

Solar Education for NY
SchoolPowerSM
...Naturally

Junior Solar Sprint Series: Electrical Power
SPN LESSON #11



TEACHER INFORMATION

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 collector to determine how the solar cells are arranged to produce electrical output.

GRADE-LEVEL APPROPRIATENESS: This Level II Physical Setting, technology education lesson is intended for students in grades 5–8.

MATERIALS

2 photocells (about 5V each)
1 small motor (1.5V)
1 milliammeter
1 voltmeter
Junior Solar Sprint solar cell
School solar array

SAFETY

There are no safety concerns 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:

- 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.

After these initial discussion sessions, prepare the cells (if not already prepared) by soldering the red wire to the backside or positive pole. Solder the black wire to the front or negative pole.

ACCEPTABLE RESPONSES FOR DEVELOP YOUR UNDERSTANDING SECTION

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. [Since 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. No, because changing circuitry would not change the power produced.
7. Yes. The panels must be wired in series with one another.
8. Higher voltage indicates series circuitry.

ADDITIONAL SUPPORT FOR TEACHERS

SOURCE FOR THIS ADAPTED ACTIVITY

This lesson was adapted from materials developed for Junior Solar Sprint by the Northeast Sustainable Energy Association and NREL and the Minnesota Renewable Energy Society.

BACKGROUND INFORMATION

This lesson is one of several preliminary classroom investigations leading to an understanding of the scientific phenomena underlying the operation of, and the eventual building of, a competitive model solar car. This competition is sponsored by the Junior Solar Sprint (JSS) Program, developed originally under the auspices of the U.S. Department of Energy and currently sponsored by the Northeast Sustainable Energy

Association (NESEA) and the U.S. Army. Visit NESEA at www.nesea.org for complete information and more learning activities.

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.

REFERENCES FOR BACKGROUND INFORMATION

nesea.org

Northeast Sustainable Energy Association, 50 Miles Street, Greenfield, MA 01301,
phone 413-774-6051

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(NYSERDA)*

www.nyserda.ny.gov

(STUDENT HANDOUT SECTION FOLLOWS)

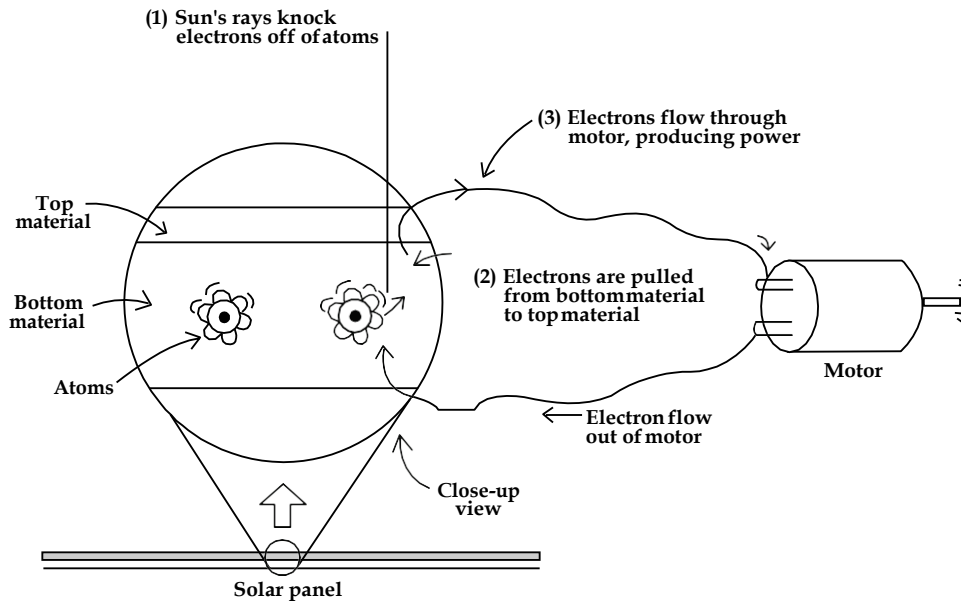
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Junior Solar Sprint Series: Electrical Power

Part A: How the Solar Panel Works

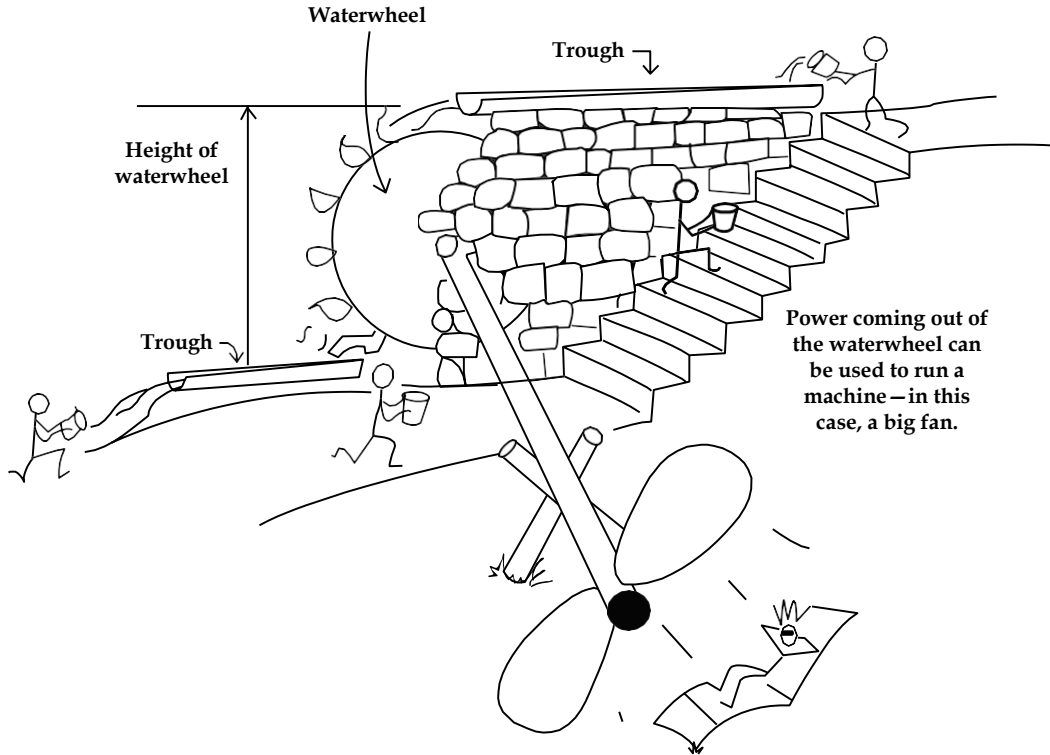
A solar cell is made of a “sandwich” of two materials known as semiconductors. [Each is made of millions of atoms. Atoms have a positively charged nucleus, and moving around the nucleus are negatively charged electrons.] When this sandwich is placed in sunlight, electrons are pulled from the bottom half 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 (The Minnesota Renewable Energy Society) 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.

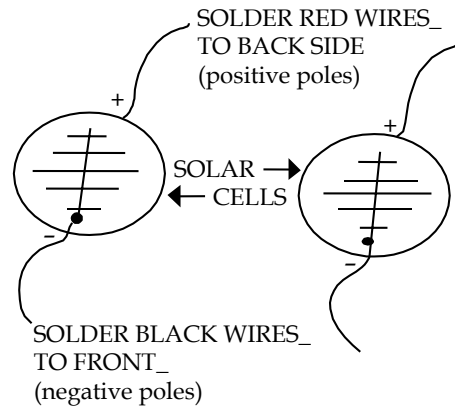
The power produced by the wheel is represented by:

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

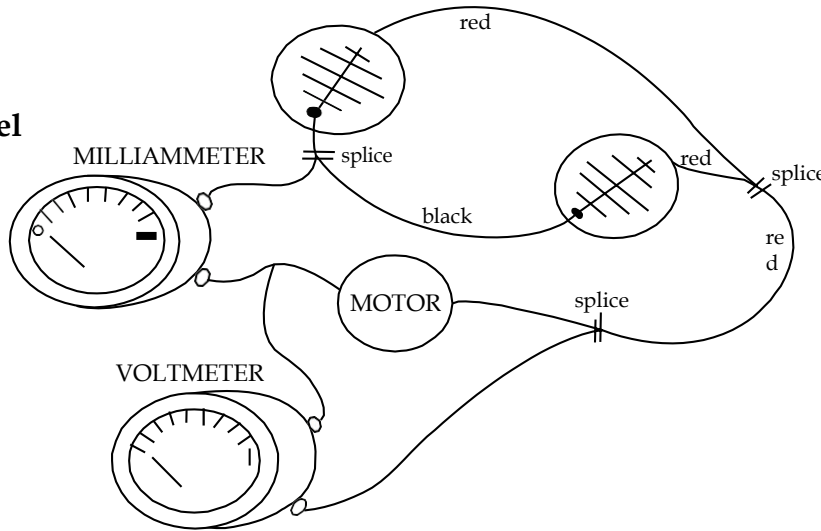
1. What could be done to increase the power of the waterwheel model?

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

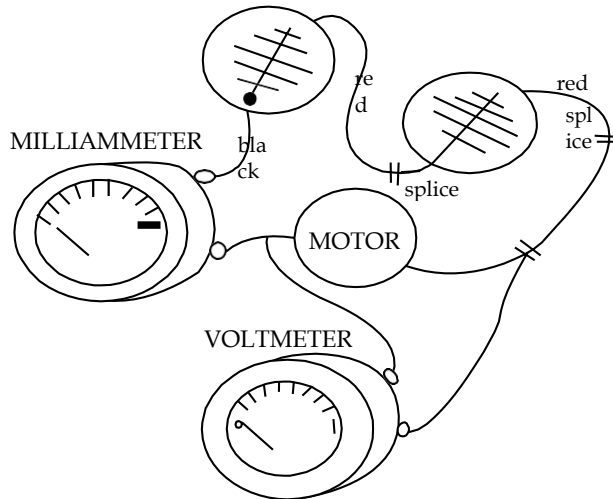
Parallel Circuit/Series Circuit Diagrams
GEAR



Parallel



Series



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. Does it matter that you have only a single solar panel to use to power your Junior Solar Sprint car?
7. Is the voltage of the Junior Solar Sprint panel different from that of the smaller panels used in this activity? What does this indicate regarding the circuitry of the Junior Solar Sprint panel?
8. How does the voltage output of your school’s 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?