4th - 8th Grade

4-H PROJECT LESSON PLANS:

4-H Helps YOUth Leap into the 21st Century

Series 2

"Wired for Magnetism"

LSU AgCenter
Research & Extension

Dear Project Helper,

This lesson, "Wired for Magnetism," is part of an effort by the 4-H Youth Development Department of the LSU AgCenter to provide teaching activities that are fun as well as educational. We are pleased you have agreed to work with youth as they learn and grow. You will help them learn scientific concepts that they will use for many years.

These lessons address the Louisiana Content Standards Science Benchmarks; therefore, what you do with this activity should help strengthen students for LEAP testing.

Thank you for your time and effort.

In this lesson, the following Benchmarks will be addressed:

SI-M-A2: designing and conducting a scientific investigation

SI-M-A6: comparing alternative explanations and predictions

SI-M-A7: communicating scientific procedure, information, and explanation

PS-M-A2: recognizing different forces and describing their effects (gravity, electrical, magnetic)

PS-E-C6: exploring and describing simple energy transformations

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Series 2

Learning Activity: “Wired for Magnetism”

Key Concepts:

1. When electricity flows through a wire, a magnetic field is produced around it, creating an electromagnet.
2. An electromagnet is a “temporary” magnet and exists only when electricity is flowing.
3. Different forces can create change.

How Can Members Apply this Information?

1. Identify the parts of an electromagnet.
2. Teach others what they have learned.
3. Apply team-building skills and research skills.

Getting Ready:

1. Gather all supplies and package into kits for each team in large zippered plastic bags.
2. Read lesson and background information to become familiar with the lesson.
3. Pre-strip wire with wire-stripping tool or paring knife.

What You Need for the Lesson:

Each electromagnet kit contains:

1. One 3- or 4-inch steel or iron nail or carriage bolt and nut
2. 24 to 30 inches of 22-gauge insulated magnet wire with 1 inch of the insulation stripped off at each end
3. One D cell battery
4. Two small pieces of electrical tape (to be given out by leader)
5. 22 paper clips
6. Instruction card with diagram. (Laminating will prolong use.)
7. One small scale for measurement (optional)
8. Experiment Record Sheet
9. Fact Sheet

Track:
Physical Science

Life Skills:
Problem Solving, Acquiring and Applying information, Observing and Experimenting

Character Focus:
Responsibility and Citizenship

Project Skill:
Creating an electromagnet

Louisiana Content Standards Benchmarks:
SI-M-A2, SI-M-A6, SI-M-A7, PS-M-A2, PS-M-C6, PS-E-C4, PS-E-C6, ELA-4-M2, ELA-4-M6, ELA-7-M2

Delivery Mode:
4-H club meetings, school enrichment and after-school programs

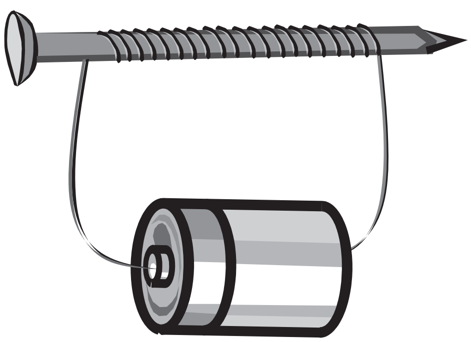
Time Allotted:
30 – 45 minutes

Minimum Number of Participants:
2-5 to a team

Background:

Magnetism is one kind of natural force that can be felt but not seen. Magnets radiate a force field. The area of space that surrounds a magnet is called a magnetic field.

An electric current flowing through a wire produces a magnetic field. Coiling the wire produces a stronger magnetic field. Coiling it around a soft iron core increases the effect; raising the electric current or the number of coils increases it further. Electromagnets are based on this simple principle.



An electromagnet starts with a battery (or some other source of power) and a wire. What a battery produces is **electrons**.

If you look at a battery such as a normal D-cell from a flashlight, you can see that there are two ends, one marked plus (+) and the other marked minus (-). Electrons collect at the **negative** end of the battery, and, if you let them, they will gladly flow to the **positive** end. The way you "let them" flow is with a wire. If you attach a wire directly between the positive and negative terminals of a D-cell, three things will happen:

1. **Electrons will flow** from the negative side of the battery to the positive side as fast as they can.
2. **The battery will drain** fairly quickly (in a matter of several minutes). For that reason, it is generally not a good idea to connect the two terminals of a battery to one another directly. Normally, you connect some kind of **load** in the middle of the wire so the electrons can do useful work. The load might be a motor, a light bulb, a radio or whatever.
3. **A small magnetic field is generated** in the wire. This small magnetic field is the basis of an electromagnet.

A basic electromagnet can be constructed around a large nail, a long carriage bolt or even a tightly scrunched "cigar" of aluminum foil. Almost any iron core will work. When the wires are attached to a battery (dry cell), the electric current around the wire and the "core" will form a magnetic field creating an electromagnet. When constructing an electromagnet:

- It is best to use magnet wire, because it is thinner, and you can get more turns in a smaller space.
- The best core to use is soft iron. If cast iron or steel is used, it will be magnetized after the current ceases.
- The wire of the coil is usually separated from the soft iron core by a layer or two of paper, which serves as an insulator.
- The wire should be wound in smooth, even layers.
- The outside diameter of the electromagnet should not be more than twice the diameter of the core.

4th-8th Grade "Wired for Magnetism"

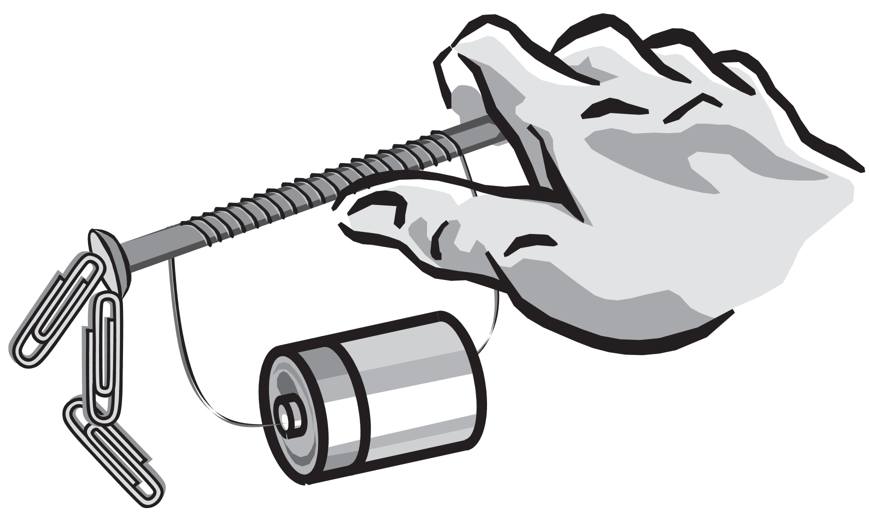
What You Say:	What You Show or Do:	What Participants Do:
Everyone knows about normal "permanent" magnets, such as the ones you use on your refrigerator at home to hold notes and pictures. All magnets have two poles, north and south, and magnets attract items made of steel or iron. Opposite poles attract, and like poles repel. Can anyone think of other uses for magnets besides holding up notes? (Radio, telephone, compass, other electronic devices)	Allow time for responses and discussion.	Name other uses for magnets.
An electromagnet acts the same way as a permanent magnet except it is temporary. A magnetic field exists only when an electric current is present. The first electromagnet was built by William Sturgeon in 1823 in England. He used a soft iron bar as the core because iron magnetizes more easily and makes a magnet stronger than steel. In 1831 Joseph Henry, an American, created an even stronger electromagnet by wrapping additional coils over the first coil and was able to lift a ton (2,000 pounds) of iron ore with a electromagnet powered by a single battery. We will form teams and make a simple electromagnet using things you are familiar with and see what it can do for us.	Show the electromagnet kit and help participants form teams of 2-5 members.	Form teams of 2-5 members.

4th-8th Grade "Wired for Magnetism"

What You Say:	What You Show or Do:	What Participants Do:
(Experience) Carefully empty the kit's contents on a table. What can we do with these materials? (Create a magnet, create an electrical circuit) What type of magnet can we create with the contents of your kit? (A temporary magnet because the magnetic properties are lost when the flow of electricity is turned off) The nail (or bolt) will become the magnet's "core." Touch the nail (or carriage bolt and nut) to two paper clips and see if they are attracted to it. Did anything happen?	Allow time for kit review and experiment with paper clips. Then have team members respond to question.	Look over the kit's contents and make predictions. Report findings.
You will use your instruction cards to build an electromagnet by following these steps: 1. One member of the team holds the wire about 6 inches from one end of the wire, against one end of the nail (or carriage bolt and nut) that will become the "magnet core." 2. Begin wrapping the longer end of the wire around the "core" in a tight even coil until you are about 6 inches from the other end of the wire. 3. Another team member attaches one end of wire at the "stripped" section to the positive end of your battery and the other stripped wire end to the negative end using the electrical tape. The electromagnet is now "charged."	You will want an instruction card with diagram for each team to follow. Assist groups as needed. Allow time for discussion and assembly.	Discuss, follow instructions and assemble their electromagnets.

4th-8th Grade "Wired for Magnetism"

What You Say:	What You Show or Do:	What Participants Do:
Let's see if your electro-magnet works by touching the paper clips again. Have a spokesperson from your group describe what happens.	Have each group pick up the electromagnet and touch the charged nail (or carriage bolt and nut) to the paper clips to see what happens now that a magnetic field has been created.	Each team does the experi-ment and reports its findings.
(Share) What happened to change the nail (or carriage bolt and nut) into a magnet? (Electricity passed through the coil of wire creating a magnetic field that attracted the paper clips.) Where did the electricity come from? (The battery was our source of power. Electro-magnets are powered by electricity.) What would happen if one wire were disconnected from the battery? (The electrical circuit will be broken, no electricity will flow and the magnetic field will not exist.) Electromagnets are temporary magnets. Why? (When the power is turned off or, in our case, the wire disconnected, the core has no magnetic properties. The flow of electricity creates the magnetism.) **SAFETY TIP:** Take the wires out from under the electrical tape to turn off the electro-magnet when you are not using it. You have probably noticed that the wire gets hot from all the electron traffic. It can use up your battery if you're not careful	Allow time for discussion and responses.	Discuss what happened and why.



4th-8th Grade "Wired for Magnetism"

What You Say:	What You Show or Do:	What Participants Do:
To test the strength of your electromagnet, let's see how many paper clips you can lift off the table. Experiment and discover what other items in the room your magnet is strong enough to pick up or attract. Remember that magnets attract many, but not all, metals. (They attract iron and nickel for example, but not aluminum.) Enter experimental results on the Experiment Log.	Provide a variety of metal and non-metal items to be tested if they do not exist normally in the room. (It will attract a food can, for example, but not an aluminum soft drink can. It will attract a dollar bill because the ink has a little bit of iron in it, so that vending machines can tell if it's the real thing. Provide a few items like coins, nails and hair pins in quantity, since their log asks for numbers attracted.)	Each team conducts the experiment, counts its clips and reports the results. Each team tests other items in the room. Enter items and totals on the Experiment Log.
(Process) As a team, decide what you could do to make your magnet stronger. (Add more batteries to increase the amount of electricity flowing through the wire. Additionally, adding more length to the wire coil or even wrapping several layers over each other concentrates the magnetic field. By increasing these two things together, engineers have developed very powerful electromagnets.) Why is it important to harness and use this type of force? (Decreases the need for other fuel sources to lift and move things. It produces less pollution.) Can you think of uses for these powerful electromagnets? (Junkyards use cranes with electromagnets to lift and move heavy scrap metal like cars from one location to another.) **CAUTION** - Why would you not want to put a magnet, especially an electromagnet, near a computer, floppy disks, VCR, video or cassette tapes? (The electromagnet can damage all of them.)	Allow time for discussion and responses. If a team has not finished filling in all of the information on its Experiment Log, have team do so at this time in preparation for the conclusion of the lesson.	Brainstorm, discuss and then respond with their answers.

4th-8th Grade “Wired for Magnetism”

What You Say:	What You Show or Do:	What Participants Do:
(Generalize) What did you learn about electromagnets? (An electromagnet is a temporary magnet. Electromagnets work only when electricity passes through a coil of wire. A battery serves as the energy source. Electromagnets can pick up several paper clips and other metal items. You can make an electromagnet stronger by adding more wire to the coil or by adding an additional battery. Strong electromagnets can pick up heavy metal objects such as cars, etc.) What are the three basic materials needed to make an electromagnet? (Electric magnet wire, a battery, a nail or carriage bolt and nut) Can you think of some other places you might find an electromagnet? (Electric motors, tape drives, speakers, medical equipment such as MRIs, sensors, automatic car-door locks, vehicles. A new type of spacecraft that would be jolted through space by ***electromagnets*** instead of propellants is being proposed.)	Allow time for discussion and responses.	Reflect and discuss.

4th-8th Grade "Wired for Magnetism"

What You Say:	What You Show or Do:	What Participants Do:
(Apply) How did this activity change your thinking about magnets and electricity? (I now know how electricity causes an object to become magnetized.) How can you use what you have learned in the future? (Answers will vary. Younger participants may want to make an electric motor. Older ones may be interested in researching the Internet for experiments with electromagnets or electricity.)	Allow time for discussion and responses. Go over suggestions in the "Ways to Help Members Learn More" section. Distribute handouts.	Reflect on the concepts they learned in the activity. Discuss ways to apply the concepts. Respond to questions.
Being a **responsible** person is critical to the successful completion of any project. It is your job to carry out experiments safely and to take care of all the items entrusted to you. A good **citizen** shows respect and cooperation when working with others. A good citizen also shares his or her knowledge with others. How could you teach others about electromagnets? What type of activity would you plan?	Discuss responsibility and citizenship. Suggest ways participants can teach others what they have learned in this activity. (Workshop for other members, science fair, summer camp, etc.)	Discuss possible activities for teaching others.

Ways to Help Members Learn More:

1. To learn how magnetism and electricity work together to create motion, construct a simple electric motor. Using most of the supplies you already have for this experiment and the 4-H project book, Magic of Electricity, pages 32 – 33, you can expand your knowledge of electromagnetic activity and how it works.

2. Explore the similarities of electromagnetism and the Earth's magnetic core.

3. Research use of electromagnets in the medical field.

Resources:

Community Service Learning: A Guide to Hands-On Science by Yolonda George, Maria Sosa, and Gaynelle Bowden, 1997.

4-H Project Book, Magic of Electricity, 4-H Cooperative Curriculum System Publication 4-H-BU-6848-2000

Web sites:

http://schoolnet.ca/general/electric-club/e/page12.html
http://lessonplanspage.com
http://www.teachers.net/lessons/posts/l.html
http://www.howstuffworks.com
http://home/houston.rr.com/molerat/mag.htm
http://www.thirteen.org/edonline/nttidb/lessons/kc/magntkc.html
http://www.si.edu/archives/ihd/jhp/joseph21.htm

Career Options:
Medical technician, biomedical engineer, science teacher, electrician, electrical engineer, inventor

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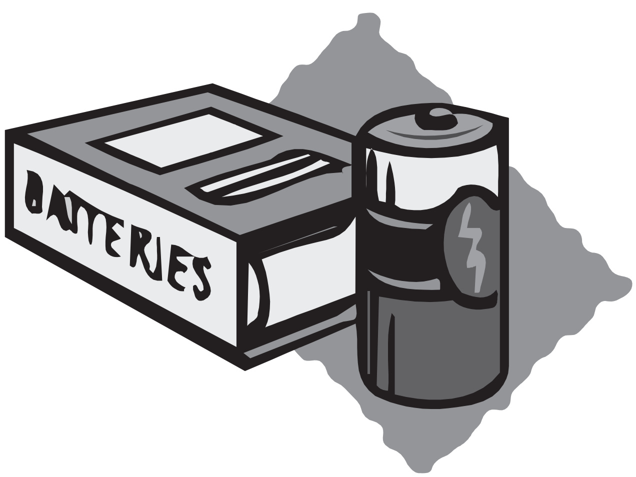
Evaluating 4-H Curriculum through the Design Process: Pilot Testing and Collecting Data for the 4-H National Jury Review Process, ©1999 by Purdue University, The Ohio State University. *Louisiana Content Standards,* published by the Louisiana Department of Education.



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Tips and Glossary of Electromagnetic Terms

1. **SAFETY TIP:** Take the wires out from under the electrical tape to turn off the electromagnet when you are not using it. You have probably noticed that the wire gets hot from all the electron traffic. It can use up your battery if you are not careful.
2. **CAUTION:** Don't put magnets, especially electromagnets near computers, VCR's, video or cassettes tapes.

Glossary:

Battery – A device for storing electricity.

Battery Terminals – The two points (one positive, one negative) for connecting a battery in a circuit.

Circuit – A path for electricity to flow.

Conductor – A material that allows electrons to flow easily.

D-cell battery – A common size of dry cell battery used in flashlights and other small devices.

Electricity – A form of energy; the flow of electrons.

Electromagnet – A magnet that operates through an electric source.

Electron – Everything in the world is made of tiny particles called atoms. Atoms are made up of particles called electrons, protons and neutrons. Electrons have a negative charge and protons have a positive charge. Electricity is produced when something upsets the balancing force between electrons and protons in atoms.

Insulator – A material that provides resistance to the flow of electrons.

Magnet – An object that attracts other magnetic materials.

Magnetic Field – The area surrounding a magnet where a force exists.

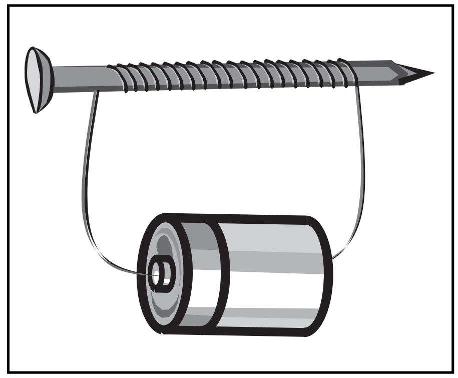
Poles – The opposite ends or sides of a magnet, referred to as north and south poles.

Repels – To force away; the opposite of attract.

Wire Stripper – A small tool used to remove insulation from the ends of wire.

Experiment Log for Electromagnets

Team #_____



You are the scientific research team exploring the "hold strength" of an electromagnet your team has designed. On this *Experiment Log Sheet,* record the following:

1. Total Number of Paper Clips our Electromagnet attracted and held in Experiment Number 1

____

2. List of other items attracted to our Electromagnet:

Item	Approximate weight	Total Number of this item attracted by our Electromagnet

3. What did you observe while doing your experiments?

____

____

4. Your team's conclusions from your experiments with your electromagnet:

____

____

5. Based on your experiments, what could you do differently, to design a stronger electromagnet?

____

____

Instructions for Building an Electromagnet

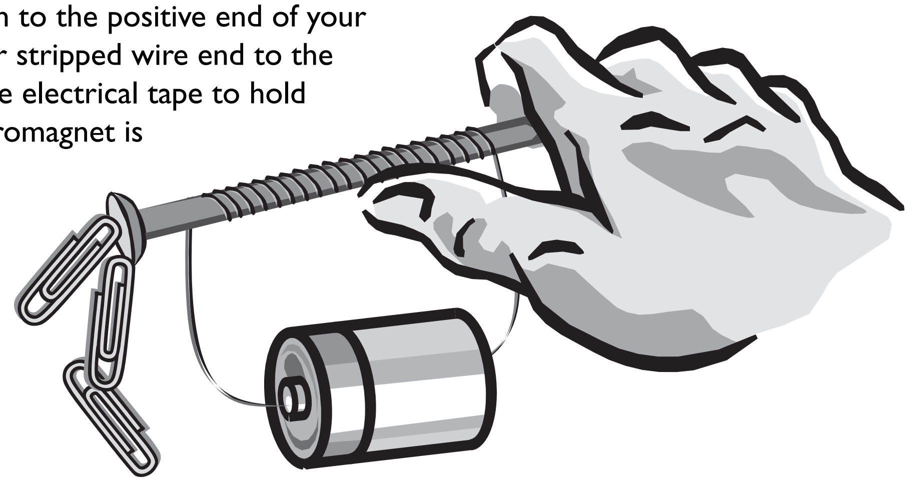
In your kit you have:

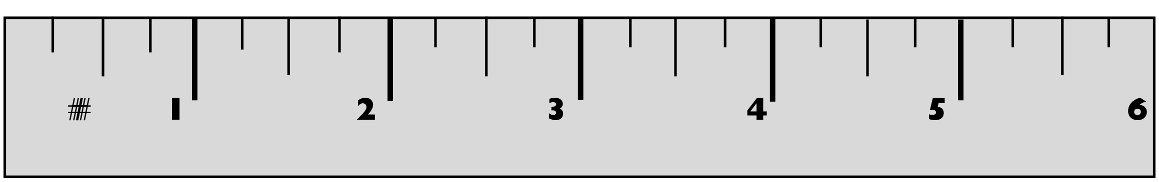
- one 3 – 4 inch steel or iron nail or carriage bolt and nut
- 24 – 30 inches of 22 gauge insulated magnet wire with one inch of the insulation stripped off at each end
- one D cell battery
- twenty-two paper clips
- This instruction card and diagram.

Your Project Leader will give you 2 small pieces of electrical tape

To assemble your electromagnet:

1. One team member will hold the wire about 6 inches from one end of the wire, against the nail or carriage bolt and nut that will become the "magnet core". There is a ruler at the bottom of this sheet to help you measure 6 inches)
2. Begin wrapping the longer end of the wire around the "core" in a tight even coil until you are about 6 inches from the other end of the wire. Stop – you are finished winding.
3. Another Team member attaches one end of the wire at the "stripped" section to the positive end of your battery and the other stripped wire end to the negative end using the electrical tape to hold it in place. The electromagnet is now "charged."





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