# Coursework: An Investigation into the strength of an electromagnet by Gareth Jones

**Aim**

To investigate how the number of coils of wire on a C-core affect the strength of an electromagnet.

**Prediction**

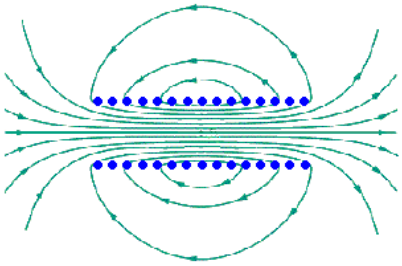
As the umber of coils of wire on the strength of the magnet increases, the strength of the magnet will increase. I believe that as the number of coils doubles, the strength of the magnet will double also. I also believe that as another coil is added the strength of the magnet will increase by the same amount, and so a linear relationship of direct proportionality between the number of coils and the strength of the magnet will be formed.

**Scientific Reason**

I believe that this will happen because when current passes through a wire, a magnetic field is created.

In a piece of iron, there are thousands of "domains". Each of these acts like a very small magnet, and has its own polarity. In a normal bar of Iron, these polarities are random and have a neutralising effect on each other – the iron has no magnetic field.


If a magnet is placed near to the iron bar, then all the domains will align and turn the iron bar into a magnet. This effect is only temporary, and when the magnet is removed the effect.



As the magnetic field produced inside a solenoid is the same as that produced by a bar magnet, placing an iron bar inside has the same effect as with a magnet – the field created by the wire causes the domains to line up, and polarizes the iron bar. The same principle can be applied to the C-core used in my experiment.

**Fair Test**

Variables:
*Coils*: I will change only the number of coils on the magnet, and I will change this from 5 to 50 with 5 coil intervals. I will count a coil as a complete circle round the core. This will be the only factor I change in my experiment.
Controls:
I will keep all other factors in the experiment the same so as to give a fair test. If another factor is changed it may have an effect on the results, and this would mean my results would be unreliable.
*Wire*: Will be the same length and type for all of the experiments. This will be achieved by all the experimentation being carried out in a single session. Different wire may have a different resistance, length or type and conduct differently.
*Voltage*: Needs to be 6V all the time. The same power supply will be used at all times, meaning that the slight differences that different power packs deliver will not affect the results.
*Paper clips*: The same number, 500 paper clips will be used for each test. This means that there is the same potential to pick up the paper clips. They will be arranged in a similar fashion for each test.
*Time*: All tests shall allow the magnet to have the same amount of time in the tub, not leaving one test for an extended period of time where it may pick up more.
*Other Conditions*: As all the tests will be completed in a single session, the same equipment will be used, and the conditions the tests are carried out in will all be the same (humidity etc..)

**Equipment List**

To perform my experiment I will use the following equipment:

500 paperclips (in margarine tub)
2.5m length of wire
Power pack capable of delivering 6V DC
C-core

**Diagram**

**Method**

1. Wrap 5 coils of wire around the centre of the C-core, assembling so it looks like the diagram.
2. Attach the two ends of the wire to DC terminals on a power pack capable of delivering 6V.
3. Turn on the power supply (this will make the electromagnet become magnetic) and place the magnet into a margarine tub full of paper clips.
4. Remove the C-core with the paper clips attached, and place over a sheet of paper.
5. Turn the power pack off, and the magnet will deposit the paperclips onto the paper. Any left attached to the magnet need to removed and placed on the paper.
6. Count the paper clips, and record the result.
7. Forcefully tap the C-core on the bench to re-scramble the domains.
8. Repeat this experiment for five coil intervals from five to fifty coils inclusive. Do five repetitions for each value.

**Trial**

To decide on appropriate values for my experiment I did some trial tests to obtain suitable values for the variables.

Using a 1V and picking up Iron filings.

| Number of coils | Mass of iron filings remaining (total 162.98) (grams) | Mass of iron filings picked up (grams) |
|---|---|---|
| 25 | 162.62 | 0.36 |
| 35 | 161.90 | 1.08 |
| 50 | 161.75 | 1.23 |

I decided that the differences were too small and irregular. The maximum number of coils which could be sensibly coiled round the C-core was about 50, this meant that our results would have very small differences and any slight differences would cause great irregularities in our results.

In my second preliminary test I increased the voltage to 4V and changed from picking up iron filings to picking up paper clips. Compared to the error made in other areas of the experiment using paper clips will help with more consistent results, as the scales are too accurate.

| Number of coils | Number of paper clips picked up |
|---|---|
| 5 | 12 |
| 20 | 50 |
| 45 | 105 |
| 50 | 130 |

I decided that these results were rather low, and therefore in my method I will use 6V as opposed to the 1V and 4V used previously.

**Results**

| Number of coils | Number of paperclips picked up | | | | | |
|---|---|---|---|---|---|---|
| | Repetition 1 | Repetition 2 | Repetition 3 | Repetition 4 | Repetition 5 | Average |
| 5 | 14 | 15 | 20 | 22 | 19 | 18 |
| 10 | 39 | 39 | 40 | 43 | 41 | 41 |
| 15 | 59 | 59 | 59 | 59 | 59 | 59 |
| 20 | 77 | 77 | 77 | 77 | 77 | 77 |
| 25 | 100 | 100 | 100 | 100 | 100 | 100 |
| 30 | 121 | 119 | 120 | 129 | 126 | 123 |
| 35 | 142 | 140 | 146 | 135 | 142 | 141 |
| 40 | 160 | 158 | 188 | 165 | 165 | 175 |
| 45 | 180 | 188 | 175 | 185 | 187 | 183 |
| 50 | 200 | 203 | 212 | 207 | 208 | 206 |

I carried out my experiment as specified in the method above.

**Graph**

See graph paper

**Analysis**

My results show that as the number of coils around the C-core increases, the strength of the magnet increases, so it is able to pick up more paperclips. My results are very consistent with my prediction. As the number of coils on the magnet doubled, or increased by a certain amount the number of paperclips picked up increases proportionally, showing a directly proportional relationship between the number of coils and the number of paperclips picked up. For every five coils on the C-core an extra twenty paperclips were picked up. This can be simplified to for every additional coil added to the C-core, 4 more paperclips were picked up.

Where
P = Number of paperclips
C = Number of coils around the C-core

**C= 4P**

This fully supports my prediction, and my scientific reasoning fits with this. The more coils that are added, the stronger the field created by the wire becomes, giving it the power to align more domains. This however could not continue forever, and so perhaps my results indicate a flat beginning on a curve which will eventually reach a maximum.

**Evaluation**

When testing I had on anomalous result which I have highlighted in the above table. I included it when I was making averages as the result was not too far away. I have also ringed it on my graph to display it.

My method left lots of room for error, the paperclips were not all of uniform size, and left a gap, an entire paperclip had to be picked up, which led to inaccuracies in our results. The power pack did also not deliver a perfect 6V; the voltage would have intermittently changed. When the wire was coiled round the C-core it went over other wire, so was not creating a solenoid, and the wire would get in a knot.

If I repeated the experiment I would use a balance and iron filings which would allow for much more accurate results to be taken. I would use a more reliable power supply and use an ammeter to measure this. As the wire was used it warmed up, increasing the resistance and time constraints did not allow for time for the wire to cool down. The time that the magnet spent in the paper clips was not uniform, if I were to repeat this I would time accurately the time spent in the iron filings and if possible automate this area of the experiment to a greater degree of accuracy than that a human could perform to.

My results were reasonably reliable, my results all fell close to each other and I was able to come to a quantitive conclusion. I obtained only one unexpected result and all other results fell within reasonable degree of error. I have marked on my graph the degree of error for each test by using error bars. The point has a line above and below to indicate the highest and lowest values scored for this value, and a line connecting the two through the value to show that the three are joined.