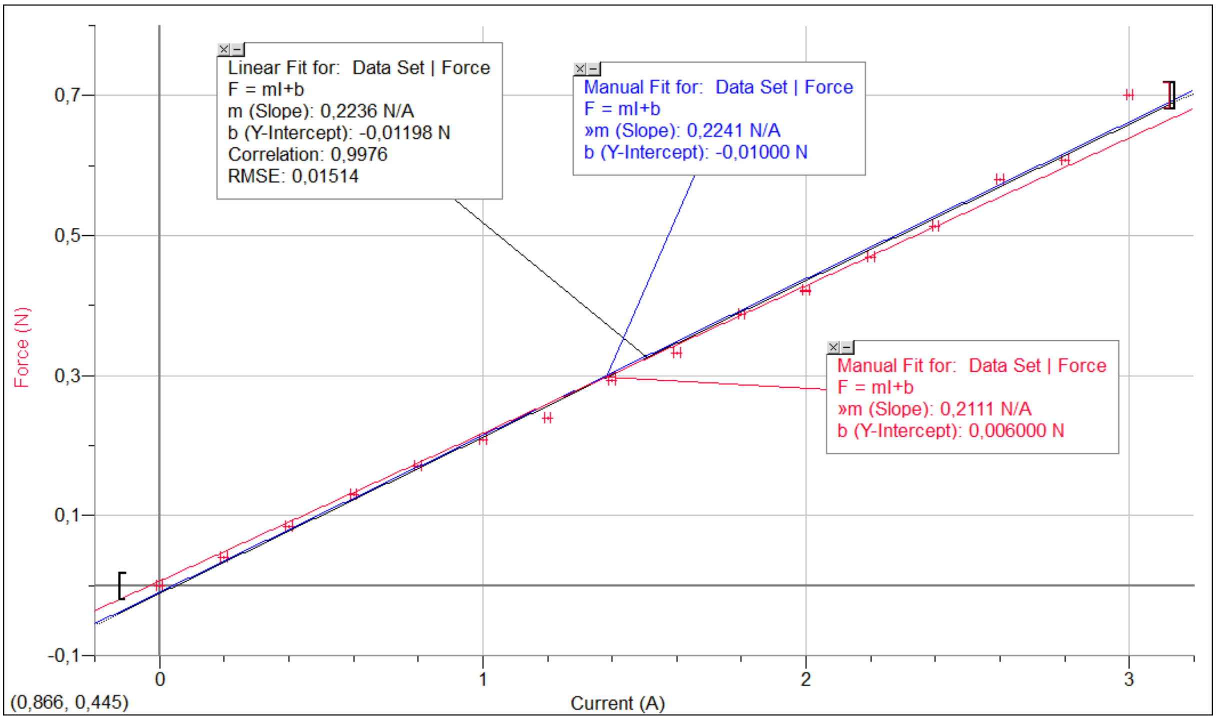
3		29,5	
1	1,60	34,1	33,9
2		33,3	
3		34,3	
1	1,80	41.1	39,6
2		38,4	
3		39,3	
1	2,00	43,0	43,0
2		43,0	
3		43,0	
1	2,20	48,0	47,9
2		45,5	
3		50,2	
1	2,40	52,6	52,3
2		52,0	
3		52,3	
1	2,60	60,1	59,2
2		58,0	
3		59,5	
1	2,80	63,0	61,9
2		60,9	
3		61,8	
1	3,00	71,5	71,4
2		71,4	
3		71,3	

Table 4: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in Mass (±0.1g)	Change in Mass	Magnetic Force

	$(\pm 0.0001kg)$	$(\pm 0.0001N)$
0,0	0,000	0,000
4,1	0,004	0,040
8,6	0,009	0,084
13,3	0,013	0,130
17,4	0,017	0,171
21,2	0,021	0,208
24,4	0,024	0,239
29,9	0,030	0,293
33,9	0,034	0,332
39,6	0,040	0,388
43,0	0,043	0,421
47,9	0,048	0,469
52,3	0,052	0,513
59,2	0,059	0,580
61,9	0,062	0,607
71,4	0,071	0,700

Table 5: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to $9.8m/s^2$



<u>Graph 3:</u> The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.2236\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ setup\ in\ tap\ water = \frac{0.2236}{600 \times 0.06} = 0.0062\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I}\ value = \frac{|0.2241 - 0.2111|}{2} = 0.006N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.006}{0.2236} \times 100 = 2.68\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength\ = \ 2.68 + 1.67 = 4.35\%$$

$$Absolute\ Uncertainty\ of\ Magnetic\ Feidls\ Strength = 0.0062 \times \frac{4.35}{100} \cong 0.0003T$$

The magnetic field strength around the coil when the setup is placed in the tap water without salt is stated as following;

$$= 0.0062 \pm 0.0003T$$

8.2 Trials in Salty Water with 4g of Salt

In this section data taken from the experiment which is established in tap water with 4g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current(±0.01A)	Change in Mass (±0.1g)	Average Changes in Mass (±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	4,5	4,8
2		5,0	
3		5,0	
1	0,40	8,0	8,7
2		9,0	
3		9,0	
1	0,60	12,5	12,8
2		13,0	
3		13,0	
1	0,80	17,0	17,2
2		17,5	
3		17,0	
1	1,00	21,0	21,2
2		21,5	
3		21,0	
1	1,20	25,0	25,3
2		25,5	
3		25,5	
1	1,40	29,0	29,5

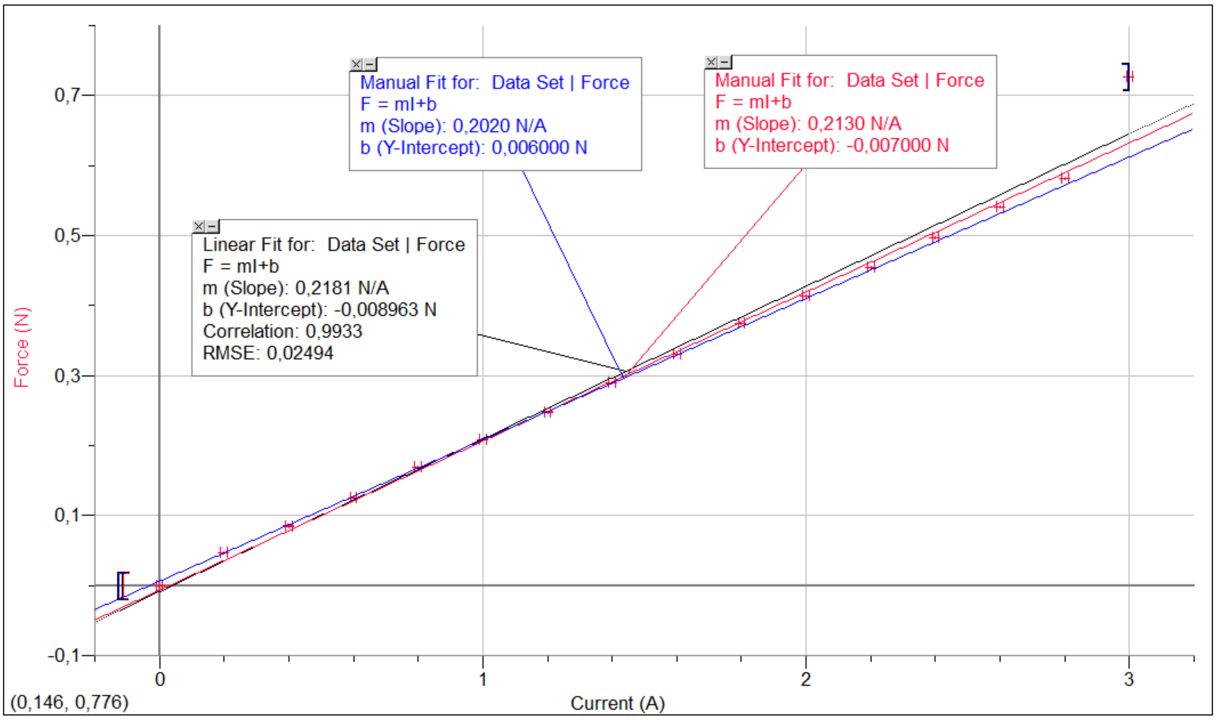
2		30,0	
3		29,5	
1	1,60	33,5	33,8
2		34,0	
3		34,0	
1	1,80	38,0	38,2
2		38,5	
3		38,0	
1	2,00	42,0	42,2
2		42,5	
3		42,0	
1	2,20	46,5	46,3
2		46,5	
3		46,0	
1	2,40	50,5	50,7
2		51,0	
3		50,5	
1	2,60	55,0	55,2
2		55,5	
3		55,0	
1	2,80	59,0	59,3
2		59,5	
3		59,5	
1	3,00	74,0	74,2
2		75,5	
3		73,0	

Table 6: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in	**Change in**	**Magnetic**

Mass(±0.1g)	**Mass(±0.0001kg)**	**Force (0.0001N)**
0,0	0,000	0,000
4,8	0,005	0,047
8,7	0,009	0,085
12,8	0,013	0,125
17,2	0,017	0,169
21,2	0,021	0,208
25,3	0,025	0,248
29,5	0,030	0,289
33,8	0,034	0,331
38,2	0,038	0,374
42,2	0,042	0,414
46,3	0,046	0,454
50,7	0,051	0,497
55,2	0,055	0,541
59,3	0,059	0,581
74,2	0,074	0,727

Table 7: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to 9.8m/s^2



Graph 4: The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.2181\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.2181}{600 \times 0.06} = 0.0060\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I}\ value = \frac{|0.2130 - 0.2020|}{2} = 0.0055N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0055}{0.2181} \times 100 = 2.52\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength\ = 2.52 + 1.67 = 4.19\%$$

$$Absolute\ Uncertainty\ of\ Magnetic\ Field\ Strength = 0.0060 \times \frac{4.19}{100} \cong 0.0002T$$

$$= 0.0060 \pm 0.0002T$$

8.3 Trials in Salty Water with 8g of Salt

In this section data taken from the experiment which is established in tap water with 8g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current(±0.01A)	Change in Mass(±0.1g)	Average Change in Mass(±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	4,5	4,3
2		4,5	
3		4,0	
1	0,40	8,5	8,3
2		8,0	
3		8,5	
1	0,60	12,5	12,5
2		12,5	
3		12,5	
1	0,80	16,5	16,2
2		16,0	
3		16,0	
1	1,00	20,5	20,3
2		20,5	
3		20,0	
1	1,20	25,0	24,7
2		25,0	
3		24,0	
1	1,40	28,5	28,5
2		28,5	

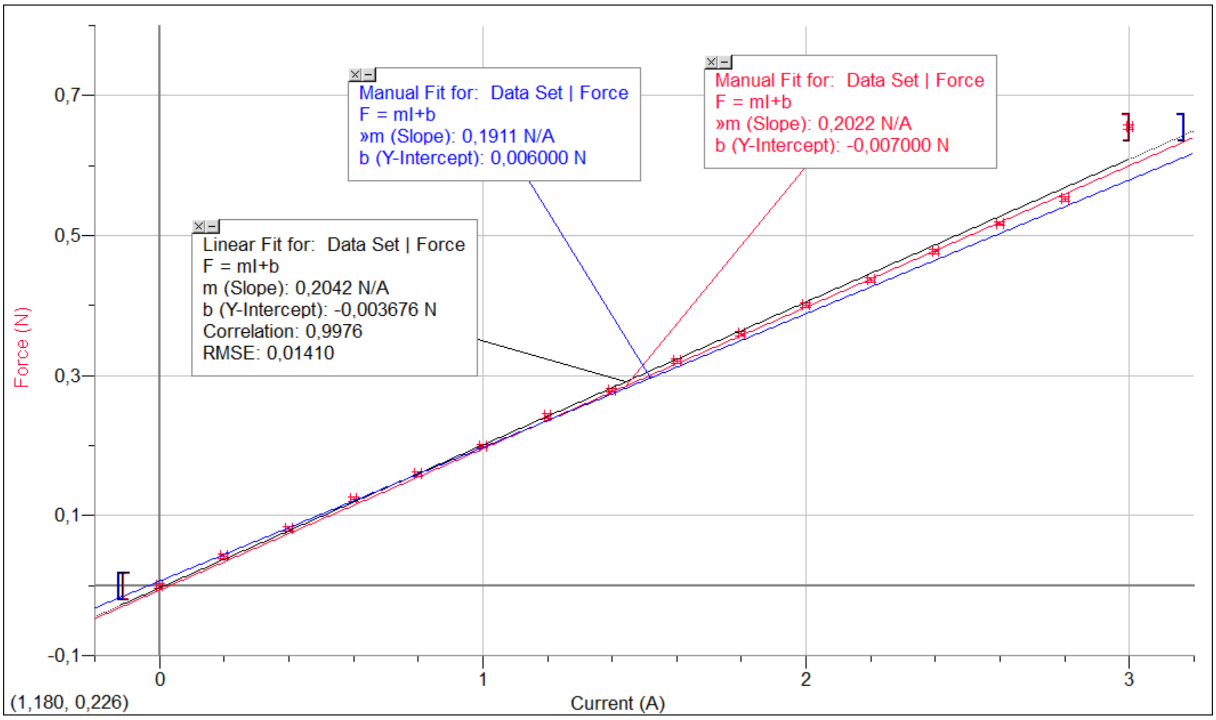
3		28,5	
1	1,60	33,0	32,8
2		33,0	
3		32,5	
1	1,80	37,0	36,7
2		36,5	
3		36,5	
1	2,00	41,0	40,8
2		41,0	
3		40,5	
1	2,20	44,5	44,5
2		44,5	
3		44,5	
1	2,40	49,0	48,7
2		48,5	
3		48,5	
1	2,60	53,0	52,8
2		52,5	
3		53,0	
1	2,80	56,5	56,3
2		56,0	
3		56,5	
1	3,00	69,0	66,8
2		60,5	
3		71,0	

Table 8: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in Mass (±0.1g)	Change in Mass (±0.0001kg)	Magnetic Force

		(0.0001N)
0,0	0,000	0,000
4,3	0,004	0,042
8,3	0,008	0,081
12,5	0,013	0,123
16,2	0,016	0,159
20,3	0,020	0,199
24,7	0,025	0,242
28,5	0,029	0,279
32,8	0,033	0,321
36,7	0,037	0,360
40,8	0,041	0,400
44,5	0,045	0,436
48,7	0,049	0,477
52,8	0,053	0,517
56,3	0,056	0,552
66,8	0,067	0,655

Table 9: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to $9.8 m/s^2$



Graph 5: The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.2042\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.2042}{600 \times 0.06} = 0.0056\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I}\ value = \frac{|0.2022 - 0.1911|}{2} = 0.0056N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0056}{0.2042} \times 100 = 2.74\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength\ = \ 2.74 + 1.67 = 4.41\%$$

$$Absolute\ Uncertainty\ of\ Magnetic\ Field\ Strength = 0.0056 \times \frac{4.41}{100} \cong 0.0002T$$

$$= 0.0056 \pm 0.0002T$$

8.4 Trials in Salty Water with 12g of Salt

In this section data taken from the experiment which is established in tap water with 12g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current (±0.01A)	Change in Mass (±0.1g)	Average Change in Mass (±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	4,0	4,3
2		4,5	
3		4,5	
1	0,40	8,0	7,8
2		8,0	
3		7,5	
1	0,60	12,0	12,0
2		12,0	
3		12,0	
1	0,80	15,5	15,8
2		16,0	
3		16,0	
1	1,00	19,5	19,7
2		20,0	
3		19,5	
1	1,20	23,5	23,3
2		23,5	
3		23,0	
1	1,40	27,5	27,3
2		27,5	

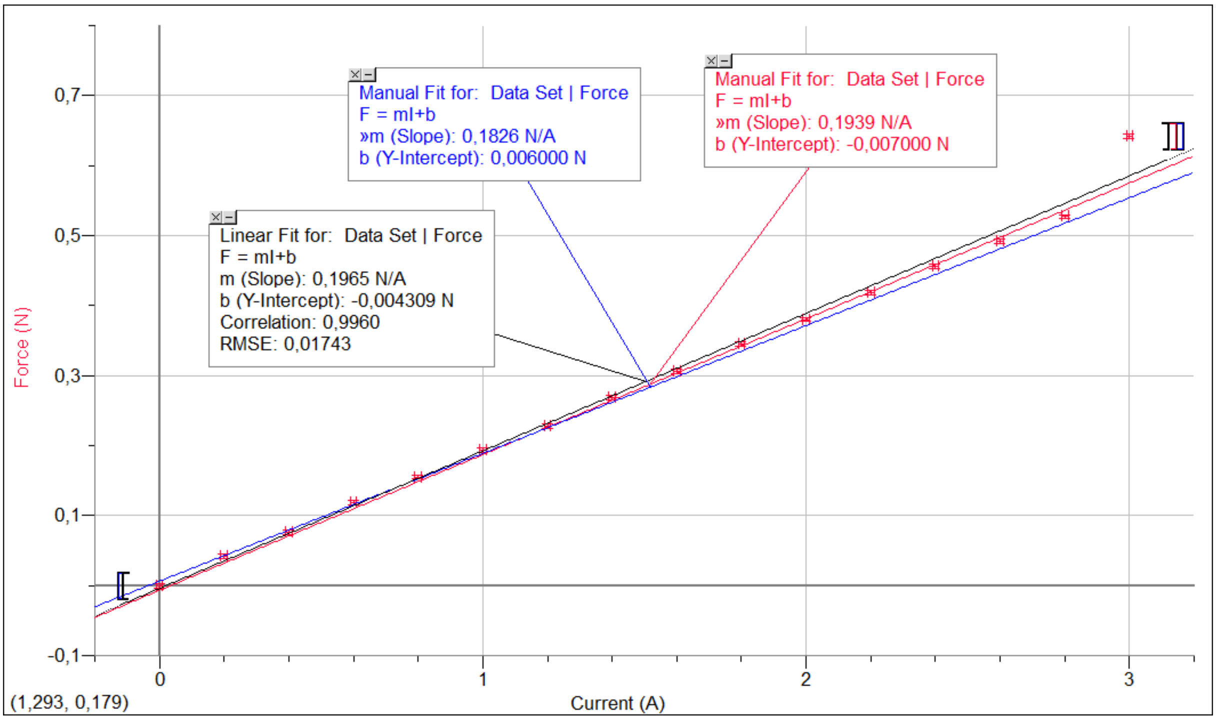
3		27,0	
1	1,60	31,0	31,2
2		31,5	
3		31,0	
1	1,80	35,0	35,2
2		35,5	
3		35,0	
1	2,00	39,0	38,8
2		39,0	
3		38,5	
1	2,20	43,0	42,7
2		42,5	
3		42,5	
1	2,40	47,0	46,5
2		46,5	
3		46,0	
1	2,60	50,5	50,2
2		50,5	
3		49,5	
1	2,80	54,0	53,8
2		54,0	
3		53,5	
1	3,00	66,0	65,5
2		65,5	
3		65,0	

Table 10: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in Mass	**Change in Mass (±0.0001kg)**	**Magnetic Force**

(±0.1g)		(±0.0001N)
0,0	0,000	0,000
4,3	0,004	0,042
7,8	0,008	0,076
12,0	0,012	0,118
15,8	0,016	0,155
19,7	0,020	0,193
23,3	0,023	0,228
27,3	0,027	0,268
31,2	0,031	0,306
35,2	0,035	0,345
38,8	0,039	0,380
42,7	0,043	0,418
46,5	0,047	0,456
50,2	0,050	0,492
53,8	0,054	0,527
65,5	0,066	0,642

Table 11: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to 9.8m/s^2



Graph 6: The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.1965\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.1965}{600 \times 0.06} = 0.0054\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I}\ value = \frac{|0.1939 - 0.1826|}{2} = 0.0056N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0056}{0.1965} \times 100 = 2.85\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength = 2.85 + 1.67 = 4.52\%$$

$$Absolute\ Uncertainty\ of\ Magnetic\ Field\ Strength = 0.0054 \times \frac{4.52}{100} \cong 0.0002T$$

$$= 0.0054 \pm 0.0002T$$

8.5 Trials in Salty Water with 16g of Salt

In this section data taken from the experiment which is established in tap water with 16g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current(±0.01A)	Change in Mass (±0.1g)	Average Change in Mass (±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	4,0	4,0
2		4,0	
3		4,0	
1	0,40	8,0	8,0
2		8,0	
3		8,0	
1	0,60	12,0	12,0
2		12,0	
3		12,0	
1	0,80	16,5	15,8
2		15,5	
3		15,5	
1	1,00	20,5	19,8
2		19,5	
3		19,5	
1	1,20	24,5	23,8
2		23,5	
3		23,5	
1	1,40	28,5	27,8
2		27,5	

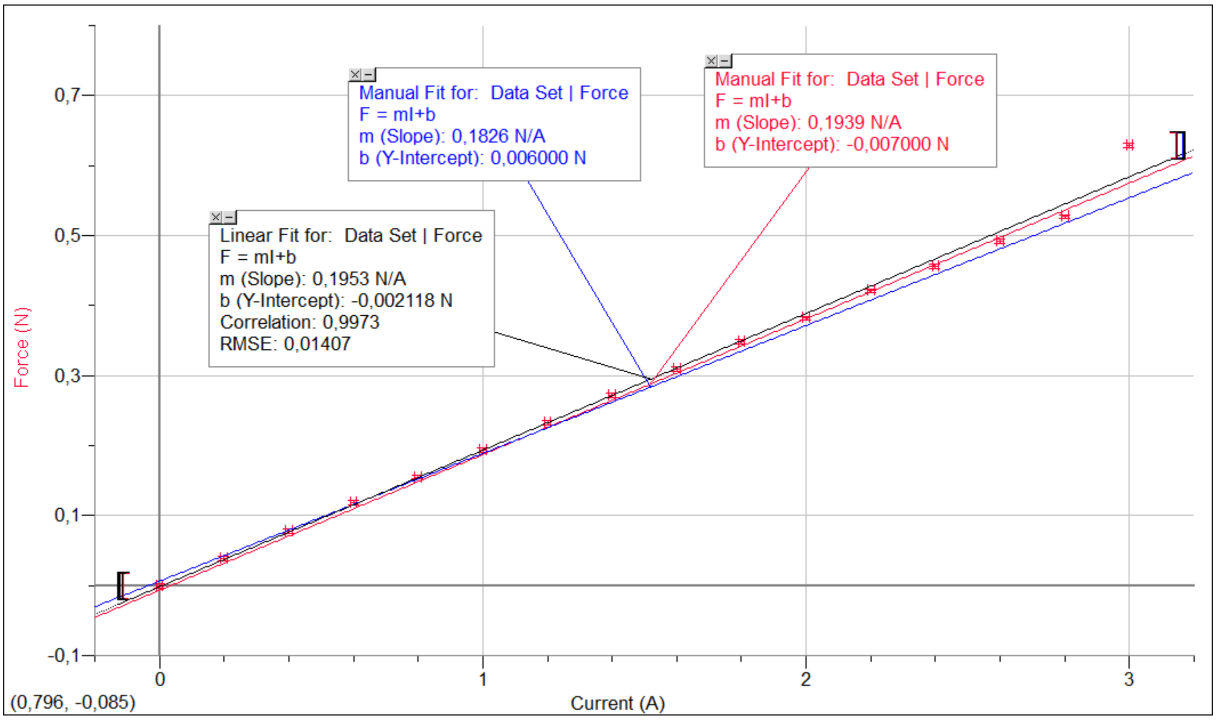
3		27,5	
1	1,60	32,5	31,5
2		31,5	
3		30,5	
1	1,80	36,5	35,5
2		35,5	
3		34,5	
1	2,00	40,0	39,0
2		39,0	
3		38,0	
1	2,20	44,0	43,0
2		43,0	
3		42,0	
1	2,40	47,5	46,5
2		46,5	
3		45,5	
1	2,60	51,5	50,2
2		50,0	
3		49,0	
1	2,80	55,5	53,8
2		53,5	
3		52,5	
1	3,00	65,0	64,2
2		64,5	
3		63,0	

Table 12: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in Mass (±0.1g)	Change in Mass (±0.0001kg)	Magnetic Force

		(0.0001N)
0,0	0,000	0,000
4,0	0,004	0,039
8,0	0,008	0,078
12,0	0,012	0,118
15,8	0,016	0,155
19,8	0,020	0,194
23,8	0,024	0,233
27,8	0,028	0,272
31,5	0,032	0,309
35,5	0,036	0,348
39,0	0,039	0,382
43,0	0,043	0,421
46,5	0,047	0,456
50,2	0,050	0,492
53,8	0,054	0,527
64,2	0,064	0,629

Table 13: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to 9.8m/s^2



Graph 7: The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.1953\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.1953}{600 \times 0.06} = 0.0054\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I}\ value = \frac{|0.1939 - 0.1826|}{2} = 0.0056N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0056}{0.1953} \times 100 = 2.86\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength\ = \ 2.86 + 1.67 = 4.53\%$$

$$Absolute\ Uncertainty\ of\ Magnetic\ Field\ Strength = 0.0054 \times \frac{4.53}{100} \cong 0.0002T$$

$$= 0.0054 \pm 0.0002T$$

8.6 Trials in Salty Water with 20g of Salt

In this section data taken from the experiment which is established in tap water with 20g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current (±0.01A)	Change in Mass (±0.1g)	Average Change in Mass (±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	4,5	4,3
2		4,0	
3		4,5	
1	0,40	8,5	8,0
2		7,5	
3		8,0	
1	0,60	12,5	12,0
2		12,0	
3		11,5	
1	0,80	16,0	15,7
2		15,5	
3		15,5	
1	1,00	20,0	19,7
2		19,5	
3		19,5	
1	1,20	24,5	23,8
2		23,5	
3		23,5	
1	1,40	28,5	28,0
2		27,5	

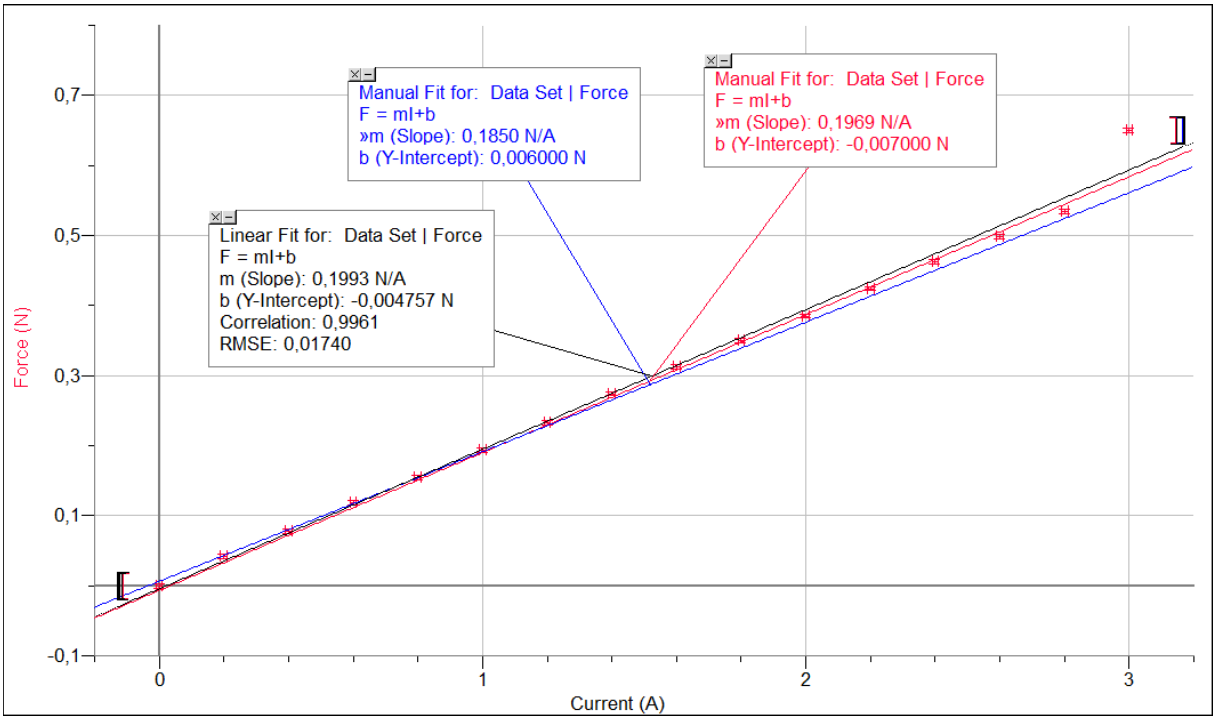
3		28,0	
1	1,60	32,0	31,8
2		31,5	
3		32,0	
1	1,80	36,5	35,7
2		35,0	
3		35,5	
1	2,00	40,0	39,3
2		38,5	
3		39,5	
1	2,20	44,0	43,3
2		42,5	
3		43,5	
1	2,20	48,0	47,2
2		46,5	
3		47,0	
1	2,60	51,5	50,8
2		50,0	
3		51,0	
1	2,80	55,0	54,5
2		54,0	
3		54,5	
1	3,00	67,0	66,3
2		65,5	
3		66,5	

Table 14: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in	Change in Mass (±0.0001kg)	Magnetic Force

Mass(±0.1g)		**(±0.0001N)**
0,0	0,000	0,000
4,3	0,004	0,042
8,0	0,008	0,078
12,0	0,012	0,118
15,7	0,016	0,154
19,7	0,020	0,193
23,8	0,024	0,233
28,0	0,028	0,274
31,8	0,032	0,312
35,7	0,036	0,350
39,3	0,039	0,385
43,3	0,043	0,424
47,2	0,047	0,463
50,8	0,051	0,498
54,5	0,055	0,534
66,3	0,066	0,650

Table 15: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to $9.8 m/s^2$



Graph 8: The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.1993\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.1993}{600 \times 0.06} = 0.0055\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I}\ value = \frac{|0.1969 - 0.1850|}{2} = 0.0060N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0060}{0.1993} \times 100 = 3.01\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength\ = \ 3.01 + 1.67 = 4.68\%$$

$$\text{Absolute Uncertainty of Magnetic Field Strength} = 0.0055 \times \frac{4.68}{100} \cong 0.0003T$$

$$= 0.0055 \pm 0.0003T$$

8.7 Trials in Salty Water with 24g of Salt

In this section data taken from the experiment which is established in tap water with 24g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current(±0.01A)	Change in Mass(±0.1g)	Average Change in Mass(±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	3,5	3,7
2		3,5	
3		4,0	
1	0,40	7,5	7,3
2		7,0	
3		7,5	
1	0,60	11,5	11,5
2		11,0	
3		12,0	
1	0,80	15,5	15,5
2		15,0	
3		16,0	
1	1,00	19,5	19,3
2		19,0	
3		19,5	
1	1,20	23,5	23,2
2		23,0	
3		23,0	
1	1,40	27,0	27,2
2		27,0	

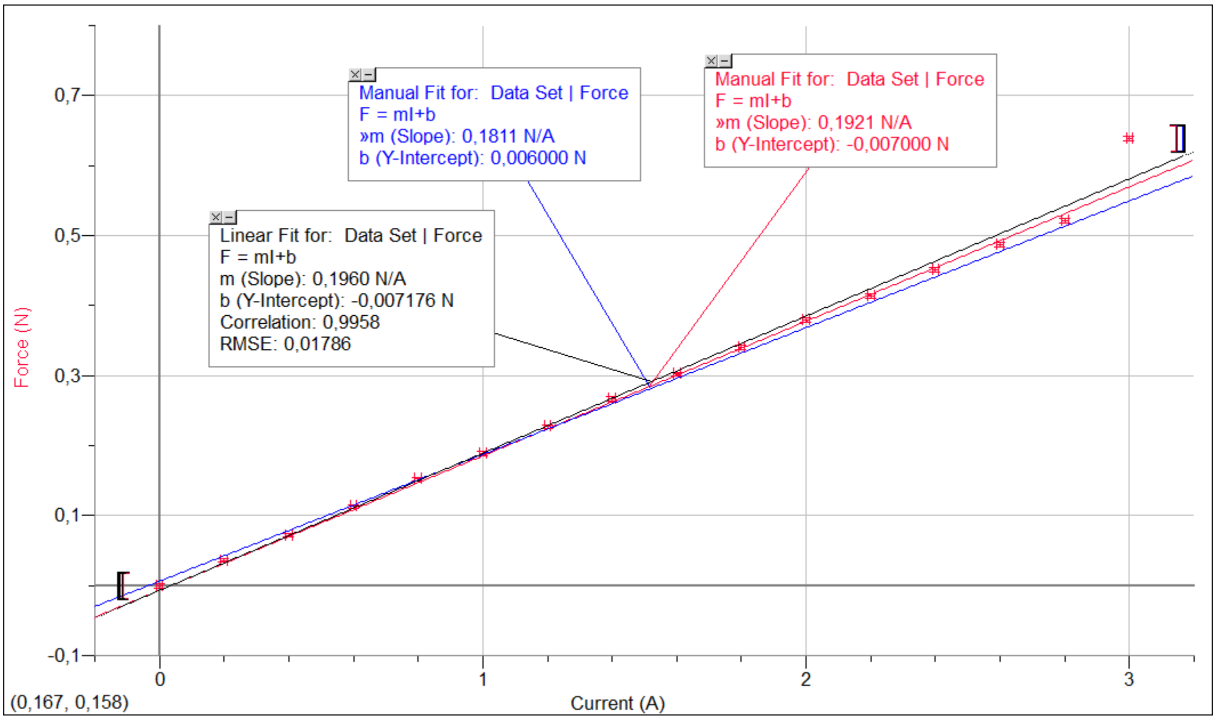
3		27,5	
1	1,60	31,0	30,8
2		30,5	
3		31,0	
1	1,80	35,0	34,7
2		34,0	
3		35,0	
1	2,00	39,0	38,7
2		38,5	
3		38,5	
1	2,20	42,5	42,2
2		42,0	
3		42,0	
1	2,40	46,5	46,0
2		45,5	
3		46,0	
1	2,60	50,0	49,7
2		49,5	
3		49,5	
1	2,80	53,5	53,2
2		53,0	
3		53,0	
1	3,00	65,0	65,2
2		65,0	
3		65,5	

Table 16: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in Mass	Change in Mass (±0.0001kg)	Magnetic Force

(±0.1g)		**(±0.0001N)**
0,0	0,000	0,000
3,7	0,004	0,036
7,3	0,007	0,072
11,5	0,012	0,113
15,5	0,016	0,152
19,3	0,019	0,189
23,2	0,023	0,227
27,2	0,027	0,267
30,8	0,031	0,302
34,7	0,035	0,340
38,7	0,039	0,379
42,2	0,042	0,414
46,0	0,046	0,451
49,7	0,050	0,487
53,2	0,053	0,521
65,2	0,065	0,639

Table 17: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to 9.8m/s^2



Graph 9: The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.1960\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.1960}{600 \times 0.06} = 0.0054\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I} = \frac{|0.1921 - 0.1811|}{2} = 0.0055N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0055}{0.1960} \times 100 = 2.81\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength\ = \ 2.81 + 1.67 = 4.48\%$$

$$Absolute\ Error = 0.0054 \times \frac{4.48}{100} \cong 0.0002T$$

$$= 0.0054 \pm 0.0002T$$

8.8 Trials in Salty Water with 28g of Salt

In this section data taken from the experiment which is established in tap water with 28g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current (±0.01A)	Change in Mass(±0.1g)	Average Change in Mass(±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	4,0	3,7
2		3,5	
3		3,5	
1	0,40	7,0	7,0
2		7,0	
3		7,0	
1	0,60	10,5	10,7
2		11,0	
3		10,5	
1	0,80	14,5	14,5
2		14,5	
3		14,5	
1	1,00	18,0	18,0
2		18,0	
3		18,0	
1	1,20	21,5	21,8
2		22,0	
3		22,0	
1	1,40	25,5	25,3
2		25,5	

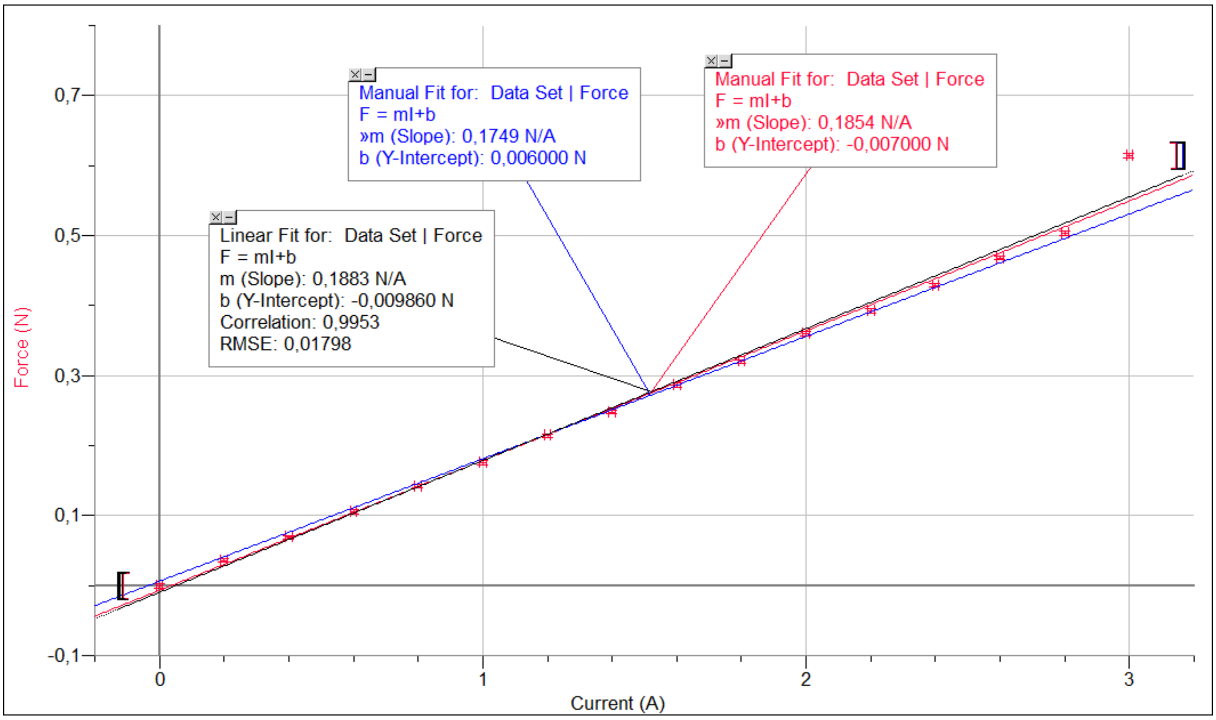
3		25,0	
1	1,60	29,0	29,2
2		29,5	
3		29,0	
1	1,82	32,5	32,7
2		33,0	
3		32,5	
1	2,00	36,5	36,7
2		37,0	
3		36,5	
1	2,20	40,0	40,0
2		40,0	
3		40,0	
1	2,40	43,5	43,8
2		44,5	
3		43,5	
1	2,60	47,5	47,8
2		48,0	
3		48,0	
1	2,80	51,0	51,3
2		51,5	
3		51,5	
1	3,00	62,5	62,7
2		63,0	
3		62,5	

Table 18: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in	**Change in Mass (±0.0001kg)**	**Magnetic Force**

Mass(±0.1g)		(±0.0001N)
0,0	0,000	0,000
3,7	0,004	0,036
7,0	0,007	0,069
10,7	0,011	0,105
14,5	0,015	0,142
18,0	0,018	0,176
21,8	0,022	0,214
25,3	0,025	0,248
29,2	0,029	0,286
32,7	0,033	0,320
36,7	0,037	0,360
40,0	0,040	0,392
43,8	0,044	0,429
47,8	0,048	0,468
51,3	0,051	0,503
62,7	0,063	0,614

Table 19: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to $9.8m/s^2$



<u>Graph 10:</u> The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.1883\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.1883}{600 \times 0.06} = 0.0052\ \frac{N}{A.m}$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{|0.1854 - 0.1749|}{2} = 0.0052N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0052}{0.1883} \times 100 = 2.76\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength\ = 2.76 + 1.67 = 4.43\%$$

$$Absolute\ Uncertainty = 0.0052 \times \frac{4.43}{100} \cong 0.0002T$$

$$= 0.0052 \pm 0.0002T$$

8.9 Trials in Salty Water with 32g of Salt

In this section data taken from the experiment which is established in tap water with 32g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current(±0.01A)	Change in Mass(±0.1g)	Average Change in Mass(±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	4,5	4,0
2		4,0	
3		3,5	
1	0,40	8,0	7,8
2		7,5	
3		8,0	
1	0,60	11,0	11,7
2		12,0	
3		12,0	
1	0,80	15,5	15,3
2		15,0	
3		15,5	
1	1,00	19,0	19,5
2		20,0	
3		19,5	
1	1,20	23,0	23,3
2		24,0	
3		23,0	
1	1,40	27,5	27,3
2		27,5	

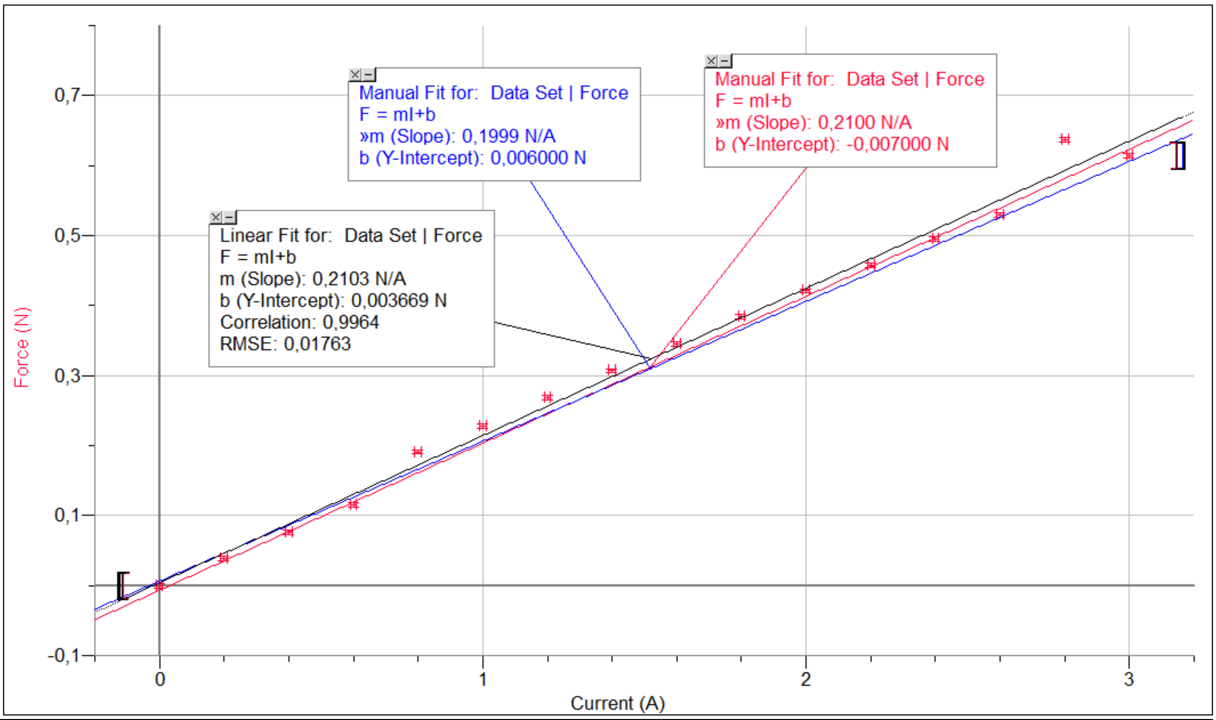
3		27,0	
1	1,60	31,5	31,3
2		31,5	
3		31,0	
1	1,80	35,5	35,2
2		35,0	
3		35,0	
1	2,00	39,5	39,2
2		39,5	
3		38,5	
1	2,20	43,5	43,0
2		43,0	
3		42,5	
1	2,40	47,5	46,7
2		46,5	
3		46,0	
1	2,60	51,5	50,5
2		50,5	
3		49,5	
1	2,80	55,0	54,0
2		53,5	
3		53,5	
1	3,00	66,5	65,0
2		64,0	
3		64,5	

Table 20: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in	**Change in Mass**	**Magnetic Force**

Mass(±0.1g)	(±0.0001kg)	(±0.0001N)
0,0	0,000	0,000
4,0	0,004	0,039
7,8	0,008	0,076
11,7	0,012	0,115
19,5	0,020	0,191
23,3	0,023	0,228
27,3	0,027	0,268
31,3	0,031	0,307
35,2	0,035	0,345
39,2	0,039	0,384
43,0	0,043	0,421
46,7	0,047	0,458
50,5	0,051	0,495
54,0	0,054	0,529
65,0	0,065	0,637

Table 21: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to 9.8m/s^2



Graph 11: The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.2103\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.2103}{600 \times 0.06} = 0.0058\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I} = \frac{|0.2100 - 0.1999|}{2} = 0.0050N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0050}{0.2103} \times 100 = 2.38\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength = 2.38 + 1.67 = 4.05\%$$

$$Absolute\ Uncertainty = 0.0058 \times \frac{4.05}{100} \cong 0.0002T$$

$$= 0.0058 \pm 0.0002T$$

8.10 Trials in Salty Water with 36g of Salt

In this section data taken from the experiment which is established in tap water with 36g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current(±0.01A)	Change in Mass(±0.1g)	Average Change in Mass(±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	4,0	3,8
2		3,5	
3		4,0	
1	0,40	7,5	7,3
2		7,5	
3		7,0	

1	0,60	11,5	11,2
2		11,0	
3		11,0	
1	0,80	15,0	14,7
2		14,5	
3		14,5	
1	1,00	19,0	18,7
2		18,5	
3		18,5	
1	1,20	23,0	22,3
2		22,0	
3		22,0	
1	1,40	26,5	26,2
2		26,0	
3		26,0	
1	1,60	30,0	29,7
2		29,5	
3		29,5	
1	1,80	33,5	33,2
2		33,0	
3		33,0	
1	2,00	37,5	36,5
2		37,0	
3		35,0	
1	2,20	41,0	39,8
2		40,5	
3		38,0	
1	2,40	42,5	42,3
2		43,5	
3		41,0	

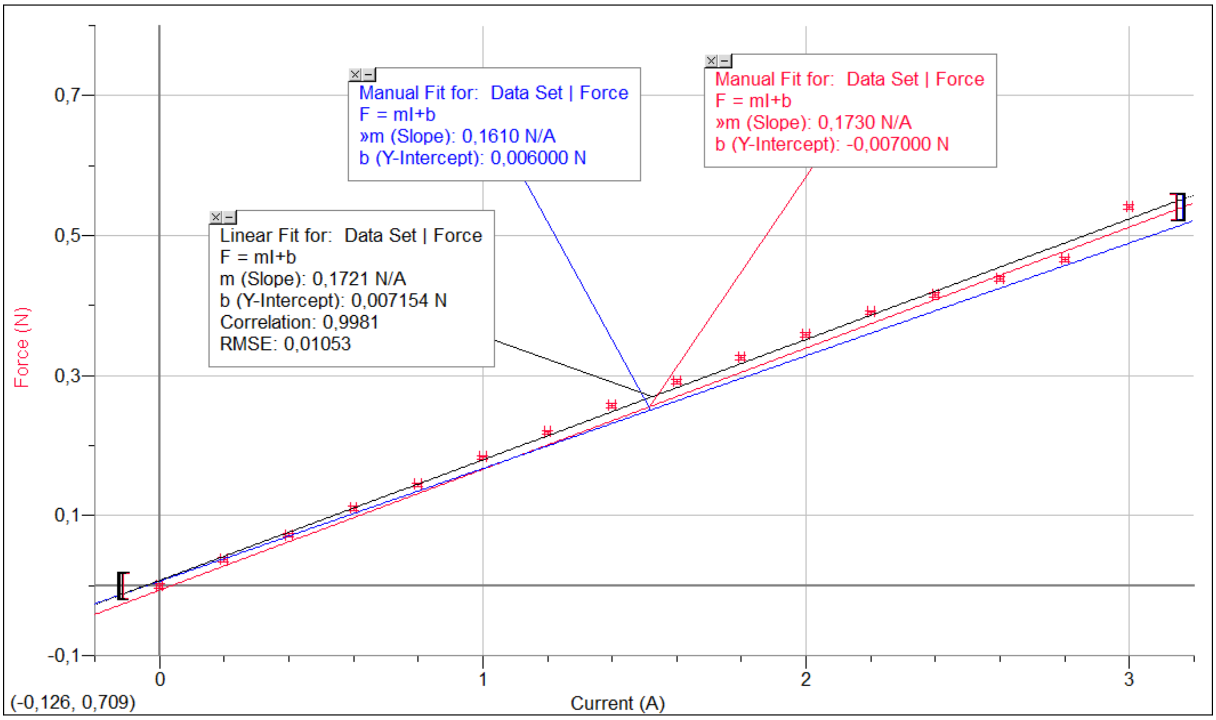
1	2,60	44,5	44,7
2		45,5	
3		44,0	
1	2,80	48,0	47,5
2		48,0	
3		46,5	
1	3,00	55,5	55,2
2		56,0	
3		54,0	

Table 22: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in Mass(±0.1g)	Change in Mass (±0.0001kg)	Magnetic Force (±0.0001N)
0,0	0,000	0,000
3,8	0,004	0,037
7,3	0,007	0,072
11,2	0,011	0,110
14,7	0,015	0,144
18,7	0,019	0,183
22,3	0,022	0,219
26,2	0,026	0,257
29,7	0,030	0,291
33,2	0,033	0,325
36,5	0,037	0,358
39,8	0,040	0,390
42,3	0,042	0,415
44,7	0,045	0,438
47,5	0,048	0,466

55,2	0,055	0,541

Table 23: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to 9.8m/s^2



Graph 12: The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.1721\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.1721}{600 \times 0.06} = 0.0047\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I} = \frac{|0.1730 - 0.1610|}{2} = 0.0060N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0060}{0.1721} \times 100 = 3.49\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength\ = \ 3.49 + 1.67 = 5.16\%$$

$$Absolute\ Uncertainty = 0.0047 \times \frac{5.16}{100} \cong 0.0002T$$

$$= 0.0047 \pm 0.0002T$$

8.11 Trials in Salty Water with 40g of Salt

In this section data taken from the experiment which is established in tap water with 40g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current(±0.01A)	Change in Mass(±0.1g)	Average Change in Mass(±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	3,5	3,8
2		4,0	
3		4,0	
1	0,40	7,0	7,3
2		7,5	
3		7,5	
1	0,60	11,0	11,3
2		11,5	
3		11,5	
1	0,80	14,5	14,7
2		14,5	
3		15,0	
1	1,00	18,0	18,3
2		18,5	
3		18,5	
1	1,20	21,5	22,0
2		22,0	
3		22,5	
1	1,40	25,5	25,8
2		26,0	

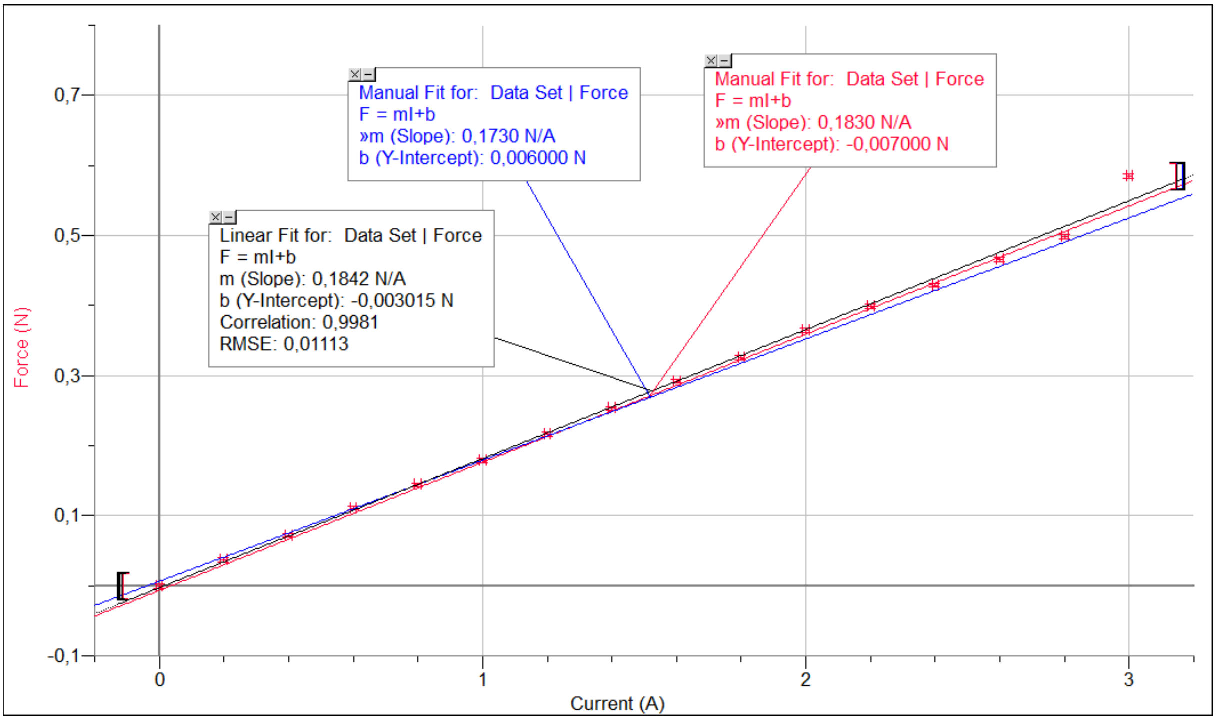
3		26,0	
1	1,60	29,5	29,8
2		30,0	
3		30,0	
1	1,80	33,0	33,3
2		33,5	
3		33,5	
1	2,00	37,0	37,2
2		37,0	
3		37,5	
1	2,20	40,0	40,7
2		41,0	
3		41,0	
1	2,40	43,5	43,8
2		44,0	
3		44,0	
1	2,60	47,0	47,5
2		47,5	
3		48,0	
1	2,80	50,5	50,8
2		50,5	
3		51,5	
1	3,00	59,0	59,7
2		59,5	
3		60,5	

Table 24: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in	Change in Mass	Magnetic Force

Mass(±0.1g)	(±0.0001kg)	(±0.0001N)
0,0	0,000	0,000
3,8	0,004	0,037
7,3	0,007	0,072
11,3	0,011	0,111
14,7	0,015	0,144
18,3	0,018	0,179
22,0	0,022	0,216
25,8	0,026	0,253
29,8	0,030	0,292
33,3	0,033	0,326
37,2	0,037	0,365
40,7	0,041	0,399
43,8	0,044	0,429
47,5	0,048	0,466
50,8	0,051	0,498
59,7	0,060	0,585

Table 25: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to $9.8 m/s^2$



<u>Graph 13:</u> The magnetic force(N) exerted on the coil depending on current (A) passing through it

$$Slope\ of\ best\ fit\ line = 0.1842\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.1842}{600 \times 0.06} = 0.0051\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I}\ = \frac{|0.1830 - 0.1730|}{2} = 0.0050N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0050}{0.1842} \times 100 = 2.71\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength\ =\ 2.71 + 1.67 = 4.38\%$$

$$Absolute\ Uncertainty = 0.0051 \times \frac{4.38}{100} \cong 0.0002T$$

$$= 0.0051 \pm 0.0002T$$

8.12 Trials in Salty Water with 44g of Salt

In this section data taken from the experiment which is established in tap water with 44g of salt are shown. Different magnetic forces for different current values are calculated and represented below.

Trials	Current(±0.01A)	Change in Mass(±0.1g)	Average Change in Mass(±0.1g)
1	0,00	0,0	0,0
2		0,0	
3		0,0	
1	0,20	4,0	3,7
2		3,5	
3		3,5	
1	0,40	7,5	7,3
2		7,5	
3		7,0	
1	0,60	11,5	11,2
2		11,0	
3		11,0	
1	0,80	15,0	14,7
2		14,5	
3		14,5	
1	1,00	19,0	18,5
2		18,5	
3		18,0	
1	1,20	22,0	21,7
2		21,5	
3		21,5	
1	1,40	25,0	25,0
2		25,0	

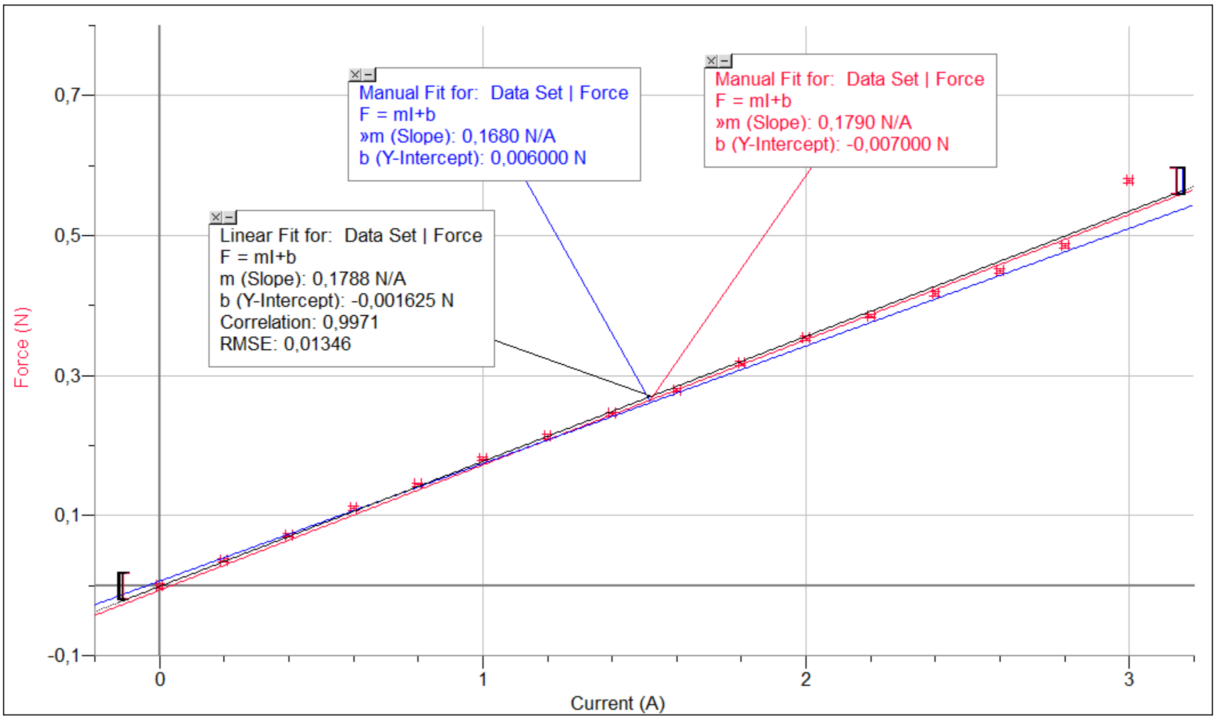
3		25,0	
1	1,60	29,0	28,5
2		28,5	
3		28,0	
1	1,80	33,0	32,3
2		32,0	
3		32,0	
1	2,00	37,0	36,0
2		35,5	
3		35,5	
1	2,20	40,0	39,3
2		39,0	
3		39,0	
1	2,40	43,0	42,5
2		42,5	
3		42,0	
1	2,60	46,5	45,8
2		45,5	
3		45,5	
1	2,80	50,0	49,5
2		49,5	
3		49,0	
1	3,00	60,0	59,0
2		59,0	
3		58,0	

Table 26: Change in the value read on electronic scale (g)(caused by magnetic effects) depending on the current passing through coil

Average of Change in	**Change in Mass (±0.0001kg)**	**Magnetic Force**

Mass(±0.1g)		**(±0.0001N)**
0,0	0,000	0,000
3,7	0,004	0,036
7,3	0,007	0,072
11,2	0,011	0,110
14,7	0,015	0,144
18,5	0,019	0,181
21,7	0,022	0,213
25,0	0,025	0,245
28,5	0,029	0,279
32,3	0,032	0,317
36,0	0,036	0,353
39,3	0,039	0,385
42,5	0,043	0,417
45,8	0,046	0,449
49,5	0,050	0,485
59,0	0,059	0,578

Table 27: Unit conversion of change in mass of the system from gram to kilogram and force calculation by multiplying by gravitational acceleration constant which is equal to $9.8m/s^2$



<u>Graph 14:</u> The magnetic force (N) depending on current (A) passing through the wire

$$Slope\ of\ best\ fit\ line = 0.1788\frac{N}{A}$$

$$Magnetic\ field\ strength\ of\ the\ system\ with\ water = \frac{0.1788}{600 \times 0.06} = 0.0049\ \frac{N}{A.m}$$

$$Absolute\ Uncertainty\ of\ \frac{F}{I} = \frac{|0.1790 - 0.1680|}{2} = 0.0055N/A$$

$$Percentage\ Uncertainty\ of\ \frac{F}{I} = \frac{0.0055}{0.1788} \times 100 = 3.08\%$$

$$Percentage\ Error\ of\ Magnetic\ Field\ Strength\ = \ 3.08 + 1.67 = 4.75\%$$

$$Absolute\ Uncertainty = 0.0049 \times \frac{4.75}{100} \cong 0.0002T$$

$$= 0.0049 \pm 0.0002T$$

9 References

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