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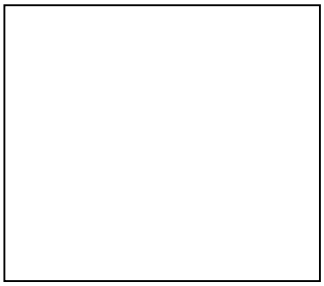
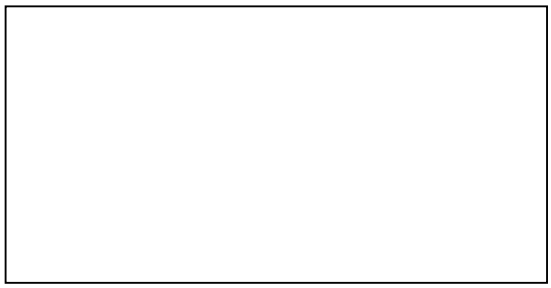
The Electromagnet

Aim: To find out what factors affect the strength of an electromagnet.



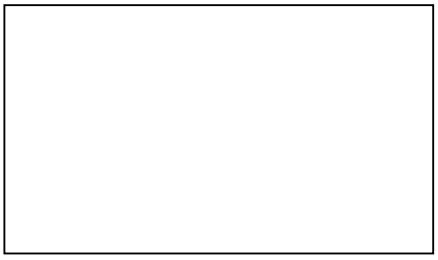


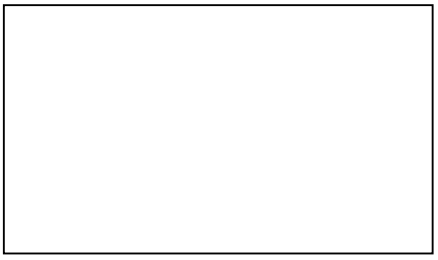
In 1831, an English scientist called Michael Faraday and Joseph Henry from USA both separately showed that moving a magnet through coils of wire would generate a current flowing through the wire. If this magnet was thrust into the coil of wires, current flows in one direction but if it was taken out, the direction of current is reversed. This is called **electromagnet induction**.

Electromagnets are solenoid (coil of wire) with a piece of iron inside. We say that this iron is 'soft.' This means that it changes easily between being magnetised and demagnetised. Electromagnets become a magnet with the use of electric current flowing through them. This means the 'soft' iron is ideal for electromagnets, as they are constantly turned on and off.

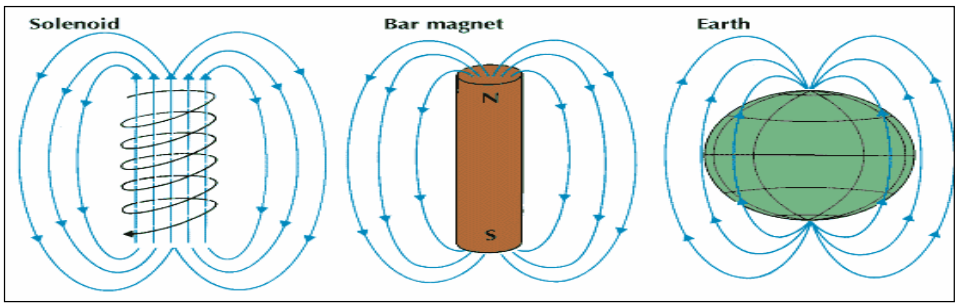
In contrast, steel is magnetically 'hard' so it is therefore suitable for permanent magnets. The material holds on to its magnetism, which means it will be hopeless as an electromagnet but ideal for what a permanent magnet needs.

The magnetic field around an electromagnet is similar to that around a bar magnet but this one can be made stronger. This means that the ends of the solenoid act like the South Pole and North Pole of a bar magnet, incidentally. When the direction of the current is reversed, the North and South Poles will also reverse.





The diagrams above show that if the direction of the current is clock-wise, it is a South Pole and similarly if the direction is anti-clockwise, it is a North Pole.



Today, electromagnets are used for very useful things around the world that would be much harder without the use of them. The photograph below shows a powerful electromagnet lifting a 400-pound block of scrap steel onto a railroad car. The crane on which it is mounted can lift up to ten tons of scrap. Smaller electromagnets are used in relays, switches, and valves.

The **strength** of an electromagnet can be increased in various ways.

1) Increasing the size of the current
2) Increasing the number of turns in the coil
3) Exchanging the core with an IRON core.

A scientist, Oersted's, original discovery was that an electric current flowing through a wire would set up a magnetic field around the wire and that increasing the current would strengthen the magnetic field. He also said that forming the wire into a loop would also strengthen the field. The lines of force are circles around each bit of wire; where these circles overlap, a stronger magnetic field is produced.

If you wind the wire to form a hollow cylinder in which a continuous series of loops are next to one another (this can be done by winding wire around a pencil) the magnetic field inside the cylinder is equal to the sum of the magnetic fields associated with all the loops. A magnet in this form is called a solenoid.

I have stated above that replacing the core with an iron core strengthens the electromagnet. This is because the magnetic filed of the solenoid generates magnetism on the bar and the total field outside the solenoid is the sum of the solenoid's field plus

the field induced in the soft iron. The magnetic field of this magnetized iron bar can be made much stronger than the solenoid on its own.

Increasing the current in the solenoid increases the magnetic field induced in the bar magnet--but only up to a certain point. This is called the saturation value. The strength of an electromagnet depends on the saturation value of the bar magnet. This is the factor I am interested in for my investigation.

Prediction: I think that if the current is increased, the strength of the electromagnet is increased. My objective in the investigation is to find a relationship between the increase in current and what happens to the increase of electromagnet strength. For example, I want to answer the question "Does the strength of the electromagnet double if the current is doubled?"

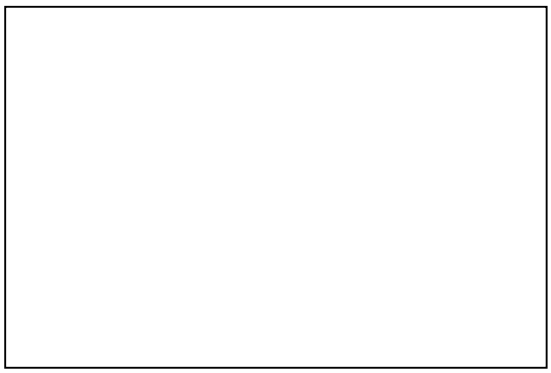
Before doing the experiment, I am thinking that the electromagnet strength will double if the current is doubled, in the same way the electromagnet strength will triple or halve if the current is tripled or halved. I think this because the size of the current is directly proportional to the strength of the electromagnet, meaning if one is changed, the other is changed in exactly the same way.

Plan: I will plan a fair test to see if my factor (increasing the strength) makes a difference to the strength of the magnet. I will obtain at least three results and find the average between them when plotting the graph. I will plot a graph to observe my results, as it is easer this way to spot trends and reach conclusions.

The apparatus I will need are:

1) Power pack – to supply the power in the circuit
2) Variable resistor – to change the resistance to control the current.
3) Ammeter – measure current for me to record
4) Electromagnet – subject of investigation.

Experimental set-up:



I will set up the experiment as shown. To change the current in the circuit, I will use the variable resistor because resistance and current affect each other. If there is more resistance, less current will flow and in the same way if there is less resistance, more current will flow. I will start of with a small current and work my way up. If any results do not seem to fit a pattern or trend, I will repeat them until they do.

To make sure this is a fair test, I will not change anything else apart from the current in the circuit. To achieve this, I will not play with the other factors, thus I will

not change the number of turns the electromagnet has or replace the core. I will use the same apparatus throughout, especially keep the same electromagnet so that my results are not influenced in any way. For example, different ammeters could measure differently, especially if they are very old and do not work properly. Same with the variable resistor and the wires used. To ensure this, I will obtain all my results in the same day.

Results:

Current	Strength 1	Strength 2	Strength 3	Average Strength
0.5	0.4	0.5	0.4	0.4
1.0	1.2	1.2	1.1	1.2
1.5	2.1	2.0	2.2	2.1
2.0	2.4	2.5	2.6	2.5
2.5	3.9	4.0	3.7	3.9
3.0	4.8	4.6	4.3	4.6
3.5	4.6	4.6	4.6	4.6
4.0	4.3	4.3	4.3	**4.3**
4.5	6.6	5.1	5.2	5.6
5.0	6.3	5.2	5.9	5.8

This result does not seem to follow the pattern. All the others are increasing.

I repeated this twice and obtained the results shown below.

Current	Strength 1	Strength 2	Strength 3	Average Strength
4.0	5.8	5.9	5.4	5.7
4.0	5.5	5.6	5.5	5.4

I wasn't satisfied with the first result as it was too big but was happy when I obtained a result of 5.4 the second time.

Analysis: My graph shows that as the current increased, so did the strength of the electromagnet. The graph shows a strong positive correlation as the points are very close to the line o best fit. The two variables are proportional to each other so as one increases, so does the other.

The graph also shows that as the current is doubled, the electromagnet strength also doubles. When the current was 1.5 amps, the electromagnet strength was around 2 volts. When doubles, the current is 3 amps and the strength of electramagnet is around 4 volts. This is because the two factors are strongly related. As I have already explained, increasing the size of the current increases the electromagnet strength and the graph supports this. It also supports what I said in my predictionabout doubling and halving the measurements.