Title:

Electromagnet Investigation

Aim:

To see how the number of coils on an electromagnet affect its strength.

Scientific Knowledge:

An electromagnet is a temporary magnet, meaning that it only goes and is in use, when you feel like it. Magnets have interesting properties. They can pull pieces of iron, cobalt or nickel towards them but not affect any other materials, even other metals such as copper or aluminium.

When a magnet is freely suspended, it always comes to rest with the same pole facing north. This term is referred to as the 'north pole'; the other is the 'south pole'. If the north pole of a magnet is brought near to a south pole of a magnet, it will attract. However, if two poles are the same, they will repel meaning they will push away one another. This is where the saying is used, "Opposites attract."

All of these things happen because they have magnetic fields around them. This 'field' can be easily seen if iron filings are shaken around a magnet. If you place a bar magnet with iron filings surrounding them, you can observe that the filings will be going around towards their respective poles on the other side. When you place iron fillings round a coil or solenoid, you will notice that the magnetic field round the solenoid has the same shape as the field round the bar magnet. You will also notice that the field inside the solenoid will be very strong and uniform, which can magnetise things. The lines of force that shows the magnetic field, is called the lines of flux. The permanent magnets, unlike electromagnets, do have their advantages and also their disadvantages. Permanent magnets cannot be produced very large and more importantly, they cannot be switched off.

A coil of copper wire will have no effect on a compass needle until an electric current is passed around it. When the process is complete, it acts and behaves just like a magnet, with poles and a magnetic field. Coils give a stronger magnet because the wire carrying the current has a magnetic field around it.

An electromagnet is just a coil of wire with an iron core. When current flows through the wires of the solenoid it creates a magnetic field around it. So the soft iron core has the effect of increasing the magnetic field strength. The magnetic field around an electromagnet is just like the one round a bar magnet, only it can be made stronger. This means that the ends of the solenoid act like the North Pole and the South Pole of the bar magnet. Therefore, if the direction of the current is reversed the north and south poles will swap ends. If you look at one end of a solenoid, you can tell whether it is the north or the South Pole. The North Pole has the current shape going in an 'N' shaped way, and the South Pole has the current going in an 'S' shaped way. In an electromagnet, the same rules apply to every experiment. "The more turns of wires there are, the stronger the magnetic field, current and electromagnet". However, bear that in mind, the flowing of electricity causes this effect, not the wire. This is mainly the reason for these devices to be called electromagnets, it an only work when switched on with coils. When and if the current is increased, the field becomes stronger; if it is reversed; and the current is switched off, the field will be lost.

The scientific term for the word, 'coils', is solenoids. When the current flows, their external magnetic field, is just like that of a bar magnet. They also have the lines of forces running through their magnets. If an iron bar is placed inside the coil, the electromagnets become stronger because it concentrates the lines of magnetic force.

A magnetic field is a region where magnetic materials such as iron or steel, and also wires carrying currents experience a force acting on them.

Pure iron does not retain any magnetism when the current is switched off but a steel bar does. Generally, the pure iron is known to be magnetically 'soft', which are ideally used as cores for electromagnets. Because 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.

So therefore, electromagnets can be made stronger by three factors that affect their strength. They are: a) increasing the number of coils: by increasing the coils, it allows more current to flow through efficiently making the process easier, b) increasing the current: by doing this, there will be more current thus making the electromagnet stronger and c) winding the coils around a 'soft' core: because by doing this, will make the electromagnet even better because the 'soft' iron is ideal for electromagnets. Also, electromagnets can obviously be switched off unlike normal magnets, which are permanent.

Lots of firms and companies nowadays use electromagnets. They play a vital role in today's society. They are used to lift cars in scrap yards and are in your own television set the controls your picture quality.

Prediction:

I predict that the increase in magnetism is proportional to the number of coils because my scientific knowledge states that when the strength of an electromagnet is increased, meaning it will become stronger, it will then be able to pick up more paper clips (as it steadily increases).

The basic theory is, "The more turns of coils there are on an electromagnet, the stronger it will become." This is correct because as the current gets increased it makes the magnetic field stronger. You can test this concept by placing small plotting compasses near a weak magnet. The compasses will then point along the curved lines; these lines are called the lines of flux, which is also called the lines of force. The lines of flux (and iron fillings) show the direction of the magnetic field at each point.

Apparatus:

The apparatus that we used were:

- 4 Volt Power pack
- Crocodile Clips
- Wires
- Solenoids
- Iron nail
- And paper clips

Diagram:

[Will Be Supplied Later]

Plan:

My plan is to see what effect the number of coils has on the strength of an electromagnet. The nature of this experiment is to see how many coils can pick certain number of paper clips. I

have already predicted that however much coils I will turn, the number of paper clips will be doubled. I will start of with five turns of coils on the iron nail; I will continue to add five more turns on the coils as the experiment progresses. I will plan to do each result to a maximum of five times. A diagram is drawn above of what my experiment will look like. This is because the more times the experiment will be carried out, the more accurate my results will be and then I can work out an average. My first step would be to set up the apparatus and take safety precautions, such as switching off the power pack at various intervals during the experiment. There will be approximately about 40 paper clips spread on the desk. I will then turn five coils on the iron nail and proceed to do the experiment, whilst turning more five coils during various intervals.
As I had mentioned in my scientific knowledge, permanent magnets are usually made small, in our case, the iron nail is the small magnet. I will test to see whether my theory will be correct or not, as the power pack will go on, the current will flow, allowing the iron nail to be magnetised. Right now, that remains to be seen.

Safety:

Whilst doing this experiment, I had to take in many considerations into account, as there were several safety hazards involved during the experiment. One thing I had to take into account is that you had should switch off the power pack several times during various intervals of the experiment. This is because it can get overheated and may cause it to blow up even. Another thing is that the power pack's voltage should always be set to four Volts, no more and no less. If I do change it, it will disrupt my experiment and cause my results to be awry.
As the circuit was switched on, the wires got hot. I made it safe by not touching the wires and by only having the circuit on for a short period of time.
We must be in a safe environment to carry out this particular experiment/investigation. However, bear that in mind the electromagnet is very susceptible due to various factors in the surroundings.

Fair Test:

I will make this a fair test by keeping everything the same apart from the number of coils. I can carry out these investigations only, according to a safe environment to work in. I will make this a fair test by switching the electromagnet on and off, reason being because if I leave it on it will cause it to overheat and will be exposed to students in the class which will be very dangerous environment.
I will also make this a fair test by using only a certain amount of coils i.e. about 35 because I am changing the coils not the current. If I do change the current it will cloud the results and we will get mixed and perhaps wrong results. In order to make this experiment fair to an extent, we can get the paper clips to be the same. If the paper clips are not the same in terms of size, weight and appearance, the outcomes could be incorrect. So, to avoid this situation, we can get paper clips of the same source and measure their weight to see the similarities. We will be using a 4 Volt power pack. During the experiment, the paper clips will obviously be magnetised because we will wrap coils around it and current to pass. So what we can do is replace the coils by the same amount. Also you have to repeat the experiment about five times to get an idea of what the results will be. On a side note, heating can destroy the magnetism because it can get saturated and will not allow it to attract any other materials or metals. So therefore, generally, everything will be kept the same in terms of the paper clips and same piece of coil, which will be turned at various segments.

Method:

To carry out the experiment first of all we collected and gathered all of our apparatus and equipment together and demagnetised the nail and paper clips. When we demagnetised the nail and paper clips, we used the ‘alternating current’ method. We passed the alternating current through the coil we used in the experiment, and then we gradually pulled the nail out of the coil. It was then demagnetised. Then we connected everything together and put the voltage to 4 Volts. Then we switched the power supply on and wrapped the coil 5 times around the nail. We tried to see how many paper clips it would pick up; our first result recorded was 4. Then we turned the power supply off. However, by the way we were picking up the paperclips had an effect on the outcome. So, we laid out all the paper clips and picked them up one by one, to see how many can get attached to the nail simultaneously. The paper clips got attached to the nail with the coils wrapped around it, because there was a magnetic field formed. The magnetic field round a solenoid has the same shape as the field round a bar magnet. This proves that my scientific theory was correct because I stated that when the current flows through a coil, a magnetic field is produced. That is exactly what happened in my experiment. Figure 1.0 shows what the paper clips looked like before we picked them up We did not attach the paper clips together We tried the experiment several more times, winding the coils 5 times each to a total of 35 times.

Figure 1.0

Results:

We conducted the experiment several times and realised that the statistics were proving to be the same. The following are our final recorded results:

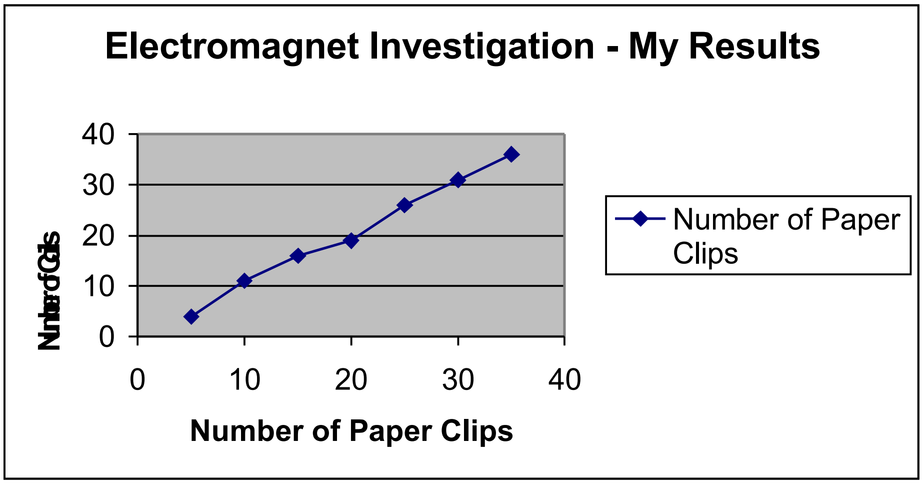
Number of Coils	Number of Paper Clips Supported
5	4
10	11
15	16
20	19
25	26
30	31
35	30

We then acquired results of another group and compared. Their results are as follows:

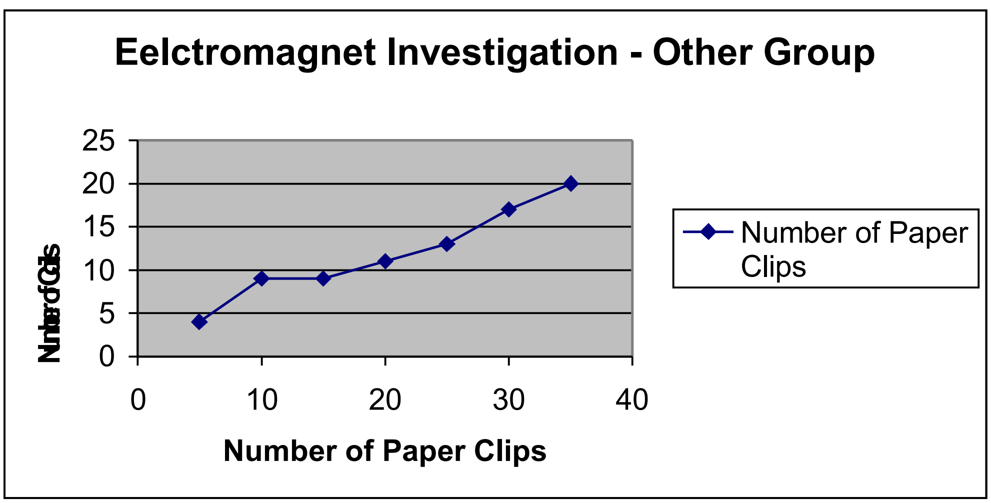
Number of Coils	Number of Paper Clips Supported
5	4
10	9
15	9
20	11
25	13
30	17
35	20

We noticed that their results were a bit different, but more or less similar in terms of the line of best fit (featured on the graph papers). This was because both respective parties carried out the experiment sufficiently and properly.

Graph: [Will BE drawn by hand, two graphs not entirely correct]



Our results came out reasonably good and accurate as you can see from the line of best fit on my scatter graph. I expected my results to come out correct because I followed the procedures of the experiment correctly. However, I noticed that there were some anomalies in my final out of results. As you can see in the graph, when I picked up paper clips on the 35th turn of coil, 30 paper clips were picked up. This was peculiar because the previous paper clips picked up were 31 with 25 coils. I think this may have happened because I may have not demagnetised the paper clips properly or the paper clips might have been different to the ones I was currently using. Now, in comparison, other then one anomalies in my graph, my graph is similar to that of the other respective group as you can see below:



However, bear that in mind, both line graphs look similar, except my graph had one anomaly in it. One of the major differences in our respective graphs is that Group 2 picked up less paper clips then I did. This may be because of the nature of the paper clips.

I believe that my graph is correct because judging from my theory from the scientific knowledge, it states that, the more turns on the coil is proportional to the number of paper clips that be supported and picked up. My graph proves just that because it has a strong positive correlation. The number of paper clips increases in comparison to the number of coils that increase.

Analysis:

We investigated to see how the numbers of coils on an electromagnet affect its strength (i.e. how many paper clips are picked up with particular number of coils). To find out this we recorded our results and looked to see if there was any pattern involved.

The results that were recorded did indeed show a pattern. As the number of coils gradually increased so did the number of paper clips that were attracted. For example, when the coils were turned 20 times, the number of paper clips that were picked was a total of 19. We tried picking up the paper clips several times and the number of paper clips that were picked up was always 19 when the turn on the coil was 20.
This happened because as the coils were increased it had an effect on the strength of the electromagnet therefore making it stronger to picking up more paper clips. We expected this to happen because our graph shows a line of best fit and my theory had proven to be correct. As there were more turns of coils on the nail, current was flowing through thus creating a magnetic field. Because of the magnetic field, the nail and paper clips became magnetised hence the iron nail supported the paper clips.

Conclusion

I found out that the number of paper clips picked up, does indeed change depending on the strength of the electromagnet. My prediction was correct because I had predicted that as the number of coils will increase, so will the strength of the electromagnet. Therefore making the electromagnet stronger, with enables it to carry out more specific tasks.
My graph does show a line of best fit although there was an error in the result. My graph shows that as the coils increased, so did the number of paper clips.
Judging by looking at my graph and its line of best fit, you can perfectly see that there is a pattern involved. My graph shows a strong positive correlation in comparison to the other groups. My graph states that as the number of coils increased, so did the number of paper clips. I did make an error because my scatter graph shows an anomaly. When the coil was turned 35 times, only 30 paper clips were supported. I think that this may have happened because I may have not demagnetised the current paper clips that I was using.
I got these results to test how strong an electromagnet can get, and to test this; I used paper clips as an example of its strength. I keep on doing 5 turns on the coils to test its strength. The more turns I did, the stronger it got. You can find out this from my table of results and my graph.
From the graphs it is easy to see that my graph is steeper than the other groups graph. This is what I would expect since my magnet was stronger that the other groups. If we compare the gradient, it proves that my magnet was stronger than the other groups.
Table 2 shows another group's results, you can notice the differences in terms of statistics. It seems that their iron nail supported much less paper clips then my groups. This may be because taking all factors into account such as the length of the coils; the weight, size and appearance of the paper clips may have influenced the outcome. This is why in comparison our results differ to one another. I cannot comment on the other group's results further because I do not know what they did.
Judging from my prediction, I proved my theory that the number of coils will be proportional to the number of paper clips, only by increasing the strength of the electromagnet. The prediction that I made was, "I predict that if the number of turns on the coil is doubled, the number of paperclips will also double." This proved to be correct because that is what exactly happened and what my graph of results show.

Evaluation:

My experiment was correct according to my scientific theory and prediction. To improve it, beforehand recording the official results, I could have done a preliminary investigation. This

means that to do the experiment beforehand (at least five times) to get overall readings you expect to get.
To make the results even more accurate, I could have first measured the paper clips to see if they are all the same weight. Because if they were all different or out, then the results would have some strange numbers. So therefore, if the paperclips were the same weight the maybe the results would have been even more successful.
I agree that my method was right, because I conducted everything in my plan, which eventually became my method.
In order to have gotten more reliable results, there are many factors, which could have influenced the results. For example, the most important thing was perhaps the paper clips. To get more accurate results, I could have weighed all the paper clips and made sure that they were the same weight. But, as we did not have the resources and equipment specifically, I assumed that all the paper clips weighed the same. Another thing to take into account is that the length of the coil may not have been the same amount, as I turned it around the iron nail.
There are many ways in which how I could measure the strength of an electromagnet accurately. I could have used an ammeter to test the current and record the readings during various intervals. I could have also used a Variable Resistor or a Rheostat to increase the current so the electromagnet would get stronger and therefore pick up more paper clips.
Another thing is by the way I held the iron nail in order to pick up the paper clips. By the coils safely wrapped around the iron nail, I may have without realising, picked up the paper clips by the end of the nail, in the middle or any other part of the nail. This may have caused my results to differ from Group 2's. Also, different nails will magnetise differently and therefore will give different results.
As the number of coils increased so did the strength of the magnet and therefore the number of paperclips it picked up. If you look at the results closely you can see that with 30 coils it picked up 31 paperclips, and with 35 coils it only picked up 30 paperclips. This lost value seems wrong because the magnet may have been demagnetised in a slight-way or that the maximum number of paperclips that the magnet could hold was approximately 30 paperclips (the number did not increase because it was perhaps saturated). I could have proved this by repeating with more paperclips.