Electromagnetism: Home-made Electromagnet

Lab Plan
In this lab we will discover the correlation between electricity and magnetism and the resulting force provided. The electromagnetic force is one of the fundamental physical forces that govern much of what we experience in our daily lives. In this lab we will determine how to use electricity to magnetize metal. From this experiment we can answer some questions that arise about the relationship between electricity and magnetism. The relationship between electricity and magnetism is used in a wide array of applications that range from powering motors to recording sound and information.

Parts Choice
Here are the materials we will need to construct our electromagnet:

- Several feet of insulated wire
- 9-Volt Battery
- A nail (or a bolt)
- Permanent Magnet
- Small metal objects (e.g., thumbtacks, paper clips, etc.)
Lab Write up

**Home-made Electromagnet**

We begin at one end of the nail (or bolt) and wrap the wire in small tight loops around the nail. Next we attach the ends of the wire to the terminals of the battery. Touch the end of the nail (or bolt) to one of the metal objects. The object should stick to the nail. See how many objects you can pick up.

![Image of Electromagnet picking up clips](image)

Figure 1: image of Electromagnet picking up clips

The phenomenon we see here is Ampere’s law. The magnetic field in space around an electric current is proportional to the electric current which serves as its source, just as the electric field in space is proportional to the charge which serves as its source. Ampere's Law states that for any closed loop path, the sum of the length elements times the magnetic field in the direction of the length element is equal to the permeability times the electric current enclosed in the loop. What this basically means is that the magnetic field will increase when there is more current flowing around an object.

\[ \oint_C \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_{\text{enc}} \]

Now we will wrap more wire back over the loops previously made. The wire should still wrap around the nail (or bolt) the same way as before. Attach it to the battery again and see how many objects you can pick up now.

**Question 1:** What is the relationship between the magnetic field and electric current that enables a nail (or bolt) to become magnetized? *The relationship is Ampere’s law which is stated above. The magnetic field is proportional to the electric current which serves as its source.*

**Question 2:** Why did the magnetic field increase when you wrapped the wire back the other way? *The magnetic field increased because you increased the number of coils, and thus, the*
strength of the field. As long as you wrap it in the same direction, the field will continue to increase with each additional coil.

**Question 3:** What would happen if we used a larger voltage source? We would be increasing the current and would thus have a more powerful electromagnet by Ampere’s law.

**Question 4:** What would happen if you wrapped the wire around a plastic or wooden object instead of a metal nail? Why? There would still be some magnetic field but not as much. The wood or plastic does not conduct electricity well and is more used as an insulator. With a metal core, especially iron, the field is strengthened because of the material’s properties as a conductor.

**Question 5:** What would happen if we disconnected the wire from the battery? Would the nail still be magnetized? Why or why not? The magnetic field is created from the flow of current of the battery and would therefore not produce a strong enough current to make the nail magnetized. This relationship is described in Ampere’s Law.

Now we will determine which side of the electromagnet is north and which is south. Bring the north side of the permanent magnet to one end of the nail. Does the electromagnet repel or attract the permanent magnet? If the electromagnet repels the permanent magnet, then it is the north side of the electromagnet; if the electromagnet attracts the permanent magnet, then it is the south side. Opposite charges attract and so do opposite poles.

**Question 5:** How could you determine the direction of the earth’s north and south poles? The easiest way is to use a compass. You can actually create a compass using an electromagnet that we created in this lab.

**Conclusion**

Hopefully you are now familiar with the relationship between electricity and magnetism and how the two forces combine to produce the electromagnetic force. In fact electromagnets, also known as solenoids, can become quite sophisticated and are used in a variety of applications. It’s hard to imagine life without electromagnetism at work. For further exploration of electromagnetism try using wires with various resistances.