

Electromagnetism: Magnets and Motors

Student Version

In this lab, we will see how electricity and magnetism can be used together to create motion. Our source of electricity will be from a battery, and our source of magnetism will come from, of course, a magnet. With these two objects we will be able to create a motor, which will create motion in a piece of wire.

Key Concepts:

- An **electron** is a negatively charged particle.
- The flow of these negatively charged is called an **electric current**.
- When the electrons flow in this current, they carry an electric charge, which causes electricity. This is the same electricity used to power many machines that you see everyday. Batteries are used to store electricity until you are ready to use it.
- Electricity is closely related to magnetism. You are familiar with magnets. Motors work by using electromagnets. This means that the magnetic part of something is turned on and off by using electricity.
- Motors use electrical energy (from electricity) to create **mechanical energy**. In other words, motors are responsible for the movement of many devices including cars and computers. In fact, small motors and magnets are important parts of many kinds of medical equipment. Can you think of any other devices that use motors?
- A **conductor** is an object that allows a charge to flow. Depending upon a material's conductance, electricity can flow freely through the material. Metals are good conductors of electrical current. Another thing to consider when talking about electricity is resistance.
- **Resistance** is the opposition of electron flow. Materials with a high resistance are not good conductors of electricity since they keep the current from forming. The wire is a good conductor, and the coating that protects it does so because it has high resistance. In order for the current to complete the circuit, it must be allowed to flow from the wire to the paperclip with little resistance. To do so, we must remove the insulation (what allows the resistance to occur).

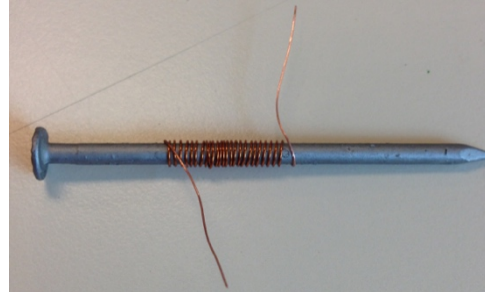
Part 1 - Electromagnets

In this part of the lab, we will see how an electric current can create a magnet out of normal metal objects. The metal objects that will be used are several different size iron nails, and the electricity will be provided by nine-volt batteries. The reason the nail becomes temporarily magnetic is because the electric current running through the wire creates a magnetic field. We will experiment with variations of the components of the electromagnets to see how changing these elements will affect the power of the magnets.

Effects of different amount of wires:

1. Wrap wire tightly around nail 10 times, leaving around 2 inches on each end. Remember to remove the insulation at the end of the wire using sandpaper or scissors.
2. Attach each end of the wire to battery using alligator clips.

****WARNING:** AFTER THE CIRCUIT IS COMPLETED, THE WIRES WILL GET HOT.



3. Straighten a paperclip.
4. On one end make a small loop that you can stick to the nail
5. On the other end make a little hook that you can tie the string to
6. Tie the string to the end of the hook and tie paper clips to the string every two inches starting 2 inches away from the magnet.
7. Slowly pick the string up and count how many paper clips make it fully in the air before the paper clip attached to the magnet falls off.
8. Record number of paperclips on the chart below.
9. Change the number of wraps around the nail to 25, then 50. Make sure the first coil is the same distance from the flat nail head each time.
10. Record number of paperclips on the chart each time.

Number of wraps of wire	Number of paperclips
25	
50	

Effects of different voltages:

1. Wrap wire around nail 50 times.
2. Attach wire to 1 battery.
3. Slowly pick the string up and count how many paper clips make it fully in the air before the paper clip attached to the magnet falls off.
4. Record number of paperclips on the chart on the next page.
5. Change the number of batteries to 2, and then 3, while keeping the number of loops around the nail the same (record number of paperclips on the chart each time).

Number of batteries	Number of paperclips
1	
2	
3	

Effects of different sized nails:

1. Wrap wire around the smallest nail 50 times.
2. Attach wire to 1 battery.
3. Slowly pick the string up and count how many paper clips make it fully in the air before the paper clip attached to the magnet and falls off.
4. Record number of paperclips on a chart.
5. Repeat steps 1-4 for the medium and large sized nails. Make sure the first coil is the same distance from the flat nail head each time.

Nail Size	Number of paperclips
Small	
Medium	
Large	

Concept Questions

- Q1. Why do you use steel or iron nails?*
- Q2. Why do you use insulated wire as opposed to non-insulated wire?*
- Q3. Based on the data for changing the number of coils, why would you want to have thin insulated wire instead of thick insulated wire?*

Q4. Why do you think you hooked the paper clips to a string and held the magnet by one paperclip?

Part II- Electric Motor

In this part of the lab, we will see how electricity and magnetism can be used together to create motion. Our source of electricity will be from a battery, and our source of magnetism will come from, of course, a magnet. To power the motor, electrons must flow freely through a good conductor to create electricity. The voltage of the battery we are using will also dictate how well and how fast our current moves through our conductor. The conductor in our motor will be a thin piece of copper wire to transport our electrons. As electricity flows through the wire, the wire will begin to rotate. This is the motion we are looking for in our motor!

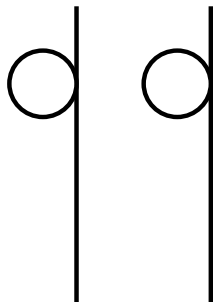
Procedure:

1. Make a coil of wire by loosely wrapping the wire around the fat marker (like a standard Crayola marker) least four or five times. Leave an inch or two of wire loose at each end of the coil.
2. Remove the coil from the marker and wrap the ends of wire around the coil to keep it from unraveling

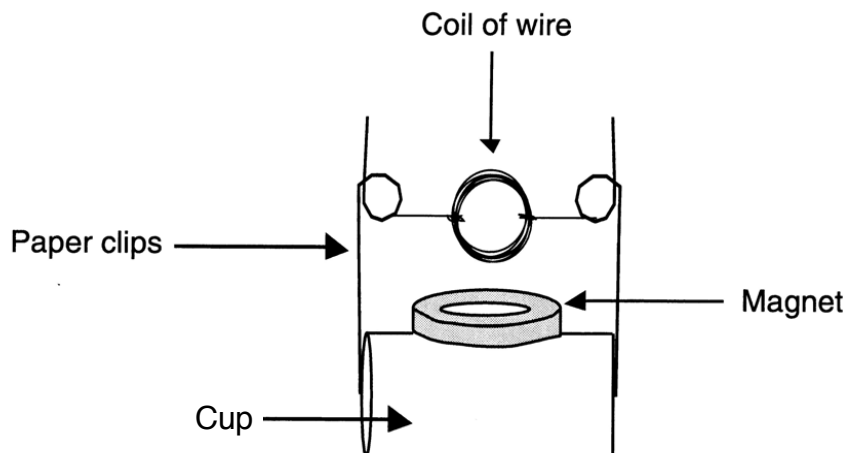


****NOTE:** The loop must be even and the end wires as straight as possible so that the coil will spin evenly. If the wires are unbalanced, the coil will be weighted down on one side.

3. The wire has a coating on it that acts as insulation. Strip .5 - 1 inch of coating off each end of the wire using the sandpaper. Don't rub too hard or the wire will break! Make sure all of the coating is off on all sides of the two ends.
4. Straighten the two paper clips and make a loop in each by wrapping the end of the paper clip around a pen or pencil. The loops should be near the end of the paper clip.



5. Place the cup upside down on the table and place a magnet on the bottom of the cup. Then attach one paper clip to each side of the cup with a rubber band so that the loops face up.
6. Place the coil of wire so that the ends stick through the loops in the paper clips and the coil is above the battery. Make sure the spinning coil just misses the magnet and the paperclip loops are level.



7. Clip one alligator clip to each of the paper clips and hook the other end to the battery.

****WARNING: AFTER THE CIRCUIT IS COMPLETED, THE WIRES WILL GET HOT**

8. Give the coil a gentle spin; adjust the paper clips and coil until the coil spins continuously.

Different Testing Ideas:

How can we make our motor more powerful?

We can test your ideas on how to create a more powerful motor. We can increase the strength of the magnet we are using (use two magnets instead of one), vary how far we have the coil from the magnet, use a different type of wire (different resistance or conductivity), or change the number of coils we have in our wire. Which change makes the motor spin faster?

Concept Questions

- Q5. An electromagnet is a magnet that runs on electricity. An electric current runs through an object (such as our wire) to produce a magnetic field. So, can you think of anything else in the motor that is magnetic beside the disk magnet we placed on top of the battery?*
- Q6. An insulator is a material that resists the flow of electric current. The insulation around the wire we used keeps the electricity within the wire. Do you think we needed to use insulated wire in order for our motor to work? Why or why not?*
- Q7. Why do you think we coiled the wire?*
- Q8. Why did we scratch the coating off the ends of the wires that touch the paper clips?*
- Q9. What happens if we increase the voltage supplied by the battery (or replace the one battery with two batteries)?*
- Q10. What would happen if the area of the loop was increased?*