ELECTROMAGNETISM

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Aim:

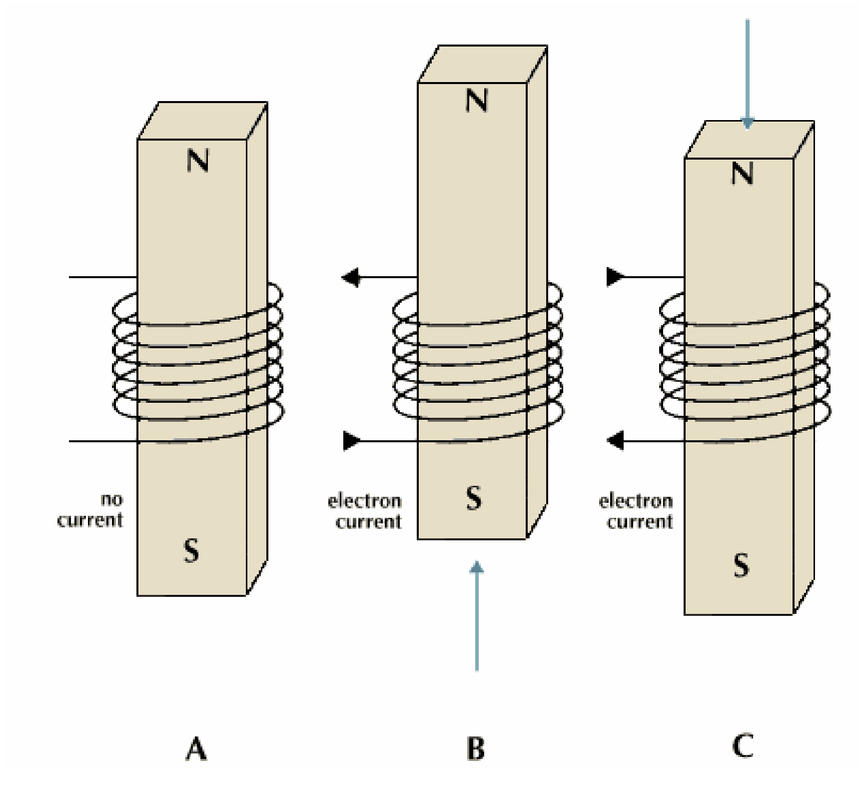
The aim of this experiment is to investigate what factors affect the strength of a magnetic field.

Predictions:

Michael Faraday, the English scientist, and Joseph Henry of the United States independently showed in 1831 that moving a magnet through coils of wire would generate a current in the wire. If the magnet was plunged into the coil, current flowed one way. When the magnet was removed, the current direction was reversed. This phenomenon is called electromagnetic induction, and it is the principle underlying the operation of the generator. As long as the magnet and the coil move relative to each other, a potential difference is produced across the coil and current flows in the coil. A potential difference is also produced if the magnetic field through the coil grows stronger or weaker. The greater the rate at which the magnetic flux through the coil changes, the greater the potential difference produced. The key is that the magnetic field through the coil must be changing.

In 1864 James Clerk Maxwell suggested: (1) if an electric field changes with time, a magnetic field is induced at right angles to the changing electric field. The greater the rate at which the electric field changes, the stronger the induced magnetic field. (2) If a magnetic field changes with time, an electric field is induced at right angles to the changing magnetic field. The greater the rate at which the magnetic field changes, the stronger the induced electric field.

Lenz's law. Whenever a changing magnetic field generates a current in a coil of wires, the current produced will generate a magnetic field. That induced magnetic field will always tend to oppose the original change in the magnetic flux through the coil. This rule was first suggested by Heinrich F.E. Lenz of Germany in 1834. The effects of the induced field can be observed during the operation of a hand-cranked generator. When the generator is cranked slowly, little current is produced and weak electromagnetic forces oppose the rotation. But as the cranking rate is increased and more current is produced, the forces on the rotating loop become stronger, and the loop is correspondingly more difficult to turn.



No electric current is induced when magnet A is at rest with respect to the loop. When magnet B is pushed up through the loop, a current is induced. When magnet C is dropped through the loop, current is induced in the opposite direction.
I predict that the electromagnet force will be at its greatest with the most coils and the force will decrease as you lower the number of coils.

Apparatus:

- Power Pack
- Variable resister
- Soft iron core
- Thin wire (solenoid)
- Small nails
- Scale

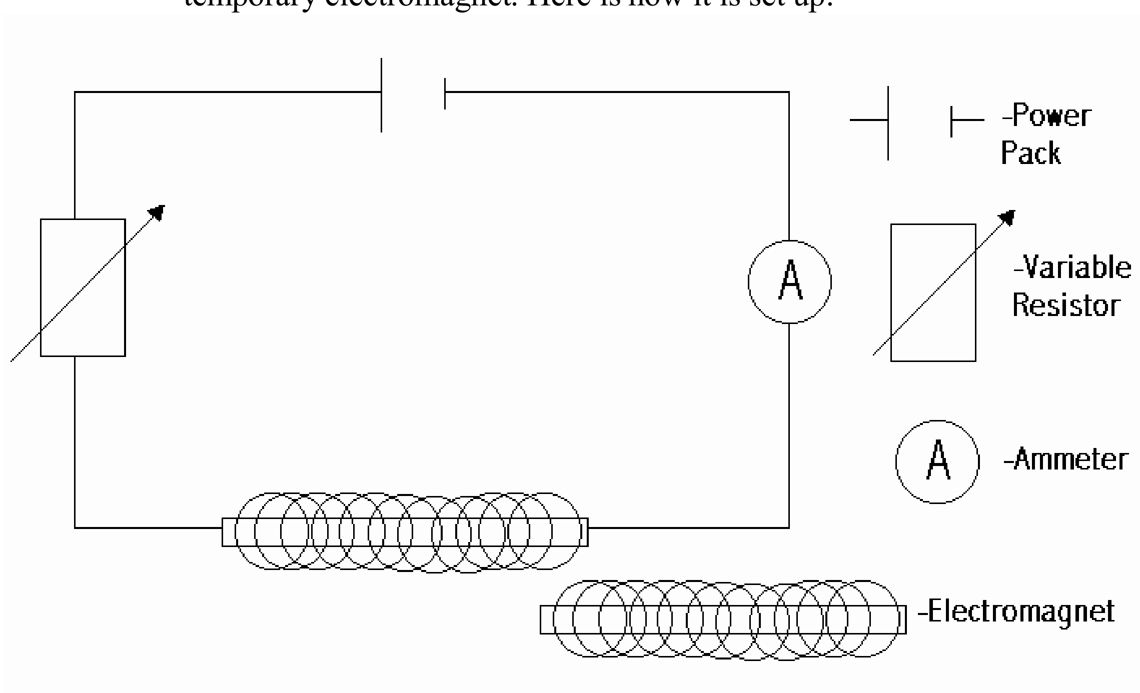
Method:

As the objective of this investigation is to study the effect of the number of coils on the strength of the electromagnet, only one factor can be varied i.e. the independent variable which in this experiment is the number of coils while the remaining factors are kept constant to ensure accuracy of results. Initially all the different variables involved are identified as constant, dependent or independent. Voltage at 4volts, current 2.69 amps and the resistance at 1.49 ohms are kept constant. The resistance is worked out using a simple equation:

Resistance = Voltage/Current or R = V/I

Consequently the values of the current and the resistance depend on the voltage.
The details of how the circuit is set up are given below:

An insulated wire of a known length is wrapped around a soft iron core with a specific number of coils, which will act as a temporary electromagnet. Here is how it is set up:



The power pack is switched on and set up on 4 volts. It is then connected to the variable resistor at one end while another connection is made to the ammeter. To complete the circuit the ammeter is then connected to one end of the solenoid and the other end of the solenoid is connected to the variable resistor. The circuit is now complete as shown below:

Initially the solenoid is wrapped around the soft iron core with 120 coils followed by a decrease 10 coils thereafter. The power is switched on; the mass of small nails is gathered beneath iron core with solenoid wrapped around it (T. Electromagnet), the iron core will pick up a certain mass of the small nails. The power is switched off while the mass of the nails picked up is measured on an electric scale. This procedure is repeated for all the remaining number of coils. The results are recorded in a table

Preliminary Experiment:

Before conducting the real experiment a preliminary experiment must be carried out. It is essential to know how to set the apparatus up and to prevent any errors occurring. Instead of starting with 120 coils, the experiment is started with 47 and is decreased each time by 5 coils.

Results table for preliminary experiment: (table 1)

No. of coils	*Mass picked up (g)*
47	1.29
42	1.15
37	0.77
32	0.63
27	0.57
22	0.41
17	0.33
12	0.21

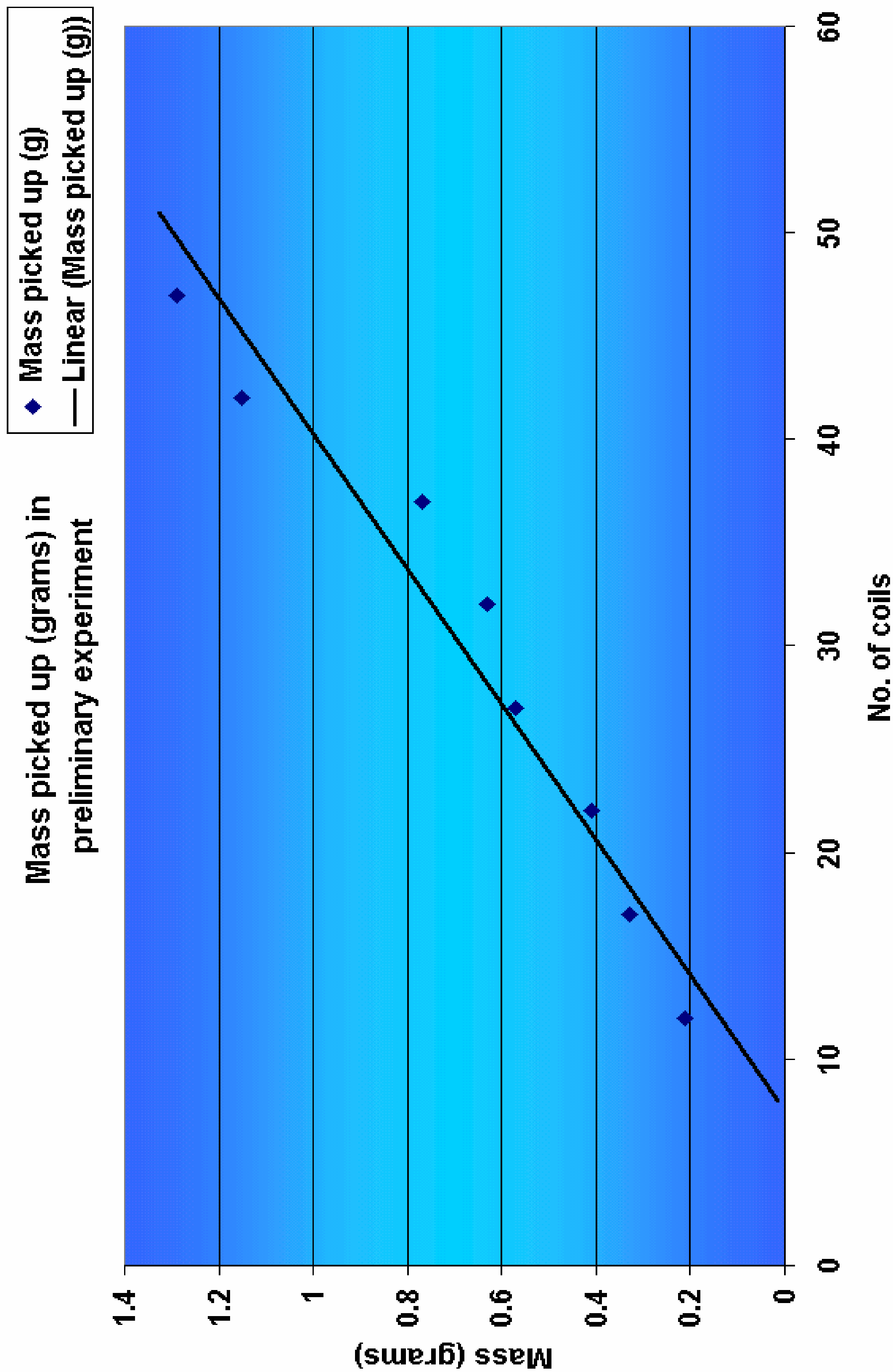
Table 1 shows the relationship between the number of coils and mass picked up in grams by the temporary electromagnet.

Results Table: (table 2)

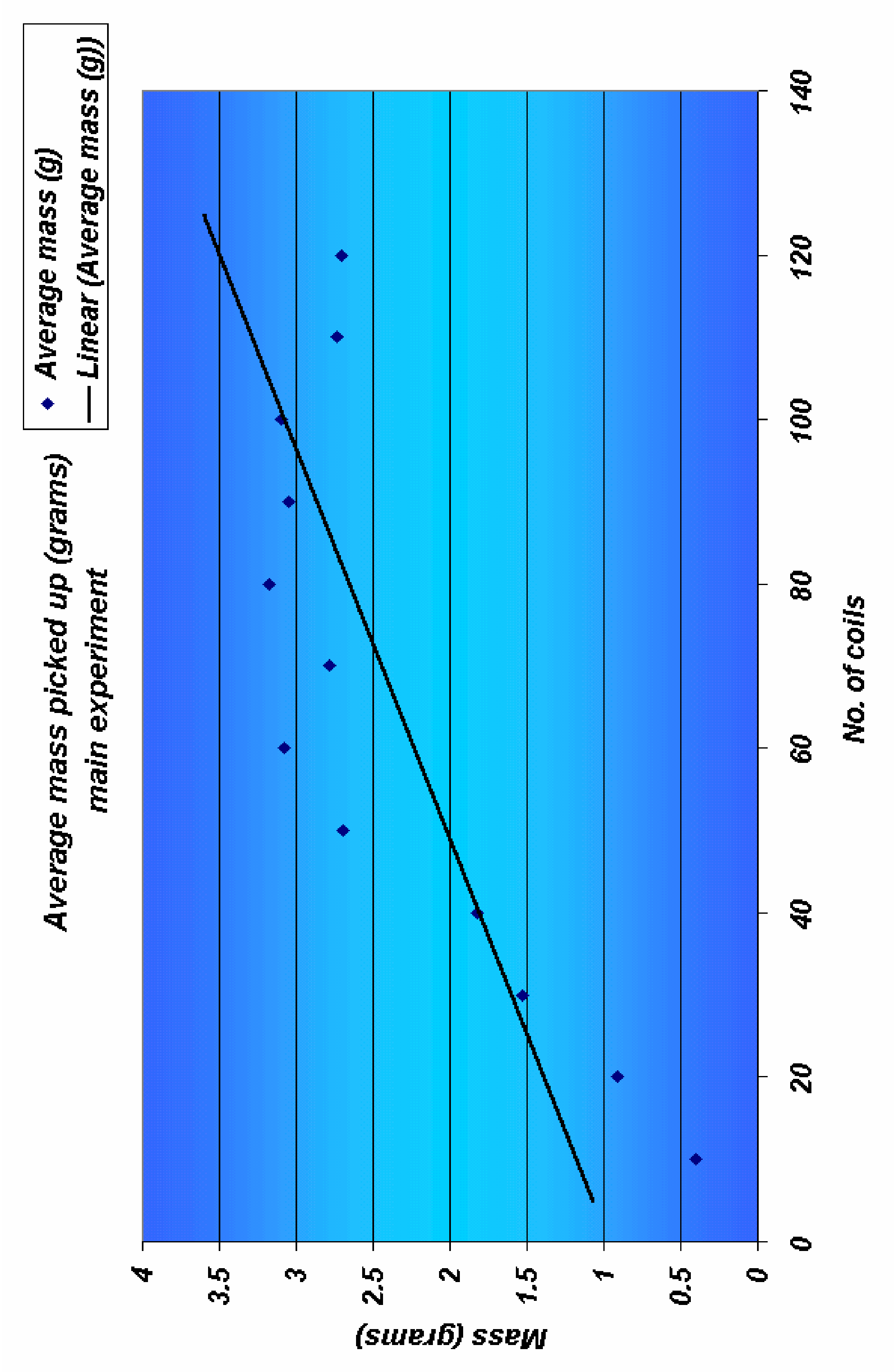
No. of coils	*Mass of nails in 1st trial (g)*	*Mass of nails in 2nd trial (g)*	*Mass of nails in 3rd trial(g)*	*Average mass (g)*
120	2.70	2.74	2.72	2.71
110	2.93	2.62	2.67	2.74
100	3.01	3.15	3.15	3.10
90	2.98	3.05	3.14	3.05
80	3.22	3.22	3.12	3.18
70	2.88	2.61	2.87	2.78
60	3.08	3.08	3.10	3.08
50	2.70	2.79	2.32	2.70
40	1.75	1.67	2.06	1.82
30	1.75	1.40	1.39	1.53
20	1.80	0.87	0.86	0.91
10	1.01	0.40	0.27	0.40

This is the results of Table 2. There are four sets of readings because three for each number of coils which are repeated for accuracy purposes.

Preliminary experiment graph: (table 1)



Main experiment graph: **(table 2)**



Conclusion:

Preliminary Experiment

The graph shows the number of coils and the mass picked up in grams by the electromagnet. Then linear line shows the average mass picked up. Some of the readings that were given (according to the linear) are too high or too low. For example:

1. The 37th coil reads as 0.77g but if the linear is used it should have been 0.90g.
2. The 12th coil read as 0.21g but if the linear is used it should have been 0.15g.

From this graph predictions can also be made using the linear line. Here are some predictions:

1. 25 coils would have picked up 0.55g
2. 30 coils would have picked up 0.63g
3. 50 coils would have picked up 1.32g
4. 5 coils would have picked up 0.00g

The linear line shows that as the coils increase the amount of mass picked up will increase as well. This means that if the number of coils was 100 the mass picked up would be around 2.00g.

There is also a pattern in the graph, the number of coils you start with 14 coils which picks up 0.2g in order to find how many coils are needed to pick up 0.4g, 6 more coils are needed and this is done for every time the mass increase by 0.2g. Here is a formula which gives an estimate of the mass picked up:

Mass picked up = $n \div 50$ (n is the number of coils)

Main experiment

The graph shows the number of coils and the mass picked up in grams by the electromagnet. Then linear line shows the average mass picked up. Some of the readings that were given (according to the linear) are too high or too low. For example:

1. The 60th coil reads as 3.08g which is too high but if the linear is used it should have been 2.3g.
2. The 120th coil read as 2.71g which is too low but if the linear is used it should have been 3.5g.

From this graph predictions can also be made using the linear line. Here are some predictions:

1. 125 coils would have picked up 3.6g
2. 38 coils would have picked up 1.53g
3. 82 coils would have picked up 2.53g
4. 63 coils would have picked up 2.4g

The linear line shows that as the coils increase the amount of mass picked up will increase as well. This means that if the number of coils was 140 the mass picked up would be around 4g.