Magnetism and Electricity: Argument Driven Inquiry

Central Question: How is the strength of an electromagnet affected by the number of coils of wire?

Knowledge Probe:

What is electricity and electric charge?
What is a magnet?
How are magnetic and electric fields similar and different?
How does magnetism and electricity affect each other?

Background Information:

Magnets and magnetic fields are useful for many applications. For example, small permanent magnets and electromagnets are used in speakers found in mobile phones or headphones. 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 like 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, like refrigerator magnets or those made from combinations of metals like 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 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 2).

Turning a coil of wire into an electromagnet is as simple as wrapping the coil of wire around a piece of metal, like an iron nail (see Figure 3). When a wire is coiled like that, the magnetic field from the wire 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. When the iron atoms inside the nail are influenced by the magnetic field from the coiled wire, however, they change their alignment and point in similar directions. Only iron atoms inside the coil of wire will change their alignment. 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

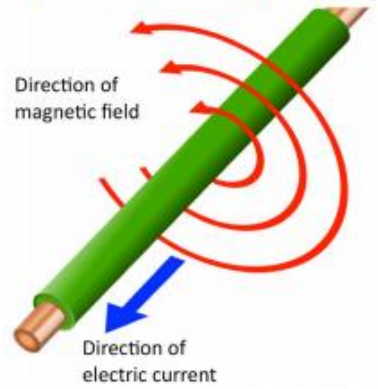


FIGURE L10.2
Concentrated magnetic field in a coil of wire

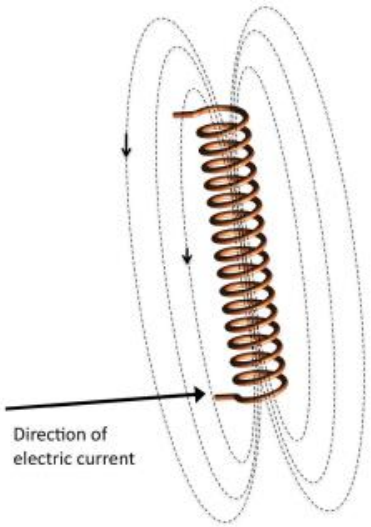


FIGURE L10.3
Electromagnet made from a D-cell battery, a copper wire, and an iron nail

The Task: Build an electromagnet using a battery, wire, and 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 to determine how the number of coils of wire around the nail affects the strength of the electromagnet.

Materials:

battery	paperclips	copper wire	iron nail
battery holder	balance	ruler	Gauss meter

Safety: Do not leave wire connected to battery for extended amounts of time. The battery and wire will become very hot.

Procedure:

1. Design and conduct an investigation to measure the strength of your electromagnet. Determine what type of data you will need to collect, how you will collect it, and how you will analyze it. Figure 3 shows how to construct a simple electromagnet from a battery, copper wire, and nail.

To determine **what type of data you will collect**, consider these 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**, consider these questions:

- What equipment will you need to collect the data you need?
- How will you make sure your data is 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 and organize the data you collect

To determine **how you will analyze your data**, consider these questions:

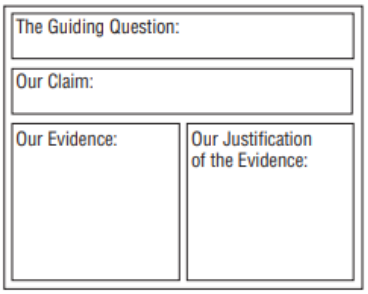
- How will you determine if the number of coils affects the strength of the electromagnet?
- What type of table or graph could you create to help make sense of your data?

Initial Argument:

Once you finish collecting and analyzing your data, develop an initial argument, including a claim, evidence to support your claim, and a justification of the evidence. The claim is your answer to the central question. The evidence is an analysis and interpretation of your data. The justification is why you think that evidence matters. This is important because scientists can use different kinds of evidence to support their claims. Create an initial argument on a poster as shown in Figure 4.

FIGURE L10.4

Argument presentation on a whiteboard



Argumentation Session:

One member of each group will stay at their poster to share your claim, evidence, and justification. The other members will rotate to other groups' posters to listen to and critique their arguments. If you are rotating and listening, your goal is to look for mistakes so they can be fixed and their argument can be better and stronger. Some good questions to ask might include:

- What did you do to collect these data? Why did you pick that method?
- How did you analyze your data? Why did you analyze it that way?
- What other ways of analyzing and interpreting data did you discuss in your group?
- What did you do to make sure your calculations were correct?
- Why did you present your evidence this way?
- What other claims did your group discuss before you decided on this one? Why did you abandon the other ideas?
- How sure are you that your claim is accurate? What could you do to be more certain?

This is also a good time to think about ways you can make your initial argument better and stronger. You will have a chance to review your own evidence with your group and revise your initial argument.

Report: Prepare an investigation report with three sections, typed in two pages or less, double spaced, TNR/Calibri, 11/12 pt font. Be sure to write in a persuasive style; you are trying to convince others your claim is acceptable and valid! Each section should provide an answer for these questions:

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