



Electrical Power

Suggested Level: Grades 5 through 8

LEARNING OUTCOME

Students are able to describe how photovoltaic cells produce electricity, what voltage and amperage are, and how each relates to electric power. They know how to arrange PV cells in series and parallel circuits and show how doing so changes the voltage and amperage output.

LESSON OVERVIEW

Students read about how photovoltaic cells produce electricity. After using parallel and series electrical circuits to see how to increase the electrical power of solar cells, they develop testable hypotheses and design laboratory investigations. They use instruments (ammeters and voltmeters) and mathematical formulas as they explore what *electrical power* means. Finally, they examine their school's solar system to determine how the solar cells are arranged to produce electrical output.

MATERIALS

- 2 photocells (about 0.5 V each)
- 1 small motor (1.5V)
- 1 milliammeter
- 1 voltmeter
- School solar array (if your school has solar)

SAFETY

There are no particular safety precautions for this lesson.

TEACHING THE LESSON

Ask students to describe their ideas of how solar cells work. Engage them in a discussion of the ideas without judging the validity of their comments. Then, give them the introduction to read and have them respond to the questions in it. You might want students to start responding to the questions in class and then finish them for homework. Review and clarify responses and elicit questions in the following class period.

After the initial discussion, ask the following:

- Whether the arrangement of solar cells in series compared to parallel circuits has an effect on solar power, and
- How their solar car's electrical energy might be increased.

ACCEPTABLE STUDENT RESPONSES

Part A:

1. Raising the height of the waterwheel (making it bigger) and increasing the amount of water falling through the wheel.
2. By increasing either the voltage or the amperage of the solar cells. Because we would have to rebuild the waterwheel to increase its potential energy, we would have to do the same with the solar cell. So our only feasible way to increase the power of the solar cell is to increase the electron flow, and that can be done by increasing the amount of sunlight energy focused on the cell.

Part B:

Procedure Sections: Lab data will vary according to the equipment used and the sunlight available. Voltage produced by the series circuit should be greater. Amperage should be greater for the parallel circuit. Wattage should be approximately the same for both circuits.

Develop Your Understanding Section:

1. Series circuit
2. Parallel circuit
3. They should be the same.
4. In parallel
5. In series
6. Higher voltage indicates series circuitry.

Cells wired in series produce a higher voltage (charge) but lower current (amperage). Cells wired in parallel produce a greater current but lower voltage. No more electrical energy is produced in either wiring method if the same amount of sunlight energy collected remains constant during the comparison.

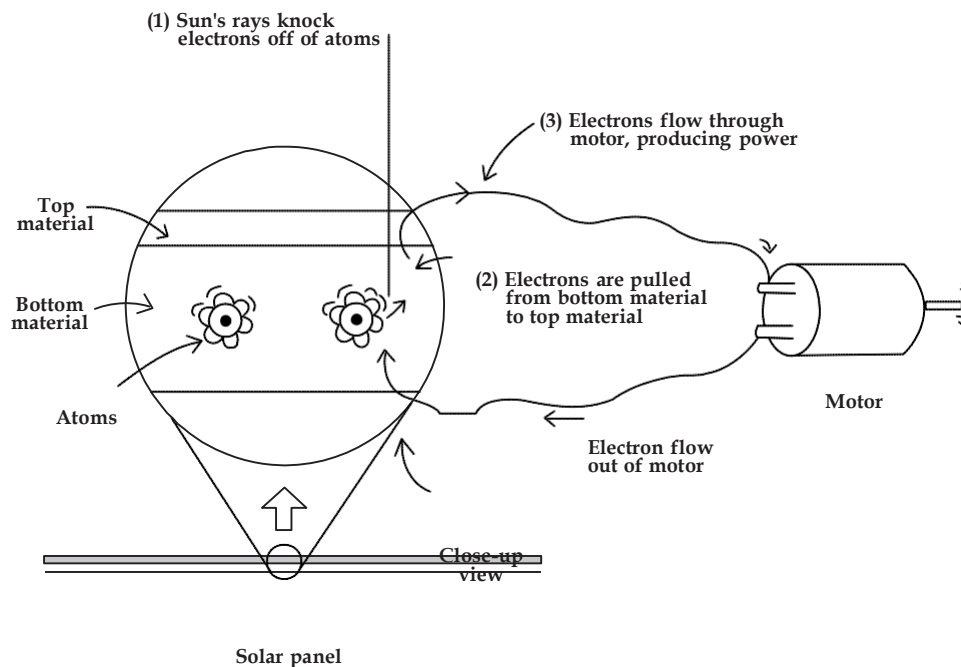
(STUDENT HANDOUT FOLLOWS)

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Electrical Power

Part A: How the Solar Panel Works

A solar cell is made of a “sandwich” of two materials known as semiconductors. Each is made of millions of atoms. Atoms have a positively charged nucleus, and moving around the nucleus are negatively charged electrons. When this sandwich is placed in sunlight, electrons are pulled from the bottom half of the sandwich to the top half. The sunlight energy knocks the electrons off the atoms of the lower layer, and they are pulled to the top of the sandwich as shown in the diagram below.

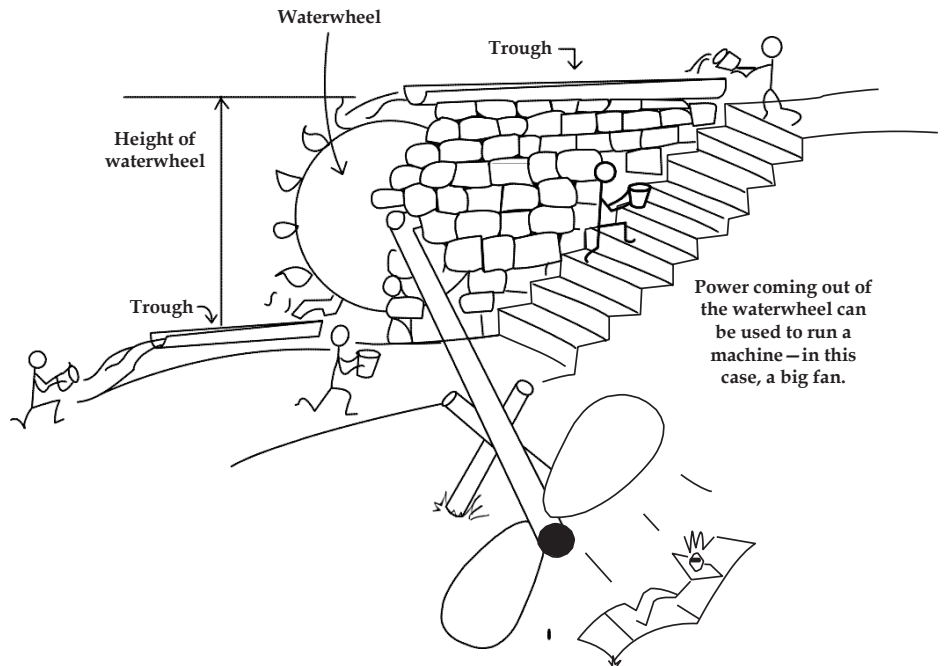


If wires from each layer are connected to a motor, the free electrons will flow from the top layer through the wire into the motor (making it spin) and then back through the wire connected to the bottom layer of the solar panel.

Power

How does a solar panel create electrical power, and how is power related to this flow of electrons? A mechanical graphic can demonstrate this relationship. Study the drawing of the waterwheel model on the next page.

In this model, people climb stairs carrying buckets of water from the bottom trough of the waterwheel, and then they pour the water into the upper trough. The water flows down over the waterwheel, which has buckets attached to it that catch the water. The weight of the water in the waterwheel buckets makes the wheel spin. The power of the spinning wheel makes a machine such as the big fan spin.



For the waterwheel, the power coming out depends on two things:

- 1) How **high** the water falls and
 - 2) How **much** water (how many buckets) is poured over the wheel.
- The power produced by the wheel is represented by:

$$\text{Power} = \text{Height} \times \text{Amount of water}$$

1. What could be done to increase the power of the waterwheel model?

How is the waterwheel model like a solar panel and motor? The water molecules are the electrons, the troughs are the wires, and the waterwheel is the electric motor. The sun's energy is used to carry the electrons up an electric "stairway" inside the solar panel, and then the electrons are "poured" down a wire and through the motor.

The solar panel uses a very similar equation to the waterwheel's equation for mechanical power to determine its electrical power. The "height," or electrical potential, of the solar panel is called **voltage**, and the buckets of water are the number of electrons flowing through the circuit, which is called the **electric current**. The electrical **power** of the solar panel is the product of the voltage and the number of electrons flowing (the current):

$$\text{Power} = \text{Voltage} \times \text{Current}$$

2. How can the power produced by solar panels be increased?

Part B: Activity: Can the power of two solar cells be increased by wiring them into a series circuit or a parallel circuit?

Materials Needed:

- 2 photocells (about 5V each)
- 1 small motor (1.5V)
- 1 milliammeter
- 1 voltmeter
- School solar array (if your school has solar)

Procedure:

1. Wire the solar cells into a parallel circuit, and connect the voltmeter and the ammeter into the circuit. (See the diagram.)
2. Place in full sunlight and measure the amperes and the volts. Record these values.

Amperes = Voltage =

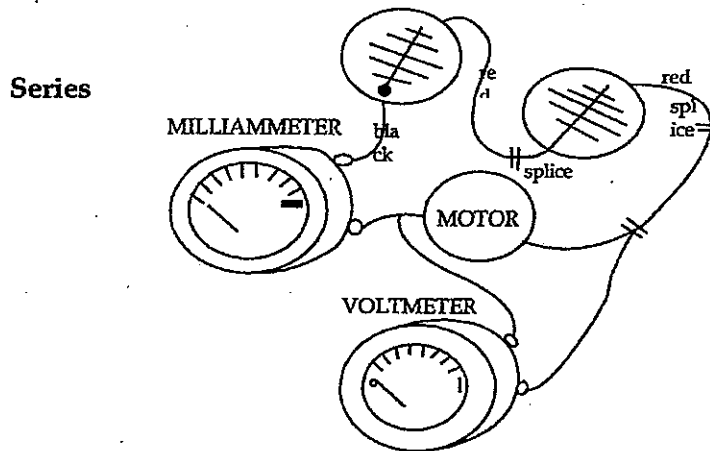
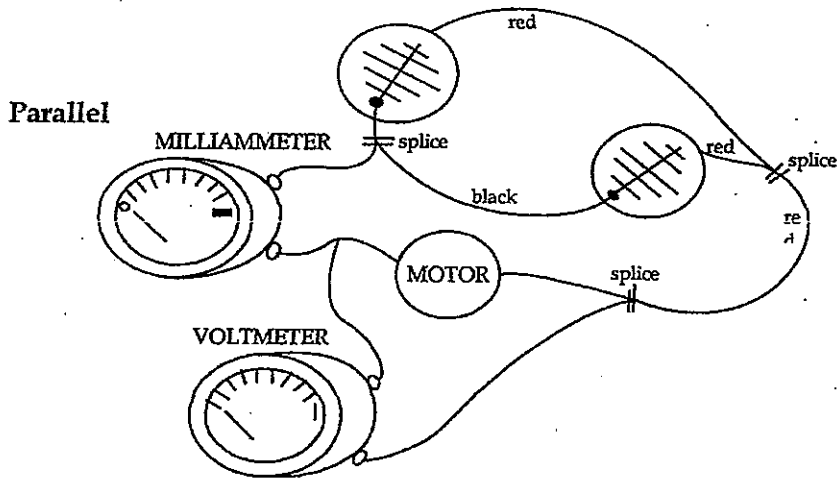
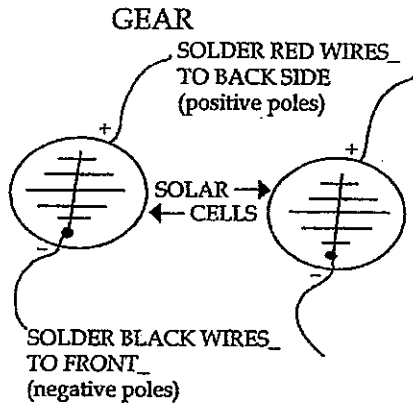
3. Wire the solar cells into a series circuit. (See the diagram.)
4. Place in full sunlight and measure the amperes and the volts. Record these values.

Amperes = Voltage =

5. Compute the power in watts that was generated in each circuit, using the following formula:

Volts x amps = Watts

Parallel Circuit/Series Circuit Diagrams



DEVELOP YOUR UNDERSTANDING

1. Which type of circuit produced a higher voltage?
2. Which type of circuit produced the higher current (amperage)?
3. Which circuit produced the greatest power in watts?
4. How is the voltmeter connected into the solar cell–motor circuit?
5. How is the ammeter connected into the solar cell–motor circuit?
6. How does the voltage output of a large school solar array compare to the voltage output for the solar cells used in your investigation? What does this indicate regarding the kind of circuitry present in the solar array panels?