

Lab Handout

Lab 10. Magnetic Force

How Is the Strength of an Electromagnet Affected by the Number of Turns of Wire in a Coil?

Introduction

Magnets and magnetic fields are useful for many applications. For example, small permanent magnets and electromagnets are used in speakers that are found in cell phones or headphones used to listen to music. In a speaker, the changes in the magnetic field of the electromagnet cause parts of the speaker to vibrate, which produces the sounds we hear when we listen to music. The electromagnets in headphone speakers are small and fairly weak, but other electromagnets can be much larger and stronger, such as those used in junkyards to pick up and move old cars. Electromagnets are also used in the medical field in devices such as MRI (magnetic resonance imaging) machines. The powerful electromagnets in MRI machines influence the atoms in our bodies and allow doctors to create images that are useful in diagnosing injuries.

Permanent magnets, such as refrigerator magnets or those made from combinations of metals such as iron (Fe), nickel (Ni), or neodymium (Nd), always demonstrate magnetic properties. Permanent magnets are surrounded by a magnetic field. This magnetic field can influence other magnets or some materials (like some metals) and cause the objects to be pulled toward the magnet or pushed away from the magnet.

Magnetic fields can also be created when electricity passes through a wire. The electric current (moving electrical charges) in the wire creates a magnetic field surrounding the wire (see Figure L10.1). The magnetic field surrounding the wire is usually weak, but it can still have an effect on other magnets or materials. Coiling the wire will help concentrate the magnetic field on the inside of the coil (see Figure L10.2).

Turning a coil of wire into an electromagnet is as simple as wrapping the coil of wire around a piece of metal, such as an iron nail (see Figure L10.3, p. 99). When a wire is coiled around the nail, the magnetic field from the wire that is concentrated inside the coils magnetizes the iron nail and produces the electromagnet. Individual iron atoms can act like very small magnets, but inside a nail, the iron atoms point in random directions; therefore, the nail on its own does not act like a magnet. But when the iron atoms inside the nail are influenced by the magnetic field from the coil of wire, they change their alignment and point in similar directions. Only iron atoms inside the coil of wire will change their alignment, and the more atoms that point in the same direction, the greater the magnetic strength of the nail. The nail will only act like a magnet when the electric current is flowing through the wire; when the electric current stops, the iron atoms return to their original and random alignment and no longer act like a magnet.

FIGURE L10.1

Magnetic field surrounding a wire

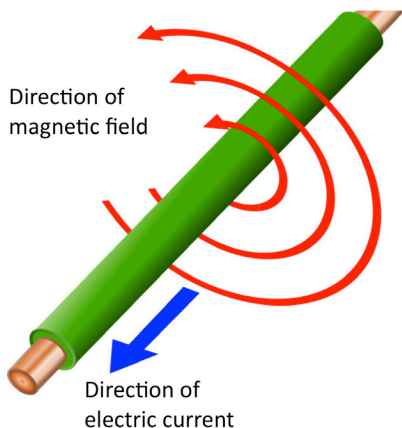
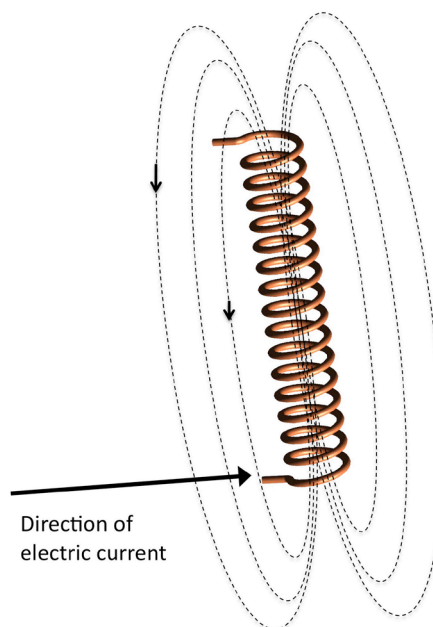


FIGURE L10.2

Concentrated magnetic field in a coil of wire



Your Task

Build an electromagnet using a battery, some wire, and a nail. Then, use what you know about magnetic fields, tracking energy in a system, and structure and function to design and carry out an investigation that will allow you to determine how the number of turns of wire wrapped around the nail affects the strength of the electromagnet.

The guiding question of this investigation is, **How is the strength of an electromagnet affected by the number of turns of wire in a coil?**

Materials

You may use any of the following materials during your investigation:

- Size D battery
- Battery holder
- Copper wire
- Iron nail
- Paper clips
- Gauss meter (optional)
- Electronic or triple beam balance
- Ruler
- Safety glasses or goggles

Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

1. Wear sanitized safety glasses or goggles during lab setup, hands-on activity, and takedown.

2. Given that the electromagnet setup will generate heat, disconnect the wire from the battery when not actively collecting data, to prevent skin burn.
3. Use caution when wrapping the copper wire around the nail. It is possible that the loose end will swing around during the wrapping process and present a hazard.
4. Use caution in handling the wire end or nails. They are sharp and can cut or puncture skin.
5. Wash hands with soap and water after completing the lab activity.

Investigation Proposal Required? Yes No

Getting Started

To answer the guiding question, you will need to design and conduct an investigation to measure the strength of your electromagnet. To accomplish this task, you must determine what type of data you need to collect, how you will collect it, and how you will analyze it. Figure L10.3 shows how to construct a simple electromagnet from a battery, a copper wire, and a nail.

To determine *what type of data you need to collect*, think about the following questions:

- How will you determine the strength of the electromagnet?
- What information or measurements will you need to record?
- What parts of the electromagnet will you change and what parts will you keep consistent?

To determine *how you will collect your data*, think about the following questions:

- What equipment will you need to collect the data you need?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- Are there different ways you can measure the amount of coils you used?
- How will you keep track of the data you collect?

FIGURE L10.3

Electromagnet made from a D-cell battery, a copper wire, and an iron nail



- How will you organize your data?

To determine *how you will analyze your data*, think about the following questions:

- How will you determine if the number of coils affects the strength of the electromagnet?
- What type of table or graph could you create to help make sense of your data?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

- why it is important to track how energy and matter move into, out of, and within systems;
- how the structure or shape of something can influence how it functions and places limits on what it can and cannot do;
- the difference between theories and laws in science; and
- the difference between data and evidence in science.

Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a *claim*, *evidence*

to support your claim, and a *justification* of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L10.4.

FIGURE L10.4

Argument presentation on a whiteboard

The Guiding Question:	
Our Claim:	
Our Evidence:	Our Justification of the Evidence:

Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique

the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they

can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- How did you collect your data? Why did you use that method? Why did you collect those data?
- What did you do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- How did your group analyze the data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that way?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most acceptable and valid answer to the research question!

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections. Each section should provide an answer to the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable and valid!