Electricity and Magnetism

Strand Magnetic field and electricity

Topic Investigating electromagnets and generators

Primary SOL

PS.11 The student will investigate and understand basic principles of electricity and magnetism. Key concepts include
- b) relationship between a magnetic field and an electric current;
- c) electromagnets, motors, and generators and their uses.

Related SOL

PS.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which
- j) valid conclusions are made after analyzing data;
- k) research methods are used to investigate practical problems and questions;
- m) models and simulations are constructed and used to illustrate and explain phenomena; and
- n) current applications of physical science concepts are used.

PS.5 The student will investigate and understand changes in matter and the relationship of these changes to the Law of Conservation of Matter and Energy. Key concepts include
- a) physical changes;
- b) chemical changes; and
- c) nuclear reactions.

Background Information

Electricity is related to magnetism. *Magnetic fields* can produce electrical current in conductors. Likewise, electricity can produce a magnetic field and cause iron and steel objects to act like magnets.

Electromagnets are temporary magnets that lose their magnetism when the electric current is removed. Both a motor and a generator use a magnet (or electromagnet) and a coil of wire that creates another magnetic field. The magnetic field from one wire is not very large. A larger field is created when the wire is arranged in a coil that puts many wires next to each other. The strength of an electromagnet can be increased in the following three ways:

- By increasing the current flowing through the coil
- By increasing the number of coils
- By putting a core of a magnetic material inside the coils so that the iron core becomes magnetized itself and makes the field stronger

A *generator* is a device that converts mechanical energy into electrical energy. Most of the electrical energy we use comes from generators. Electric motors convert electrical energy into mechanical energy that is used to perform work. There are motors in many household appliances, such as in blenders and washing machines.

Nuclear energy is an example of energy, which can be used to generate electricity. In nuclear *fission*, atoms are split apart to form smaller atoms, releasing energy. Nuclear power plants use this energy to drive generators that produce electricity.

Materials

- Iron nail
- Battery
- Wires
- Light bulb and socket
- Compass
- Paper clips
- Internet access
- Poster board

Vocabulary

electricity, electromagnet, fission, generator, magnetic field, motor

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

Review the basic principles and examples of magnets, including magnetic fields and poles, from prior lessons. Students will use a compass, electric circuit, and an iron nail to build an electromagnet and explore the relationship between electricity and magnetism.

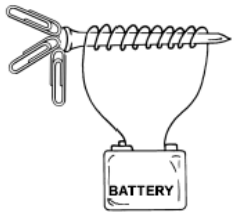
Part 1: Exploring Magnetic Fields and Electricity

1. Have students build a basic CLOSED circuit using two wires to test their batteries and light bulbs, making sure they are operating correctly.
2. While the circuit is CLOSED, students should move the compass around the circuit and record their observations.
3. Students should disconnect one wire, creating an OPEN circuit. The light bulb should be off. Have them move the compass around the circuit and record their observations.
4. Have students disconnect the light bulb from the circuit.
5. A compass has a needle that is magnetized on one end and normally points North due to the Earth's natural magnetic field. Have students compare and contrast how the behavior of the compass was affected when it was placed near each circuit.
6. Have students write a conclusion that explains why the behavior of the compass changed.

Part 2: Building an Electromagnet

1. Have students test an iron nail to see if it is magnetic by attempting to pick up paperclips with the iron nail. Have them record the number of paperclips they were able to lift with the nail.
2. Have students hold the compass near the iron nail. Ask them if the nail has any effect on the compass?
3. Have students wrap one wire around the nail 10 times and attach each end of the wire to the battery. While keeping the circuit CLOSED, and the iron nail wrapped in the wire, have

students test the number of paperclips it can pick up. Have them retest the nail and the compass and record any behavior changes.



4. Have students disconnect the wire and wrap it around the iron nail 10 more times (20 total), then reconnect the circuit and test it again. Have them retest the nail and the compass and record any behavior changes.
5. Have students repeat step 4 with 30 coils. Students should record their findings from steps 3–5.
6. Have students remove the nail, leaving the coiled wire attached to the battery.
7. Have students test the coiled wire to see how many paperclips it can pick up without the nail.
8. Have students test the iron nail by itself, recording the number of paperclips it picks up.
9. Have students disconnect all wires and record all observations.

Part 3—Investigating Motors and Generators

In Parts 1 and 2, the class observed how current flowing through a wire produces a *magnetic field.* Around every magnet there is an invisible magnetic field, and when a magnet, such as a compass, was placed in the magnetic field, it experienced a force**.** A force (***f)*** is a push or a pull. A force can lift an object, change its shape, or accelerate it. A larger magnetic field or a larger current will produce a larger force.

When the wire is shaped as a coil, the current will force the wire to rotate and cause the electrical energy to be converted into mechanical energy. A generator uses the reverse process to convert mechanical energy into electrical energy.

Power stations produce electricity by converting energy from one form to another, using a generator. The electricity produced is transferred to homes at a high voltage through a series of overhead and underground cables. Appliances such as vacuum cleaners and hair dryers contain motors which convert the electrical energy back to mechanical energy.

1. Have students work in groups of three or four to conduct Internet research on one of the following Virginia power plants and answer the questions below.

North Anna Power Plant	Gaston Hydro Station
Bath County Pumped Storage Station	Surry Power Station
Northern Neck Power Station	Bear Garden Power Station
Chesterfield Power Station	Clover Power Station

- Where is the power plant located?
- What fuel source is used to generate electricity at the power plant?
- Approximately how much power is the plant able to produce?

2. Have groups describe the process of generating electricity in the power plants they selected. Have them include details of how the energy is transformed from one type to another.
3. Have groups create diagrams showing all possible conversions of energy for a residence, beginning with the fuel source and ending at a motor used in the home. Have them circle the parts of their diagrams that represent where the generator is located and draw squares around the items that contain motors.
4. Have groups design posters to creatively display their information. Have them illustrate examples of generators and motors in their power plants.
5. Have groups share their posters with the class.

Assessment

- **Questions**
  - What is the relationship between electric current and magnetic field?
  - How would you compare and contrast generators and motors? What are some examples of each?
  - How would you diagram the operation of an electromagnet?
- **Journal/Writing Prompts**
  - The Law of Conservation of Energy states that energy can neither be created nor destroyed, but converted from one form to another. Explain how this is evident in the process of fission used by nuclear power plants.

Extensions and Connections (for all students)

- Have students visit a local power plant.
- Have students build a solar-powered toy car and identify the car's fuel source, describing how it is transferred to electrical energy and then to mechanical energy.
- Have students research the advantages and disadvantages of nuclear-powered plants and coal-powered plants. Students should decide which type they would rather operate in their neighborhood and defend their decision.

Strategies for Differentiation

- Create a T-chart in Part 1 to record class observations of open and closed circuits.
- Provide a worksheet that outlines step-by-step procedures and provides spacing for drawings and recording observations in Part 2.
- Provide small appliances (e.g., hair dryer, vacuum cleaner) that students can take apart and investigate in order to see how motors are used in real-world applications.
- Provide printed materials and photos of the power plants to help students complete Part 3.