Science Unit: *Physics Ideas*
Lesson 6: *Electromagnetism - Invisible Forces*

School year:	2006/2007
Developed for:	Tecumseh Elementary School, Vancouver School District
Developed by:	Paul Nagelkerke (scientist), Marie Chomyn and Fern Louie (teachers)
Grade level:	Presented to grades 6-7; appropriate for Grades 6-7 with appropriate modifications.
Duration of lesson:	1 hour and 20 minutes
Notes:	These activities are likely to take longer than the estimated duration. Originally they were set up in a station approach with an instructor. Students continued to work on science activities during the week following the lesson. Although the scientist utilized Lego Technic devices (which are good for manipulation by students), alternate manufacturers' devices are available.

Objectives

1. Learn about magnets, magnetism, and the properties of magnetic fields.
2. Learn about electricity and how it can be generated.
3. Learn the properties of generating electricity from movement, and movement from electricity.

Background Information

Static electricity is difficult to control and use efficiently, it is difficult to generate, can be deadly, and not efficient in converting to mechanical movement.

Current electricity is easy to control: it can be generated by simple mechanical systems or batteries, is very easy to control through switches or solid state electronics, and not very deadly.

Current electricity is generated whenever a magnet and a conducting wire interact, or when a chemical reaction is controlled in a battery. Mechanical movement can be converted into electricity, and vice-versa. "Shake" flashlights use an oscillating magnet to generate electricity, while "Squeeze" flashlights have a mechanical system to change linear motion to rotational motion in a generator. An electric motor converts electricity to magnetism to mechanical movement.

We need to efficiently transfer power from a power source to its intended destination. If we use falling water to drill a hole in a piece of wood, it would be inefficient to take the wood all the way to our waterfall. There used to be direct mechanical connections between a waterwheel and our drill, but electricity has replaced mechanical connections with copper wire.

Inefficient light bulbs are being replaced with much more efficient Light Emitting Diodes (LEDs) which convert electricity directly to light without having to generate heat.

Vocabulary

Current Electricity	Electricity produced by a flow of electrons through a circuit.
Battery	Uses a chemical reaction to produce direct current electricity
Voltage	A measure of the push a battery gives electrons to move through a circuit

Amperage	The volume of electrons moving through a circuit
Circuit	A pathway allowing electrons to travel from one terminal of a battery to the other.
Light Bulb	An illumination device consisting of a thin wire in an evacuated glass bulb. Electricity flowing though the wire encounters resistance at the thin wire, generating heat which makes the wire glow white hot. This results in light and heat radiation from the wire or "filament" of the light bulb.

Materials

- 8 simple circuit sets:
    - C or D size battery in battery holder
    - 1 metre length of insulated wire
    - 1 light bulb in holder
    - Compass

- Optional: Volt meter and Ampere meter

- LEGO Technic geared motor
- LEGO Technic direct drive motor
- LEGO Technic incandescent and LED lights
- LEGO Technic connecting wires
- LEGO Technic gears, shafts

- 8 Simple motor sets
    - AA battery
    - Round Rare-Earth magnet
    - Length of copper wire
    - Bare metal nail or screw

In the Classroom

Introductory Discussion

1. Teacher: Initially demonstrate each circuit and equipment setup.

2. You can not see a magnetic field, but you can demonstrate its shape and measure its relative strength with the compass.

3. Follow the instructions carefully; keep the magnetic flashlights away from computers, credit cards, and personal electronics.

4. Do not "short circuit" the batteries by connecting them without a light bulb in the circuit.

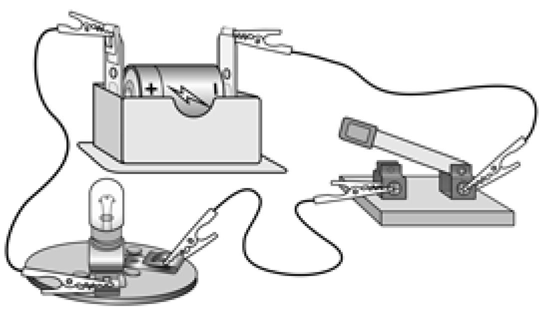
Science Activity/Experiment

Stations are set up in the classroom. One or two adults can run the entire class.

Divide the students into three or four equal groups. Save some time at the end of each class to discuss the student observations.

Part 1 – Complete the circuit

- Hook up the battery, switch, and light bulb to make a complete circuit. When the switch is closed electrons flow through the wire and heat the filament of the bulb. An electrical circuit is complete when there is an uninterrupted path from the negative side of the battery to the positive side of the battery.
- Electricity is conducted by the copper metal in the wire, and is blocked or insulated by the plastic exterior around the wire. The insulation allows control of electrical circuits, allowing wires to touch but not conduct electricity.

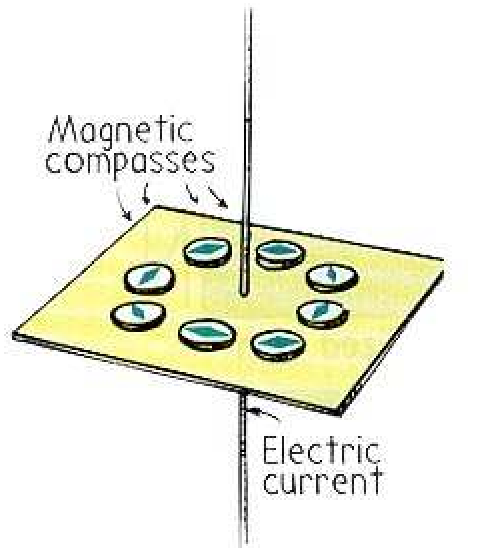


- When you complete the circuit the electricity starts to flow almost immediately. When you open a nozzle on a pressurized water hose a pressure pulse travels through the water at the speed of sound. When you complete an electronic circuit the electrical pulse travels at near the speed of light. The actual electrons flowing through the wire travel at about 1 mm/s.
- Optional: Use a Volt meter to measure the flow of electricity through the circuit. Set the Voltmeter to a scale of 2 volts, and touch the black probe to the negative terminal of the battery. With the switch open, touch the red probe to both sides of the switch, the light bulb, and the positive terminal of the battery. Record the voltage reported by the meter at each of these points in the circuit.
- Close the switch and measure the voltage at each of the same points on the circuit. Does the battery produce the same voltage when the light is illuminated? Where does the voltage change around the circuit?
- An ammeter measures the volume of electricity flowing through a circuit. Place the ammeter into the circuit and measure the volume of electricity or current. Report the current in milliamps. Put the ammeter in different places around the circuit, is the current the same at all locations?

Part 2 – Map Magnetic Fields

- Use a compass to look at the magnetic field around un-energized wires. Your compasses should align themselves to the Earth's North-South magnetic field. Close the electrical circuit and look at the magnetic field again.
- Hold the compass beside a horizontal wire while it is energized or un-energized. How does the compass needle move?

- Hold the compass around a wire arranged vertically. How does the needle move when the wire is energized? Move the compass around the wire, and up and down the wire. What is the shape of the magnetic field around the wire?



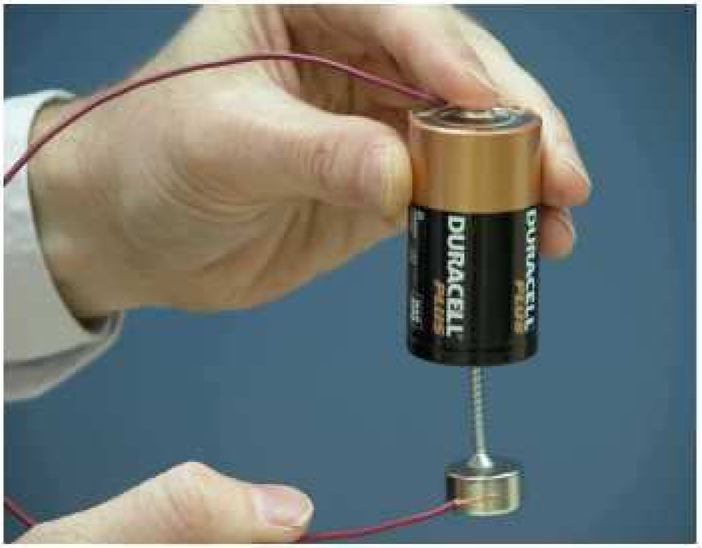
- Draw diagrams of the magnetic fields, noting the polarity of the battery and the North and South poles of the magnets. How far away can you detect the magnetic field around the wire?
- Make a loop of wire in the circuit and study its magnetic field. Does having more than one loop of wire make the magnetic field stronger or weaker? Record your observations.

Part 3 – Generator

- Take a look at the "Shaker" flashlight. When the magnet moves through the coil it generates electricity which is stored in a rechargeable battery. Does the flashlight charge up with slow movements or only fast? What do you think would happen if the oscillating magnet were replaced with a magnet going in only one direction around in a circular track?
- Hook up the LEGO motor to a light bulb. Turn the motor shaft. Does the light illuminate? How is this related to the flashlight? The motor is being used as a generator, turning mechanical movement into electricity.
- Replace the LEGO light with a motor. One person turns the generator, the other tries slowing down the motor as if they were using an electric drill. Does the generator feel the load being exerted on the motor? Write down your observation.

Part 4 – Simple Electric Motor

- Arrange the battery, wire, metal screw, and magnet and arrange them as shown in the picture.
- The screw is magnetically attracted to both the battery and magnet, yet can spin freely. Touch the wire to the side of the magnet. What happens? Turn the magnet over and try again. Does the magnet spin in the same direction? Draw a diagram of the setup, including the polarity of the battery, the polarity of the magnet, and the direction of rotation.
- Turn the battery over, and touch the wire to the magnet again. Does the magnet turn the same way as the previous setup? Turn the magnet over and try again. Record your observations.



The above image is from: http://www.grand-illusions.com/articles/homopolar_motor/

Science Journal: Students will record their observations at each station to understand the relationships between each of the simple machines.

Closure Discussion

Examples of questions to ask students

- Why should we turn off lights when we leave a room? How is electricity generated in BC? In the rest of Canada? In the rest of the world?
- Name some non-polluting methods to generate electricity.

References

- BC Hydro web site: http://www.bchydro.com/info/system/system15250.html
- http://education.jlab.org/qa/electromagnet.html
- http://www.grand-illusions.com/articles/homopolar_motor/

Extension of Lesson Plan

1. Why is the North American electrical grid 60 Hz and 120 Volts AC, while most European grids are 50 Hz and 220 Volts AC?.