

Electromagnets

Experimental Design and Control of Variables

In this lab you will design and carry out one or more experiments through which you will investigate factors that impact the strength of an electromagnet. In the process, you will practice developing and testing models and learn about the importance of controlling variables.

An **electromagnet** is a magnet that is produced by passing current through a wire or coil of wire. An electromagnet is not a **permanent magnet** like those that hold papers up on your refrigerator. If you turn off the current flow in an electromagnet, the magnetic properties disappear. However, in most other ways, an electromagnet and a permanent magnet are identical.

Explore

1. You have been given a small bag of assorted objects, a compass and a permanent magnet. Play with these objects and make observations about how they interact. Confirm things that you think you know about magnets and try to learn something new. List several facts about magnets that you learned or confirmed.
2. Are magnets attracted to all metals? What evidence do you have for your answer?
3. Using only materials on your table, what types of observations could you make that would confirm that something is a magnet?
4. Suppose that you wanted to measure the strength of a magnet (electromagnet or permanent magnet). How might you use materials available on your table to do this? If you come up with more than one way to do so, decide which technique you think is the best. Write down how you would measure the strength of a magnet clearly but briefly.

The best (most valid and accurate) techniques for measuring the strength of a magnet give the same result for both very small and large magnets provided that the magnets have the same strength. The best techniques also keep constant how far from the magnet the force is measured. Otherwise, the measurement technique is a measure of the strength of the magnet AND size or distance.



Check your progress with your instructor.

5. Reconsider your approach to measuring the strength of a magnet from question #4 above. If you are satisfied with your approach write down “see #4”. Otherwise, write down how you now think it would be best to measure the strength of a magnet. Remember, we want to design a technique in which

the ONLY characteristic that impacts the measurement is the strength of the magnet.

Create a Model of an Electromagnet

As we stated above, an electromagnet is a magnet that is produced by passing current through a wire or coil of wire. A simple, straight wire with current flowing through it is an example of an electromagnet. However, you can make a stronger electromagnet by wrapping coils of wire around a metal nail or bolt. We call the nail or bolt a **core**. Very strong electromagnets are made by wrapping many hundreds of coils of wire around large iron cores and passing large currents through the device.

6. Consider the coil of wire (with the black coating) that is on your table. Is the wire attracted to the magnet when there is no current passing through it?
7. Coil the black coated wire around the shortest silverish bolt many times. Connect the ends of the wire to a battery so that current flows through the wire. What observations can you make to confirm that you have produced a magnet? **Please don't leave the battery connected to the wire for more than a few seconds or the battery will go dead.**
8. Discuss with your group members what physical characteristics of an electromagnet might contribute to its strength. Try to list at least 6 characteristics.



Check your progress with your instructor.

Suppose that you decided you want to do an experiment on the strength of an electromagnet. The characteristics of the electromagnet that might be changed to influence its strength are called **variables**. In order to mentally organize the variables associated with a system or process, scientists create models. A scientific **model** is a collection of ideas about a system and/or how a system behaves. Scientists develop models based on experimental results, but they also use their models to suggest new experiments that might be performed. Models allow scientists to explain, and make predictions about, the behavior of physical systems.

You can begin to develop a model of an electromagnet by generating statements about whether the strength of an electromagnet will increase or decrease if you change a key characteristic. For example, you might say “If I increase the number of coils in an electromagnet then the strength of the electromagnet will increase.”

9. Write down a short statement that can serve as a starting point for your model of an electromagnet. To do this, choose a variable from your list in #8 that you would like to investigate. Write a statement of the form “The

strength of an electromagnet will increase or decrease (pick one) if X increases.”

Design Experiments to Test and Refine Your Model

Experiments often take a form in which we *change* some variable and *measure the effect*. For example, we might change the number of coils in an electromagnet and measure how that affects the strength of the electromagnet. In an experiment, the characteristic or variable that we change, or allow to change, is called the **independent variable**. The measured effect is called the **dependent variable**.

A common phrase one hears in regard to scientific experiments is “control of variables.” When we **control a variable** we keep it constant. Generally, if one is trying to determine the influence of a variable it is best to hold all other variables constant. In other words, it is typically best to have only a single independent variable. **You can design valid experiments in which you change more than one variable at a time but it is much harder to interpret the results.** So, if you want to know the impact of a particular characteristic, try to design an experiment in which you change only that characteristic.

Next, you will design and conduct an experiment that will allow you to investigate how the variable you identified in question #9 above influences the strength of an electromagnet. **Experiments are how scientists test the validity of their models. When the result of an experiment conflicts with predictions made using a model then the model must be modified to align with the observed results.**

Here are some general tips for good experimental designs (1) Try lots of different values for the variable. Start by making measurements at the upper and lower end of your range of values to make sure that the measurements are possible. (2) Make careful measurements and record them in a neat, well-organized and labeled table. (3) Carefully record how you performed the experiment. You may need to go back to this information to make sense of the experimental outcomes (data).

Now, think about and discuss how you will perform your experiment.

10. Describe your experiment in a few brief sentences. Address the following questions: What will you change? Over what range of values or types? What will you keep constant? What will you measure? How will you measure it?



Check your progress with your instructor.

Carry Out Your Experiment

11. Perform your experiment to determine how your chosen variable impacts the strength of the electromagnet. Record your data in a way that makes clear to the reader (your teacher) what you did, what you were measuring and what your measurements were. **Please don't leave the battery connected to the**

wire for more than a few seconds or the battery will go dead. This means that you must figure out how to make measurements of the strength of the magnet quickly.

12. Generate an appropriate graph of your data. What conclusion(s) can you draw from your graph?
13. Think back to your model of an electromagnet that you expressed in question #9. Did your experiments confirm aspects of your model? Or, are there aspects of your model that need to be modified based on your experimental outcomes? Modify your model of an electromagnet as needed and restate it here.
14. What is the independent variable in your experiment? What is the dependent variable in your experiment? What variables were well controlled?

Sometimes there are variables in an experiment which we would like to keep constant (control) but which change nonetheless.

15. Were there variables in your experiment that were changing inadvertently?

In some experimental designs the effect of the independent variable is measured relative to an untreated system or group called a **control group** or just a **control**. For example, if you wanted to study the impact of a certain drug you might compare the long term health of a group of people treated with the drug to that of an untreated but otherwise identical group (the control). This type of experimental design is common in biology and other settings where there is often a large number of potentially difficult to control variables.

16. In a couple of sentences, compare and contrast a “controlled variable” with a “control group” or “control”.
17. Why is controlling variables or having a control group important?
18. Suppose that you need to study the effects of two different variables. Do you think that you can design a single experiment to study the effect of changing both variables or will you be forced to do two different experiments? Explain your reasoning or give an example.

When scientists perform an experiment they always repeat it. The repeats of the experiment are called **trials** and typically at least three trials of an experiment are performed. If scientists get the same general result each time the experiment is repeated the results are called **reproducible**. **Reproducibility is one of a few requirements that must be met before scientists accept experimental results as fact.**

19. Perform three trials of your experiments. Record the data in a table. You do not need to graph it. Do your results seem reproducible?