Electromagnetic Coursework

Area P

I am going to investigate what affects the strength of an electromagnet. Things that I believe are likely to affect the strength are the strength of the current; the number of coils; the presence of a soft iron core; the type of wire; the resistance of the wire and the temperature. I will investigate how **the number of coils** affects the strength.

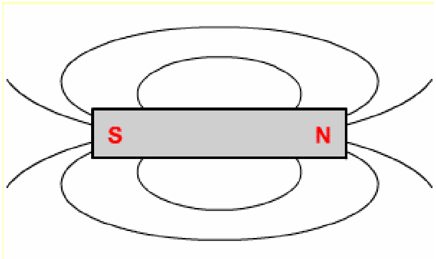
In the experiment the only changing variable will be the number of coils. Everything else will stay the same-everything else being the temperature; the wire length; the wire thickness; the resistance; the type of wire and the presence of a soft iron core. To control the temperature I will need to keep switching the current on and off, so to do this I will add a variable resistor to the circuit that will do this for me. The resistance will be controlled if the temperature is controlled, since the two are connected and inversely proportional.

I will measure the electromagnet's strength by setting up the circuit shown above. The nail will point vertically upwards, to avoid getting interference from gravity. I will slowly bring a spring balance into contact with the nail. Since the tip of the spring balance is iron, a magnetic metal, it will be attracted to one end of the electromagnet and therefore allow me to measure the number of Newtons in force before the spring balance breaks the connection. This will give me an idea of the strength of the magnet.

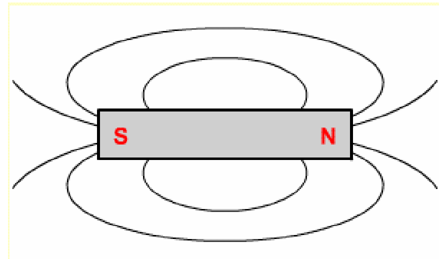
To set up our experiment, first we'll attach one end of 2 wires to a power pack and the other ends to a wire wound into coils round a nail. The number of coils will be the changing variable. The power must be off until we are ready to use the circuit, or the nail will heat up and give us anomalous results, since the resistance changes with heat. Then we will get a spring balance and we will do as described above.

We will start with 10 coils and go up in 10s. The maximum number of coils will be 60. To ensure our results are correct we will keep the power on for short periods and make sure the nail is cool before continuing. We will carry out each test 3 times and take the average of all 3 as our final test result.

I predict that as I increase the number of coils, the magnetic field will get stronger. This is because the more coils, the more electricity is able to travel through the magnet. The more current the larger the magnetic field:



←10A current
20A current→



Area O-Obtaining results

No of coils	Strength/g			
	1	2	3	Average
10	0.08	0.08	0.09	0.08
20	0.22	0.22	0.24	0.23
30	0.39	0.34	0.38	0.37
40	0.41	0.42	0.46	0.43
50	0.52	0.46	0.51	0.50
60	0.55	0.54	0.59	0.56

Analysing Results

Our results look as they do since the wires give off magnetic fields. The larger these fields, the more force in the attraction between the spring balance and the electromagnet. To make the field larger, more coils are added to the wire.

We can easily see that the more coils, the greater the strength. When the amount of coils is increased, a larger magnetic field is produced, increasing the strength. The graph backs this up, showing clearly an increase in strength with more coils. The line on the graph does not show direct proportionality between the two variables, but the proportionality is not far off. I feel maybe if the 30 coils recording had been slightly lower, our line of best fit would have shown proportionality.

The gradients of the various points on the curve also tell us something else. We can see a large difference in the early coils, where, for example, the gradient between 10 and 20 coils is 1.5. In the later stages of the graph, the gradient is smaller. We can see this if we find the gradient of the line between 50 coils and 60, which is 0.6. Therefore, we learn from our graphs that the more coils, the more strength, BUT this strength increase is not stable, since there is only so much maximum strength. The more strength a magnet gets, the less there is left to get, so the increase in strength over a certain number of coils is greater when there are few coils, as to when there are a lot of coils.

To understand why the graph line changes we need to know about the domain theory. This is the idea that in natural iron there are lots of randomly charged magnetic particles. When electricity is applied to natural iron, all these particles line up, producing a magnetic current. This is a bit like a territory of a ruler of a country (a domain). When the domain is large, the ruler is powerful. Initially a country is usually a collection of very small domains run by local rulers who are content to just balance the influence of their neighbours; no ideas of conquest. When a strong king comes along, many of the domains and their rulers align with him and his direction. The strong domains grow at the expense of weaker ones, and the country becomes a group of large domains aligned with the king. Strong local rulers keep the domains aligned with the king even when he relaxes, or is off on another quest. It is not enough that the domains are large, and have strong rulers, they must have a high population density to supply soldiers for the king's army. Large, weak domains are difficult to maintain even if they have a large population density. This idea came from a website on the net, and helps explain the Domain theory simply.

If I apply the domain theory to my graph, we can see it works. Between 0 and 0.08, the magnetic particles are beginning to line up, and the magnet is still very weak. From 0.08 to 0.23, 90% of the particles have lined up and the magnet is stronger than at the beginning. Between 0.23 and 0.37 all the particles have lined up and the magnet is at full strength-it cannot get any stronger. From 0.37 onwards the graph line goes flat, telling us the magnet continues at maximum strength, but only until the power is switched off. Since the iron core is a soft magnet, it will lose all its magnetism the moment the current stops flowing through it.

Evaluating Results

Our conclusion was fairly simple to make, since our results were clear and told us everything we needed to know. To make our experiment more precise we would have needed more results though, which would give us a more detailed line and told us about what happens after 60 coils and before 10 coils. We could also have made it more detailed by using a smaller range-for example recording strengths of coils with 3,6,9,12,15 coils, instead of 10,20,30,40.

I feel our results were fairly reliable, in that there were no abnormal results and all our results fitted a general pattern. The only result that was slightly out of sync was the 30 coils recording. This may have been because the power pack had overheated a bit, affecting the magnetic field of the wire, or simply because we had to take an average, which may change recordings a bit from what they would be if they were totally accurate.

If I had more time I would probably do the experiment in more detail and look at more tests, instead of taking the average of 3. I would stretch it over a longer time period so the wire couldn't overheat and there was less of the human error factor. I would probably use a machine to avoid this human error, and look at more coils, for example, 2,3,4,5 coils, or 3,6,9,12,15 coils.

I could also investigate thicker wires, and different sized coils. I could see how current and iron cores affect the magnetic fields and then look at other materials of wire, for example, nickel, platinum, and other magnetic metals. I would use other methods of recording the field strength instead of a spring balance-maybe use paper clips instead. From there I could try using a lighter material instead of paper clips, for example steel shavings. I could also see how heat affects the magnetic field.