

## Lesson 3: Dynamos

### Adopted/Revised From

[http://amasci.com/coilgen/generator\\_1.html](http://amasci.com/coilgen/generator_1.html)  
[www.teachingengineering.org](http://www.teachingengineering.org)

### Grade Level

6-12

### Objectives

- Construct two dynamo electric generators
- Troubleshoot and reconstruct for the most efficient design
- Compare similarities and differences between the two
- Explain how electricity is generated by identifying the common component in both

### Overview

Students observe magnetic properties of electricity flowing through a wire, construct 2 different generators, troubleshoot until they both are functioning, and compare/contrast the similarities and differences to determine how electricity is generated.

### Materials

#### Opening Activity

- Tape
- One Magnetic compass per group
- One 6" wire
- One AA battery per group

#### Generator #1

- Four ½"x1"x2" rectangular ceramic magnets per group (i.e. Radio Shack #64-1877)
- One roll of enamel-coated magnet wire, 200 feet 30 gauge (i.e. Radio Shack part # 278-1345)
- One 12V DC piezo buzzer, 3.0-28V DC, 5mA (i.e. Radio Shack 273-0060)
- One heavy duty corrugated cardboard strip 3.5" x 10" (from recycled box) per group
- One 3-4" nail per group
- One small cork per group
- Template of corrugated cardboard (see template design below)
- One craft knife (i.e. American Science & Surplus #93796)
- One multimeter per group (i.e. Kid Wind #H0022)
- Sandpaper – fine grit, ½ sheet per group
- One ruler per group
- One rubber band per group
- Adhesive tape

## Generator #2

- Six to twelve strong ½ inch diameter circular magnets (magnet strength rating = 10; i.e. Craft Power Magnets, Hobby Lobby sku# 179762)
- One roll of enamel-coated magnet wire, 200 feet 30 gauge (i.e. Radio Shack part # 278-1345)
- One 12V DC piezo buzzer, 3.0-28V DC, 5mA (i.e. Radio Shack part # 273-0060)
- One clear plastic tube at least slightly larger than ½ inch in diameter, at least 5” long (like a pen casing or a small plastic test tube or a cylinder from a container of beads)
- One multimeter per group
- One rubber band per group
- Sandpaper – fine grit, ½ sheet per group

## Elaboration Activity (optional)

- One AA battery per group
- 50 feet of 30 gauge magnet wire per group
- One large iron nail per group
- Sandpaper
- Adhesive tape
- Twelve paperclips per group

## Estimated Cost of Materials

\$50

## Computer Required

No

## Duration

2 class periods

## Primer References

- 1.1 Forms of Energy
- 1.2 Sources of Energy
- 1.3 Units of Energy
- 1.6 Electricity Generation

## Related Articles

- The Institute for Energy Research: Colorado Energy Facts (2010)  
<http://www.instituteforenergyresearch.org/state-regs/pdf/Colorado.pdf>

## Engagement

1. What is electricity?
2. How can we control electricity?
3. Why is that important?
4. How can electricity be generated?
5. Why are we using magnets when we generate electricity?

## Investigation

We are going to build two types of electric generators and compare how they are similar and how they are different in order to figure out what is producing electricity. Students will use a AA battery to explore the induction effect between magnetic and electric fields and assess how this current affects the magnetic needle of a compass:

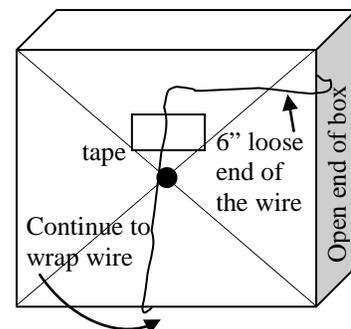
1. Divide the students into four groups.
2. Hand each group 1 AA battery, 6" length of insulated wire, tape, and a compass.
3. One student will tape one end of the wire to the positive pole of the battery.
4. One student will hold the compass level so that the needle is parallel to the floor and everyone in the group can see it.
5. The student with the battery will hold the battery directly under the compass.
6. A third student will take the dangling wire and encircle the compass with it, holding it by its insulation and bringing the exposed wire end just up to the negative pole of the battery.
7. When everyone is watching the compass needle, the student with the wire will briefly touch the negative pole of the battery. The compass needle will jump as it reacts to the changed electric field. Do this several times to be sure of the effect. **Caution: Do not hold the wire against the battery for more than a fraction of a second. The battery and wire will become very hot quickly!**
8. Have all the students read the following passage from [www.teachingengineering.org](http://www.teachingengineering.org):

Electric fields and magnetic fields are closely linked. Magnetic fields affect moving electrons, a principle that underlies iron's, nickel's, and cobalt's easy attraction to magnets. The reverse is also true: moving electrons create magnetic fields. The net movement of electrons in a simple circuit is sufficient to generate a magnetic field. The stronger the electric current, the stronger the magnetic field induced is. If there is no electric current, then there is no magnetic field.

9. Assign half of the groups to Generator 1 and the other half to Generator 2.
10. Supply each group with the materials listed according to which generator they will be building.

### Generator #1:

1. Using the template following this lesson plan, cut the corrugated cardboard outer rectangle (10"x3.5"). This is called the housing.
2. Score the four inner lines with the edge of the scissors.
3. Fold the rectangle at the scored lines, using the ruler as a brace to get straight edges.
4. Panel #5 will fold over Panel #1. Tape to secure.
5. Tape all edges of your open ended box to reinforce corners.
6. Mark your box at the center point, using your ruler to find the midpoint (draw a line diagonally corner to corner in each direction, and the midpoint is at the intersection of the two lines) as indicated by the template's black circle.
7. Use the nail to carefully poke a hole at the midpoint on both sides of the box. Reinforce the underside of the box with your hand while poking the hole so that the cardboard is not bent during this process. Poke a hole directly opposite on the other side of the box. Don't poke your hand!



8. Insert the nail into both holes and push the cork on the nail's sharp end. The cork must not rub on the box as the nail spins.
9. The wire will be wrapped around the housing, and not over the open ends of the box. Each end of the wire will be attached to a buzzer. Place 15cm (6") of wire inside the box to use later to attach your buzzer. Tape the lead wire securely to the outside of the box (see diagram).
10. Lightly wrap the wire around the outside of the cardboard housing about 300 times until you have used all the wire. Wrap the wire on either side of the nail. Do not wrap tightly, because the pressure will crush the box.
11. Leave 15cm (6") of wire to attach the buzzer.
12. Sandpaper 1" of the ends of the wire to remove any enamel insulation.
13. Sandpaper 1" of the buzzer wires to remove any insulation (if needed).
14. Securely twist the wire from the generator to one end of the buzzer wire. Double check that the wire is secure.
15. Securely twist the other wire from the generator to the other buzzer wire. Double check that the wire is secure. You can secure the buzzer to the housing with a rubber band as long as it does not restrict the movement of the nail or magnets.
16. Place the magnets around the nail.
17. Make two small spacers out of cardboard for the magnets the thickness of the nail and the width of the magnet. The length of the spacers will be less than half the length of the magnet. This will stabilize your magnet assembly. Insert between the two magnets on either side of the nail. The nail/magnet assembly needs to spin smoothly. If not, you need to alter the design, keeping the magnets as close to the inside of the box as possible. You can tape the spaces in place.
18. Spin your nail and magnet housing. If you don't hear the buzzer, spin the nail and magnet house in the opposite direction. (Why?) Make sure that the wire from the buzzer is touching the wrapped wire and not the insulated part of the wire.



### Generator #2:

1. Use the 1.5V battery to hear what the piezo buzzer sounds like when it is supplied with 1.5 volts by holding the positive (red) and negative (black) wires to the (+) and (-) ends of the battery. After listening to the buzzer, disconnect the battery.
2. Now to make the electric generator - first the wire is wrapped around the cylinder/tube: Leaving about 5 inches of wire hanging down, tape the wire down to the center of the cylinder. Wrap the red enamel-coated magnet wire carefully and neatly around the center of the clear plastic cylinder. **PLEASE NOTE:** Leave the 5 inch "tail" hanging from the beginning of the wire so that when you are finished wrapping, both the beginning and the

end of the wire are accessible. Both ends are required to connect to an electrical device. This step will take a long time – there are 200 feet of wire to wrap. Be patient and neat. Don't let the wrapping become more than about 1 inch in width.

3. When the other end of the wire is *finally* reached, leave about 5 inches hanging down and tape it in place.
4. Place all of the stack magnets carefully in the cylinder and close it up. This is the electric generator. You may want to tape the cylinder caps down. The momentum of the heavy magnets when the cylinder is shaken can sometimes cause them to burst through the cylinder cap.
5. To produce electricity, all that is needed is motion. Gently rock the cylinder back and forth to allow the magnets to travel through the wire coil. The changing magnetic field creates an electric field within the coil of wire.
6. Connect the buzzer to the ends of the wire. First carefully sand the enamel coating off the wire. Connect one of the copper generator wires to one of the buzzer wires. Tape them together to ensure a strong hold. Repeat this process with the other wires.
7. To power the buzzer, rock the cylinder back and forth. Every time the magnets travel through the coil of wire it will emit a small beep. If the buzzer is secured to the cylinder with a rubber band to make it more stable, then energetic shaking will make the buzzer emit an almost continuous noise.
8. To make the column of magnets move even faster, take one of the magnets and secure it tightly using “Tacky” or tape or clay to one end of the cylinder *in the opposite direction (repulsion) from the other magnets*. This magnet will act like a spring to “bounce” the other magnets back through the wire coil.



### Class Review

1. Pair one team who built Generator 1 with a team who built Generator 2. You will have two or three sub-groups.
2. Share how each generator was built and how it functions for the other team in the sub-groups.
3. Discuss and record similarities and differences between these two generators.
4. Determine how electricity is generated.
5. Which generator produced more electricity? Attach the multimeter to the wire/buzzer interface, and record the amount of milliamps. Graph the results.
6. Each sub-group shares their findings with the class, including the graph for milliamps. Are there any differences among the generators? Discuss the implications for those differences.

## Elaboration

1. Have students read the Primer References.
2. Make an electromagnet: (adapted from <http://www.historyforkids.org/scienceforkids/physics/electricity/doing/electromagnet.htm>)

Having produced an electric current from a changing magnetic field, now have the students create an electromagnet from an electric current:

  - a. Each group needs an AA battery, 50 feet of 30 gauge magnet wire, a large iron nail, fine sandpaper, some tape and paperclips.
  - b. Wind the wire around the nail, taking care not to wind either end underneath the coil.
  - c. Carefully sand the enamel coating off the ends of the wire.
  - d. Use the tape to attach one end of the wire to one pole of the battery, and attach the other wire to the other pole.
  - e. The electric current flowing around the iron nail will induce a magnetic field which will line up the magnetic dipoles in the iron material. Check to see if the nail is magnetic by holding it over the paperclips.
  - f. Disconnect the battery as soon as the nail starts to feel warm. **Caution: It can get very hot! Do not delay disconnecting the battery as soon as it starts to feel warm.**
  - g. Carefully slide the nail out of the coil of wire. It should hold on to a little of its magnetism. Dropping the nail will shake the dipoles and it will lose its magnetism.

## Instructor Notes

- Use alligator clips to attach the generator wires to the buzzer or multimeter.
- You can use one miniature bulb 1.5V, 25mA per group (i.e. Radio Shack 272-1139) instead of the buzzer, but you will need to darken the room when testing the generators.

## Extension and Variations

- Allow teams to design and build their generator. Have them present to the class with the pros and cons of each design.

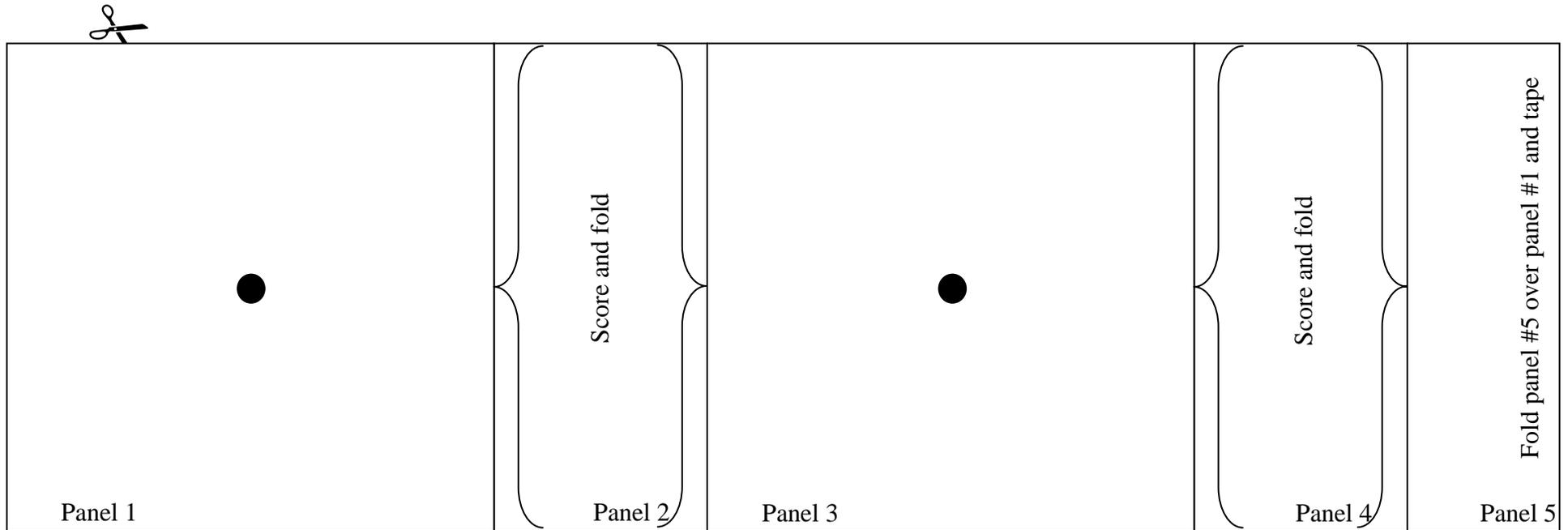
## References/For More Information

US Energy Information Administration:

<http://www.eia.gov/electricity/state/colorado/>

Template for Generator #1 corrugated cardboard rectangular housing for dynamo.

Cut out the large outer rectangle. Score on inner lines where indicated in panels #2 and #4 and fold into a box with open top and bottom. Tape panel #5 to panel #1. Black circles are centered for inserting nail on panel #1 and #3.





## Dynamos

### Qualitative Analysis

1. Record similarities between Generator 1 and Generator 2:	
1	
2	
3	
4	
5	
2. Record differences between Generator 1 and Generator 2:	
1	
2	
3	
4	
5	

3. Determine what is necessary to generate electricity (shared characteristics not excluded by any differences). Write a paragraph explaining your reasoning.

### Quantitative Analysis

4. Attach the multimeter outside the buzzer. Generate electricity in 3 states: slow, medium, and fast. Record the amps and volts for each and use that data to calculate watts.

Generator 1	Speed	milliAmps	Volts	milliwatts
	Low			
	Medium			
	Fast			

Generator 2	Speed	milliAmps	Volts	milliwatts
	Low			
	Medium			
	Fast			

5. Design a graph to best describe your subgroup results.

6. Collect data from the entire class and graph those results. How is the class graph similar and different from the individual subgroup results?

7. Discuss bias in this experiment. What steps can you do to reduce the bias in this experimental design?

8. Consider the two generators. Identify the best use for each design to harvest energy from: wind, geothermal, wave, and water.