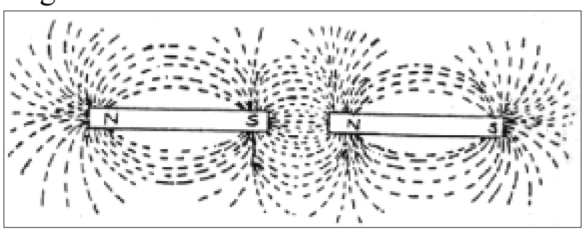
How Does The Number of Coils On An Electromagnet Affect Its Strength?

Aim: To find out how the number of coils on an electromagnet affects its strength.

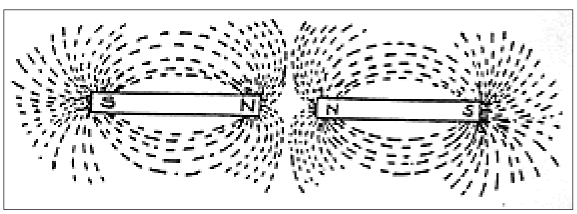
Scientific Knowledge:

An electromagnet is a temporary magnet; the magnetic field only exists when an electric current is flowing. Any electric current produces a magnetic field, but the field near an ordinary straight conductor is rarely strong enough to be of practical use. A strong field can be produced if a wire is wrapped around a soft iron core and a current is passed through the wire. The strength of the electromagnet depends on how many coils you wrap round and how high the voltage is.

The area of force (magnetic field) surrounding a bar magnet can be shown by the lines of force as shown below, although these lines are no more real than the lines of latitude and longitude on a map or globe.



When opposite poles of a magnet are brought together, the lines of force join up and the magnets pull together.

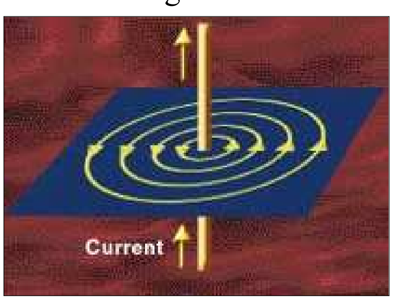


When like poles of a magnet are brought together, the lines of force push away from each other and the magnets repel each other.

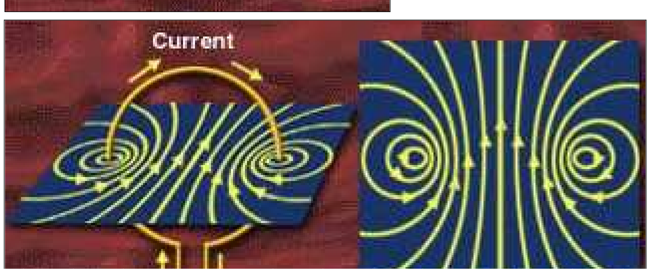
Electromagnets are used to lift large masses of magnetic material such as scrap iron. Electromagnets are also found in electrical generators, electric motors, doorbells, circuit breakers, television receivers, loudspeakers, etc.

The factors that increase the strength of an electromagnet are;

- Increasing the number of coils, which adds more field lines and makes the electromagnet stronger.

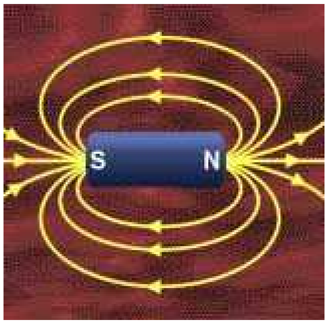


This is the magnetic field around a piece of wire, compared to a magnetic field on a loop or solenoid it is weak. Turning coils around and passing a current through them will make a much stronger electromagnet.



This is the magnetic field around a single loop of wire; there are more field lines a single loop than in a straight piece of wire. If the loop were to be repeated several times it would make the electromagnet much stronger.

- Increasing the current would make the electromagnet stronger because more electricity is passing through the solenoids. If the current is increased the field becomes stronger, if it is reversed, the field is reversed and if the current is switched off then the field is lost.
- Winding the coils around 'soft' iron core. This increases the strength because if an iron bar is placed inside the coil concentrates the lines of force and makes it stronger.

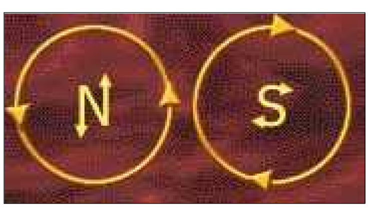


Long coils of wire are called solenoids. When a current flows through their external magnetic field is just like a bar magnets. But they also have lines of running force through the coil. If an iron bar is placed inside a coil, it concentrates these lines of magnetic force and makes the electromagnet stronger.

Pure iron does not keep any magnetism when the current is switched off, but a steel bar does. So pure iron is called magnetically soft, and is perfect to use as a core for an electromagnet. Steel stays magnetic after being in a solenoid, it is magnetically hard. This means solenoids can be used to make permanent magnets made of steel.

The magnetic field around a wire is circular and vertical to the wire, but the magnet fields from each of the turns in the coil add together, so the total magnetic field is much stronger. A coil of wire is often called a solenoid. The direction of the magnetic field can be described using the right hand rule.

The right hand rule states that if you make a fist, when you point your right hand thumb in the direction of the electric flow, the rest of your fingers curl in the direction of the magnetic field. The direction of the flow of current always goes from the positive end to the negative end.



The direction of current flow tells you whether it is the north or South Pole you are looking at. The diagram tells you how to work out which way the current is flowing in an electromagnet.

Prediction:
I predict that as the number of coils are increased the magnetic field will become stronger, because each coil has its own magnetic field, so the more coils there are the more field lines there are which means it would be a stronger electromagnet. The electromagnet will become stronger if we add more coils because there are more field lines in a loop then there is in a straight piece of wire. In a solenoid there are a lot of loops and they are concentrated in the middle, as more loops are added the field lines get

larger, therefore making the electromagnet stronger. The magnetic field becomes stronger because the magnetic field around a wire is circular and vertical to the wire, but the magnet fields from each of the turns in the coil add together, so the total magnetic field is much stronger. The magnetic field around a solenoid is much stronger than a bar magnets because each coil acts like a magnet when a current is passed through it, when the coils are repeated several times it is like having several mini magnets in a row, making it more stronger than bar magnet.

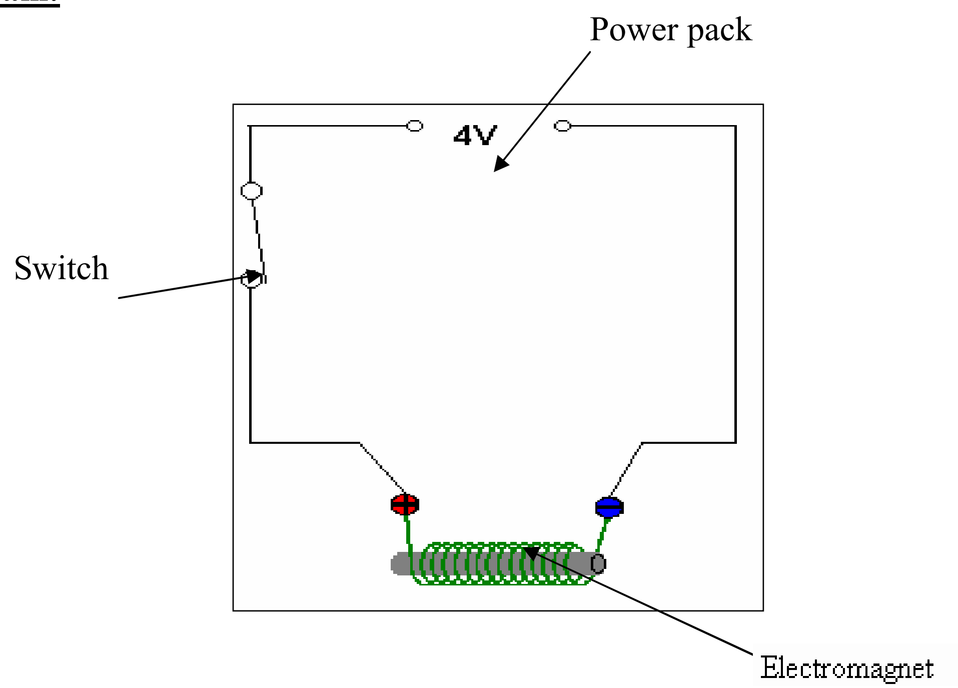
Apparatus:

Iron Core
Power supply
Paper clips
Ammeter
Coil wire
Wires
Crocodile clips

Method:

1. Connect everything together and put the voltage on the power pack to 4V
2. Enter the iron core in the circuit and turn the power supply on
3. See how many paper clips it picks up then turn the power pack off
4. Count how many paperclips it has picked up and record in a table
5. Do experiment several more times

Diagram:



Safety:

To make sure that this was a safe experiment we;

- We turned the power pack off each time we counted the paperclips, we did this because if we left the power pack on it get too hot to touch.

- We kept the voltage low because if it is to high, it would overheat, the voltage didn't exceed 4V.
- We kept the time of the experiment short because if it went on to long the wire would overheat and demagnetise the electromagnet.
- We kept the electromagnet away from any electrical equipment because if it were near any electrical equipment it would mess up the electronics in it.

Fair Test:

To make sure that this was a fair test we:

- Kept the current the same because if the current was high on one and low on another the amount of paper clips would be dramatically different because when the current is increased the magnetic field becomes stronger.
- Used the same size paperclips because if we used different size paperclips the results would be in accurate because if the paperclip is bigger it is going to be harder to pick up and if they are smaller it would be easier to pick up.

Results

	Number of	Paperclips	Lifted	
Number of Turns	Experiment1	Experiment 2	Experiment 3	Average
25	10	14	19	15.7
50	19	13	21	17.7
75	22	15	25	20.7
100	18	23	26	22.3
125	27	21	20	22.7
150	23	20	21	21.3

Conclusion

In conclusion the amount of coils do affect the amount of paperclips picked up. This is shown in the average of the graphs, which is a straight line. This shows us that the number of coils is proportional to the number of paperclips picked. As the numbers of coils are increased so does the amount of paperclips supported. These results agree with my prediction, because I predicted that as the coils increased so did the amount of paperclips picked up, and this happened. This is because as more coils are added the magnetic field becomes stronger, which means it can support more paperclips. The magnetic field becomes stronger because the magnetic field around a wire is circular and vertical to the wire, but the magnet fields from each of the turns in the coil add together, so the total magnetic field is much stronger. The magnetic field around a solenoid is much stronger than a bar magnet, because each coil acts like a magnet when a current is passed through it, when the coils are repeated several times it is like having several mini magnets in a row, making it more stronger than a bar magnet.

Evaluation

I didn't expect my results to be so different towards the end; I expected the results to roughly be the same. If I was to repeat this experiment I would use smaller turns on the core so it is more accurate and less paper clips will need to be counted. We used a power pack instead of batteries so this was more accurate. Batteries run out after a short time and their current is inaccurate because they do not give out a constant amount as they run out. I think that I didn't take enough results because I don't think that my results were accurate enough because the last 4 results began to differ. However the averages are in proportion.

By looking at the graphs and lines of best fit, a few anomalous results. The first time we done the experiment we got one anomalous result, the rest of the results were quite near the line, I think this is because some of the paperclips got tangled together. In the second experiment there were several anomalous result. I think this is because the metal was already magnetised before from the first experiment. The third experiment was the most inaccurate this is because the magnetism had built up from the two previous results. This is mainly due to the fact that the electromagnets had not been demagnetised before each of the experiments.

If I could repeat this experiment I would demagnetise the magnet after each time I repeated the experiment, this would give a more accurate result, because I didn't demagnetise the magnet the electromagnet kept increasing its magnetism each time. I would also change the way I conducted the experiment, instead of just dipping the electromagnet into the paperclips, I would dangle them off each other. This would give me an accurate reading of how strong the electromagnets field is.