



Solar vs. Wind

Lesson 4: Three Ways to Generate Electricity

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GRADE LEVEL: 7-8

LESSON DURATION: 2-3 days

SUBJECT AREA(S): science, energy, energy generation, magnetic fields, hypothesis, energy transformations, circuit, photovoltaic cell

LESSON OVERVIEW:

This lesson gives students hands-on experiences with the attraction and repulsion of magnets including experiments with how the strength of attraction and repulsion varies with distance. Students see how magnets are used in motors but also in electric generators. Finally, students learn three different methods for generating electricity (chemical/battery, magnets/turbine, and photovoltaic cells). Warning: Part 2 “magnets and distance” is very finicky and can be difficult to get good results. Try it yourself until you feel confident or this lesson will probably not go well.

OBJECTIVES:

Students will be able to:

- Detect the relative strength of magnetic fields at different distances from a magnet
- Explain the energy transformations occurring in each part of a circuit
- Identify three different methods for generating electricity

NEXT GENERATION SCIENCE STANDARDS:

MS-PS2-3

- Ask questions about data to determine the factors that affect the strength of electric and magnetic forces

MS-PS2-5

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- Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact

COMMON CORE STANDARDS:

CCSS.ELA-Literacy.RST.6-8.3

- Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks

CCSS.ELA-Literacy.RST.6-8.4

- Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 6-8 texts and topics*.

STUDENT BACKGROUND: This lesson assumes a basic knowledge of different kinds of energy, but little to no experience with electrical circuits.

EDUCATOR BACKGROUND: It will be helpful if you feel comfortable with basic circuitry and the use of a multimeter to find voltage. See, for example, “How to Use a Multimeter: Measuring Voltage”: <https://www.youtube.com/watch?v=GZX3MyBkMvA>.

KEY VOCABULARY:

- Magnet
- Magnetic field
- Compass
- Photovoltaic Cell
- Generator
- Watts
- Wind Turbine

MATERIALS NEEDED PER GROUP OF FOUR STUDENTS (IN A PLASTIC BIN/ZIPLOC BAG):

Material	Quantity per group bin
Iron filings (Carolina Biological Supply Item # 758322) or any iron filings will do.	20mL in Ziploc bag or beaker
Wires with alligator clips	2
Multimeter	1
Computer with Internet access	1
Compass (Silva Starter Type 1-2-3 or Polaris works well)	1

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Ruler	1
Roll of Masking/Painter's Tape	1
Bar Magnets	3 Identical
Plastic Box Frame (Amazon: MCS Clear Box Frame, 8.5 by 11-inch (11811))	1
Various other magnets (e.g. refrigerator magnets – weak magnets work best)	Various/Assortment
Small electric motor with plastic sleeve or wheel attachment	1
Small electrical motor with metal cover/housing removed (to show kids inside of motor)	1
"Grain of Wheat" bulb	1
Clamp light with 100 W halogen bulb (Incandescent bulb should also work)	1
Small photovoltaic cell (anything between 1.5 V and 3.0 V)	1
Protractor	1
D cell battery, AA battery, AAA battery	1 ea.
"Student Sheet #4: Three Ways to Generate Electricity"	1 per student

Notes:

- You may need more iron filings for each group
- Don't get the cheapest compass models – they don't point north
- See (Figure 3) for image of electric motor with attachment – axle needs to be able to grip a table while it is being rolled across it

PREP:

1. Gather materials above
2. Make copies of "Student Sheet #4: Three Ways to Generate Electricity" for each student
3. Make bins (or Ziploc bags) filled with required materials for each group of 4 students
4. Set up clamp lights with 100 W halogen bulb where students can work with them or have students pick them up. You will need ample electrical outlets throughout the room. You might need extension cords if there are not enough outlets.
5. Get plastic box frames and place a piece of copy paper inside.

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LESSON 4:

Part 1: Observing the shape of a magnet field (10 minutes)

- Demonstrate to students how to carefully pour the magnetic filings over the piece of paper inside the plastic box frame (which is on top of the magnet). Have students sketch the shape of the magnetic field pattern of the iron filings on the piece of paper in the box on Part 1 of “Student Sheet #4”.
- Now that students have discovered that motors have a magnetic field, they have a “jumping off” point for the future discovery that



Figure 1. Example of iron shavings from students

it is a generator’s magnetic field that excites electrons resulting in electricity generation.

The following website shows how to do this experiment: “Teacher Workshop: Make a Magnetic Field” <https://youtu.be/j8XNHIV6Qxg>

Part 2: Magnets and Distance (30 minutes)

- **Hypothesis:** Have students answer the question, “How does the distance of a magnet from a compass affect the angle of deflection?” on “Part 2” of their “Student Sheet #4: Three Ways to Generate Electricity”.
- **Explain:** Show students how to orient the face of their compass with the magnetic north pole so that the “north” on the compass face is lined up with the north-pointing needle. Also, show students how to orient the ruler so it is perpendicular to the right of the compass. Have students move the magnet closer to the compass 2 cm at a time until the needle starts to move. Move the magnet back so that it again points north (0 degrees) – this will be your “zero” measurement. All points after this will begin changing the angle of the compass. Have students measure and record the angle that the needle of the compass moves to. Have them record the data in their data table on “Student Sheet #4: Three Ways to Generate Electricity”. Students will also fill in the data table and then graph their data. They should get something of an upwards curve.

Teacher Note:

Drawing a diagram of the orientation of the compass and the ruler will save you much time! Also, there are much more specific directions for

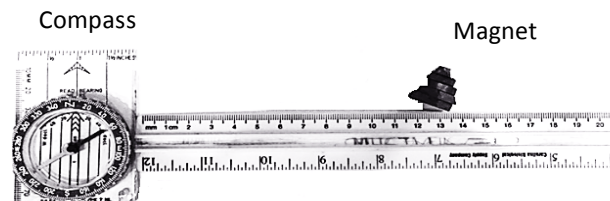


Figure 2. Diagram of orientation of compass and ruler.

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this activity on Part 2 of the “Student Sheet #4: Three Ways to Generate Electricity”.

Part 3: Can you Generate Electricity with a Motor? (10 minutes)

- Hand out a Ziploc bag/plastic bin filled with: a small motor, 2 wires with alligator clips, a grain of wheat incandescent bulb (or LED must be very low voltage such as 1.5 V), and a multimeter. Ask students to try and generate electricity using the supplies provided. Tell them to use their multimeters to test if voltage is being created. If you haven’t shown them how, show them how to use the multimeter to find voltage, using key ideas from the previous day regarding voltage, current, and power in your description.
- Once they are successful, have students attach the light bulb as well and see if they can move the motor fast enough to light it. Have students draw a labeled picture of their experimental set up in the box provided.

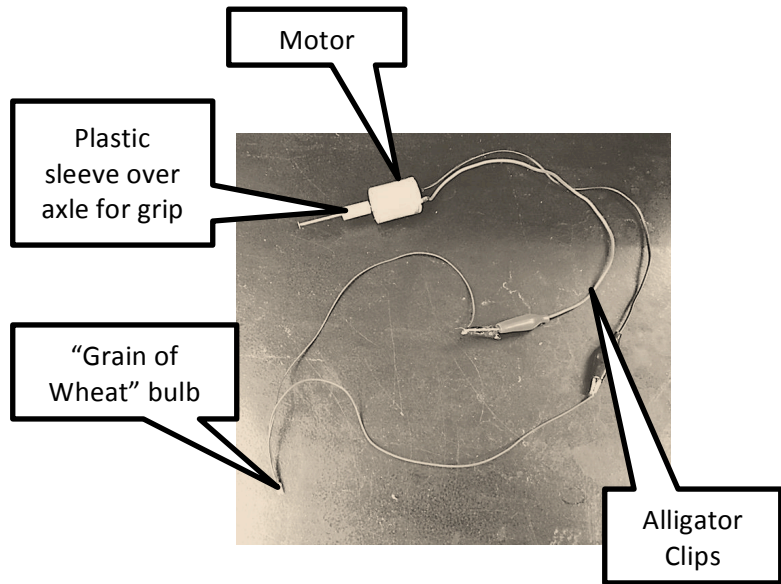


Figure 3. Circuit set-up for creating electricity.

Teacher Note:

Students simply have to spin the axle on the motor with their fingers to get the get the light to turn on once they have correctly created a circuit. Have students answer the questions on “Student Sheet #4: Three Ways to Generate Electricity”.

The site below is helpful for demonstrating how to generate electricity, though the set-up is slightly different than ours (same idea): “Simple Generator that can power LED bulb” <http://www.instructables.com/id/Simple-Generator-that-can-power-LED-bulb/>

Examining inside of a motor (5 minutes) - optional OR use YouTube Video here

- Hand out electric motors with the housing off. Let students see that there is a magnet inside. The following video is a helpful animation describing how the magnet creates an electric field inside the motor (this can also be used to generate electricity): “DC Motor, How it works?” <https://youtu.be/LAtPHANefQo>

Part 4: Generating Energy with a Photovoltaic Cell (10 minutes)

- This will take much less time than using the motor to light the bulb because students simply need to need to exchange the motor for the photovoltaic cell (PV) and expose it

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to enough light to work. Note: You can either go outside, place students by a sunny window in direct sunlight OR use 100 W clamp lights to get the amount of light necessary to make a grain of wheat bulb work.

- As in Part 3, have students draw their experimental set up in the box provided on Part 4 of “Student Sheet #4: Three Ways to Generate Electricity”.
- Finally, have students finish by answering the questions at the end.

SOURCES AND WEBSITES USED:

Much of this lesson is adapted from the following website:

Shipman, J. (Updated: 2013, July 12). *Magnetic Field Strength vs. Distance*. Retrieved from <http://www.education.com/science-fair/article/how-distance-affect-strength-magnet/>

Excellent video showing how to mark magnetic field using iron shavings:

Musselman. [MusselmanScience]. (2012, December 13). *Teacher Workshop: Make a Magnetic Field*. [Video File]. Retrieved from <https://youtu.be/j8XNHIV6Qxg>

Site Showing How to Generate Electricity with a Motor:

[sidgupta]. (n.d.). *Simple Generator that can power LED bulb*. Retrieved from <http://www.instructables.com/id/Simple-Generator-that-can-power-LED-bulb/>

How Motors Work:

[Learn Engineering]. (2014, September 22). *DC Motor, How it works?* [Video File]. Retrieved from <https://youtu.be/LAtPHANefQo>

Finding Voltage:

McDonald, R. [Alom Shaha]. (2011, September 13). *How to Use a Multimeter: Measuring Voltage*. [Video File]. Retrieved from <https://youtu.be/GZX3MyBkMvA>

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