Generator
(Electromagnetic Induction)

Objective:
Students will observe the relationship between magnetism and electricity by using a coil of wire and a magnet to produce an electric current.

Lesson Question:
How can we make an electric current?

California Science Content Standards:
Grade Four 1. d. Students know the role of electromagnets in the construction of electric motors, electric generators, and simple devices, such as doorbells and earphones.
Grade Six 3. a. Students know energy can be carried from one place to another by heat flow or by waves, including water, light and sound waves, or by moving objects.
   6. a. Students know the utility of energy sources is determined by factors that are involved in converting these sources to useful forms and the consequences of the conversion process.
Grade Eight 7. c. Students know substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity.
Physics 5. h. Students know changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.

Materials:
For each group:
Wire (solid core works best) one piece approximately 2-3 meters long, one piece approximately 6 meters long.
Sandpaper (for enamel coated wire), wire strippers or scissors (for insulated wire)
Cardboard tube (small diameter tube works best)
Masking tape
Strong magnet (cow magnets work well)
Battery
Cardboard piece (approximately 6cm x 8cm)
Scissors
Compass

Optional: galvanometer or sensitive multimeter

Extension: hand-powered generator(s), wire and light bulb
Procedure:
1. Move the magnet around near the compass to observe how the compass reacts in the presence of a magnetic field.

What does the compass needle do? (It moves around.)

To make a “current detector”:
2. Use the scissors to cut out a “curve” on each of the 8cm sides of the piece of cardboard.
3. Make a masking tape loop and secure the compass to the center of the piece of cardboard with North and South pointed towards the cut outs (East and West will be pointed towards the straight, 6 cm sides)
4. Wrap the shorter piece of wire around the compass and cardboard (wrap around the cut out on the cardboard—north and south) using masking tape on the back of the cardboard to secure. Make sure to leave approximately 15-20 cm. of wire free at each end.
5. Sand or strip both ends of the wire.
6. Test the current detector by briefly touching (touch and release, touch and release) the ends of the “current detector” wires to the battery terminals.

What does the compass needle do when there is electrical current in the coil of wire? (The compass needle moves around—similar to what was observed when the permanent magnet was near the compass.)

To make a simple electrical generator:
7. Wind the longer piece of wire around the cardboard tube leaving approximately 20 cm. free at each end. Use masking tape to secure the coil.
8. Sand or strip both ends of the wire.
9. Connect both ends of the wire to the “current detector”. Keep the current detector as far away from the cardboard tube as possible.
10. Move the magnet in and out of the coil of wire on the cardboard tube and observe the “current detector”.
What happens to the compass needle when magnet is moved inside the coil of wire? (The compass needle moves.)
What does the movement of the compass needle indicate? (It indicates the presence of an electric current.)

11. Hold the magnet still inside the coil of wire on the cardboard tube and observe the “current detector”.

What happens to the compass needle when the magnet is held still inside the coil of wire? (The compass needle moved when the magnet was first put into the coil, but then the needle is still.)

12. Move the magnet near the outside of the coil of wire on the cardboard tube and observe the “current detector”.

What happens when magnet is moved outside of the coil of wire? (The compass needle moves.)
What does moving compass needle indicate? (It indicates the presence of an electric current.)

13. Hold the magnet still outside the coil of wire on the cardboard tube and observe the “current detector”.

What happens to the compass needle when the magnet is held still outside the coil of wire? (The compass needle moved when the magnet was first put near the coil, but then the needle is still.)

Optional:
Connect the coil of wire to a galvanometer instead of the “current detector” and observe.

Extension:
Use the hand-powered generator to show the same parts [coil(s) and magnet(s)].
Use the hand-powered generator to light up a bulb. Connect the hand-powered generator to another generator so that one functions as a motor to show the relationship between the generators and motors.

**Debriefing:**
What happened when you moved the magnet inside or near the coil of wire on the cardboard tube? (The compass needle moved indicating there was electric current.)
What happened when the magnet was held still? (The compass needle did not move.)
What two things are needed to make electricity? (a coil of wire and a magnet)
What did you need to do to make an electrical current? (The magnet has to move in or near a coil of wire to make an electrical current.)
How do you think the electricity we use in our homes is generated? (The same way—coils of wire and magnets move in relation to one another, usually one or the other is spinning. Most generators use a spinning turbine to make electricity.)
How about the electricity to run our cars (the battery is only for starting the car—many cars will run without a battery if you can push start them)? (Cars generate their own electricity using coils of wire and magnets.)
How do you think the electricity in a portable generator is made? (Electricity in a portable generator is also made using coils of wire and magnets.)
What energy conversion is taking place in the generation of electricity? (movement (kinetic) energy is converted to electrical energy.)

**Assessment:**
Draw and explain how to generate an electrical current.
Generator / Motor Comparison