UNLOCKING SCIENCE HANDS ON!

BATTERY-POWERED MAGNET

The electromagnetic force is one of the four fundamental forces we use to describe physics. Until 1873, electrical and magnetic forces were thought to be separate. That is when James Clerk Maxwell demonstrated and explained that they were actually different aspects of the same force. Michael Faraday, Hans Christian Orsted, Andre'-Marie Ampere, and many other scientists contributed to our understanding of this force. William Sturgeon applied these findings to create the first electromagnet from a piece of iron wrapped in copper in 1824.

Today, we take advantage of this amazing property of matter that God created to perform all kinds of tasks. From unlocking your car doors with a click to making a doorbell ring or picking up scrap metal at a junkyard, electromagnetism helps us do lots of things. And we generate electricity in generators and run motors using electricity using coiled copper and magnets. Can you imagine life without all of these wonderful inventions? We can thank God for his gifts and all of the people who create amazing ways to use them.

Extra Family Fun: Have a family gathering to discuss the importance of electromagnetism in allowing us to operate blenders, making milkshakes or fruit smoothies for everyone to enjoy.

Battery Ballerina

Supplies

- 12 inches solid, bare copper wire of 14, 16, or 18 gauge
- Pliers
- Strong neodymium magnet(s) (a diameter larger than an AA cell works best)
- Nail/nail set/Philips screwdriver
- Hammer
- AA cell

Figure 1: Supplies

Construction

1 The construction should be done with adult supervision.

2 Using the nail, nail set, or Philips screwdriver to tap a small dimple in the positive tip of the AA cell. This will provide a place for the wire to spin without slipping.

3 Fold the wire in half and use the pliers to tightly crimp a point where the wire will spin in the dimple.

4 Fold each side of the wire in a smooth curve 180°, making each side match as closely as possible. See Figure 2.

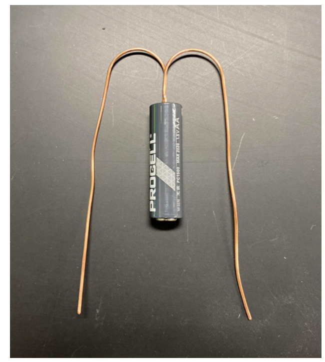

Figure 2: Bending the wire

5 Laying the cell on the table, fold a 90° bend in the wire back toward the center so that it is just longer than the battery (the wire will look like a B). See Figure 3.

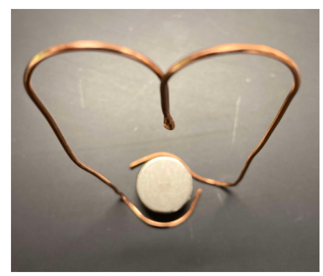

Figure 3: Bending the loop

6 Attach the magnet(s) to the negative end of the battery.

7 With each end of the wire, shape a curve that forms to the magnet in a semi-circle. The other end should be formed in the opposite direction so that the two wires will mostly encircle the magnet.

8 If needed, trim the ends of the wire so they don't contact one another.

9 Stand the magnet/cell with the magnets on the bottom.

10 Place the crimped tip of the wire into the dimple on the positive end and arrange the open loop at the bottom close to the magnet.

11 Adjust the wire with small bends so that it lightly contacts the magnet on both sides.

12 The wire should begin spinning, but it may need a gentle push to get it going.

13 Straighten and adjust the wire as needed to get a smooth spin.

14 Optional: Make other designs like a butterfly or a spiral.

Battery-Powered Electromagnet

Supplies

- 8 feet insulated copper wire (stranded or solid) in 16, 18, or 20 gauge
- Wire cutters
- Wire strippers/utility knife
- Long screwdriver, nail, or bolt made of iron/steel that is not magnetic
- Electrical tape
- Scissors
- Small paper clips or BBs (or some small iron objects)
- Assorted cells (AA, C, D) or batteries (9V, 6V/lantern)
- Marker
- 2 small plates or shallow dishes

Figure 4: Supplies

Construction

1 This activity should be done with adult supervision. **Important:** The batteries and cells can become hot very quickly, so do not leave the connections attached for more than a few seconds.

2 Test the screwdriver/nail/bolt to make sure it is not magnetic by bringing it near a paper clip.

3 Cut the wire into lengths of 18, 30, and 42 inches.

4 Use the marker to make a mark 3 inches in from each end of all three wires. This will leave a section of 1, 2, and 3 feet in the center of the three wires.

5 Strip about ½ inch of insulation from the ends of each wire. See Figure 5.

Figure 5: Mark and strip the wires on each end

6 Use a piece of electrical tape to attach the 18-inch wire near the tip of the nail/screwdriver where the mark is.

7 Coil the wire tightly and closely around the screwdriver up to the mark on the wire and use another piece of tape to attach the wire so the coil is fixed. Leave both loose ends pointing in the same direction.

8 Cut a small piece of electrical tape and attach

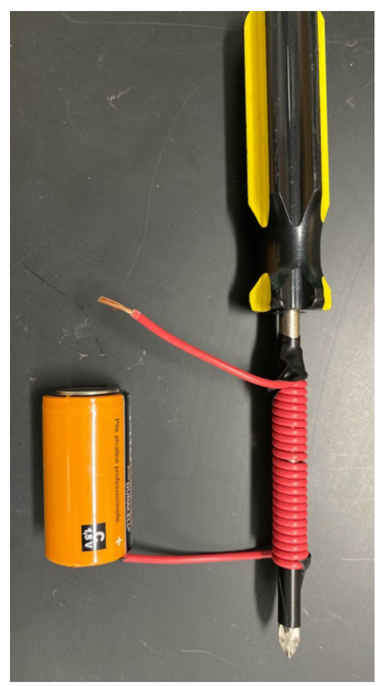

Figure 6: Coil and tape the wire to attach to the cell/battery

one end of the wire to the negative end of the cell/battery. (If there is no magnetic effect, flip the cell around.)

9 Press the other end of the wire against the positive terminal of the cell/battery to complete the circuit. This will create an induced magnetic field in the screwdriver.

10 Repeat steps 6–9 for each of the other wires as you conduct the experiment. You will create a 12-, 24-, and 36-inch coil with the three different wires.

Using the Electromagnet

You will be creating three different coils to use around the screwdriver to create an electromagnet. You can use various cells and batteries to power the magnet by connecting the ends of the cell/battery to the wires. Once you construct the 1-foot coil, test it with all of the different cells/batteries you have. Disassemble it and test all of the variables with the 2-foot and then the 3-foot coils.

To test the strength of the magnet, place a pile of small paperclips or BBs on a small plate or shallow dish. Connect the loose end of the wire on the negative terminal and bring the tip of the screwdriver into the pile. Slowly lift the magnet away and move it to the second dish. Disconnect the wire so the items are released and you can count them (do this as quickly as possible to reduce overheating). Replace them in the original dish. Make every attempt to repeat the same motions each time to limit the variables in each trial.

Important: If at any point you smell burning or the cell/battery gets hot to the touch, stop for a minute to let it cool. Never leave both ends of the wire connected to the cell/battery for more than a few seconds.

Activity: Carrying a Load

In this experiment, you will try to determine if there is a relationship between the length of the coil and the electromagnetic field produced by it. Using the three different lengths of wire, record how many items the magnet will pick up (do each length at least three times and use the average). Us the data table below to record your data. You can also try different cells or batteries for each length of wire. Get organized before you begin and have fun exploring. (Print off more data sheets if you need.)

Predictions

1 Do you think the longer, medium, or short coiled wire will pick up the most items?

2 If using different batteries/cells, which will pick up the most items using the same coiled wire?

3 Write an "if . . ., then . . ." statement about your predictions to form a hypothesis about the relationship between the length of the wire and the magnetic strength.

Data Table

Cell/Battery/ Voltage	Trial	12 inch	Average	24 inch	Average	36 inch	Average
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						

Analysis Questions and Discussion

Comparing the data in the table:

1 Were there any surprises in your data? *It is likely that the 24-inch wire picked up the most or that the 24- and 36-inch were almost the same.*

2 Did your predictions match your data? *Discuss the results in relationship to the predictions. A reasonable hypothesis would be: If the coil is longer, the magnetic force will be stronger.*

3 Which of the wires produced the strongest magnetic field? *It is likely that the 24-inch wire was able to pick up the most items, but with a higher voltage (like the lantern battery) the 36-inch wire may have picked up more. There are several factors including the strength of the cell/battery and the length of the metal rod that may affect the results. The 24 should pick up more than the 12, but the 36 may not.*

4 Why is it a good idea to do multiple trials and use an average to compare the wires? *In science, we want to verify our data by running multiple trials to make sure one or more of the trials was not a bad data point. The more times we run an experiment, the more reliable the trends in our data become. Scientists use statistics to evaluate data to ensure their values truly represent their experiments. Other scientists then seek to repeat the experiment before it is accepted as true. Good scientific experimentation is repeatable, observable, and testable.*

5 If your hypothesis or predictions was wrong, does that mean your experiment failed? *The only experiment that fails is the one you never do! As long as you learn something and move forward trying to understand it, the experiment was a success. Many of the most important scientific findings came after years of trials and exploration that may have initially seemed like failure. Being right with your predictions is not the most important part of science—continuing to look for the answer until you understand how God created it is the most important part.*

"Forever, O Lord, Your word is settled in heaven. Your faithfulness endures to all generations; You established the earth, and it abides. They continue this day according to Your ordinances, For all are Your servants." Psalm 119:89–91 (ESV)