Solar Education for NY
SchoolPower...Naturally

Solar Kit Lesson #1
Solar Cell Inquiry

TEACHER INFORMATION

LEARNING OUTCOME
After students carry on an open-ended inquiry of how solar panels and an AA battery can be used to power lamps and motors, they infer what forms of energy are used in each instance and predict how long each power source might be able to operate a device.

LESSON OVERVIEW
In this lesson, students use a selection of solar panels, lamps, motors, and an AA battery to get as many motors or lights to operate as they can in an allotted time period. For each successful arrangement, they draw a diagram of their setup, label the energy source and the forms of energy used, and make inferences and predictions.

GRADE-LEVEL APPROPRIATENESS
This Level I/II Physical Setting lesson is intended for use in grades 3–7.

MATERIALS
Per work group
- One or two (different if possible) small DC motors having an operating range of roughly 1–4 volts
- One or two (different if possible) light-emitting diodes (LEDs)
- One or two (different if possible) small incandescent flashlight bulbs
- Two 1V, 400 mA mini–solar panels with alligator clip leads*
- Sunlight, a gooseneck lamp with 100-watt incandescent bulb, or both
- One AA battery in holder with alligator clip leads

* Available in the provided Solar Education Kit; other materials are to be supplied by the teacher

SAFETY
Warn students
- not to touch lighted incandescent bulbs, since they become hot enough to cause a burn;
- not to let the alligator clips on the two wires connected to the battery touch, since the battery will quickly become “dead” (also, the battery might become hot enough to cause a burn).

TEACHING THE LESSON
Introduce the concept that there are different forms of energy, such as light, mechanical, electrical, chemical, and heat energy.

State that solar cells are objects that convert light energy into electrical energy. Hold up a mini–solar electric panel and show students that it is made up of solar cells.

Form student teams of two or three.

Provide each team with two solar cells, 1 AA battery in a holder, motor(s), a selection of light-emitting diodes (LEDs), a selection of small flashlight bulbs, and if direct sunlight is unavailable, a gooseneck lamp with a 100-watt incandescent bulb.

Challenge students with the task of connecting together items they have been given in ways that will cause a lamp to shine or a motor to spin. Each time they are successful, have them fill in a Record of Inquiry for that test.

Have students determine how long a circuit will remain "on" and compare the results with the proposal they recorded in the Record of Inquiry.

Tell students the cost of a 1V, 400 mA solar cell ($5.00), and the cost of one AA battery. Help them, as needed, as they calculate the cost of running a motor with a battery versus a solar cell for one hour, one week, and one month.

Discussion:
Review with students the different forms of energy that they encountered. Stress the particular form of energy at the source of power (light for photovoltaic-powered circuits and chemical for battery-powered circuits).

Compare the concept of power with the concept of energy. Ask students to identify which test setups produced more power as evidenced by a faster turning motor or a brighter glowing bulb, and which setups had the longer lasting source of energy.

Check to see if any teams noticed that LEDs work only when the red and black wires are connected according to the proper polarity (red to the positive terminal, black to the negative terminal), but that the motors and incandescent lamps work when the red and black wires are connected to either terminal. If so, have those students research the literature to come up with explanations for the phenomena.

Discuss the pros and cons of powering simple circuits using solar cells versus batteries (see the Background Information section).

ACCEPTABLE RESPONSES FOR DEVELOP YOUR UNDERSTANDING SECTION
Answers will vary. Complete answers will include the following.

1) Clearly drawn and labeled diagrams.
2) Correct labeling of each form of energy that exists in the circuit depicted.
3) Correct identification of the source of energy (light from the Sun or a light bulb for photovoltaic-powered circuits and stored chemical energy for battery-powered circuits).

4) An appropriate identification of the power output provided by the circuit.

5) A cogent and feasible explanation of the energy available to power the circuit depicted.

ADDITIONAL SUPPORT FOR TEACHERS

SOURCE FOR THIS ADAPTED ACTIVITY

This is not an adapted lesson.

BACKGROUND INFORMATION

Photovoltaic Cells: When a solar cell is exposed to typical light sources, negatively charged electrons almost instantly move to the top of the cell, leaving behind a crystal lattice of atoms having more positively charged protons than negatively charged electrons on the bottom of the cell. This movement rapidly reaches an internal state of equilibrium where the solar cell exhibits a voltage difference of about 0.5 volts between the top and the bottom of the cell.

When metal contacts are placed on the top and the bottom of a photovoltaic cell (solar cell) and each cell is connected to an electric circuit, electrons are drawn off the top of the cell, producing a current that can be used externally. Electrons from the top of the cell move through the electric circuit, replacing the missing electrons in the bottom of the cell. This movement continues as long as the cell is exposed to light having photons of sufficient energy to excite the photovoltaic crystal's electrons.

Power Versus Energy: Power is the rate at which work is done. Energy is the capacity of a physical system to do work. In this lesson, power is proportional to how fast a motor spins or how bright a bulb glows.

Energy available to do work depends on the circuit present. Circuits powered by batteries have energy to do work as long as the batteries are "charged" rather than "dead." The length of time that such a circuit will do work depends on the amount of energy stored in the battery. Circuits powered by solar cells have energy to do work as long as light is present.

Light-Emitting Diodes (LEDs): A light-emitting diode produces light when current passes through it. Unlike an incandescent bulb, current can pass through an LED in only one direction. LEDs are now readily available in flashlights and in strings of Christmas tree lights. LEDs typically can be purchased in electric supply stores.

REFERENCES FOR BACKGROUND INFORMATION

The Columbia Encyclopedia, Sixth Edition. 2001.
The American Heritage® Dictionary of the English Language: Fourth Edition. 2000.

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA

Standard 1—Analysis, Inquiry, and Design: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Mathematical Analysis Key Idea 1: Abstract and symbolic representations are used to communicate mathematically. (elementary)

Scientific Inquiry Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process. (elementary and intermediate)

Key Idea 3: The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena. (elementary)

Engineering Design Key Idea 1: Engineering design is an iterative process involving modeling and optimization (finding the best solution within given constraints); this process is used to develop technological solutions to problems within given constraints. (elementary and intermediate)

Standard 4—The Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 4: Energy exists in many forms, and when these forms change energy is conserved. (elementary and intermediate)

Key Idea 5: Energy and matter interact through forces that result in changes in motion. (elementary and intermediate)

Standard 5—Technology: Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

Key Idea 1: Engineering design is an iterative process involving modeling and optimization used to develop technological solutions to problems within given constraints. (elementary)

Standard 7—Interdisciplinary Problem Solving: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Interdisciplinary Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena. (elementary and intermediate)

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Should you have questions about this activity or suggestions for improvement, please contact Chris Mason at cmason@nesea.org.

(STUDENT HANDOUT SECTION FOLLOWS)

Name _____

Date _____

Solar Cell Inquiry

Complete a **Record of Inquiry** each time a new arrangement succeeds—that is, each time a lamp goes on or a motor works.

Record of Inquiry

Test Number: _____

1) Draw a diagram that shows how the items you used are connected. On your diagram, label each item and the color of the wires.

2) On your diagram, identify where each of the following forms of energy is present.

   Light Mechanical Electrical Chemical Heat

3) Where does the energy that powers the small lamp or motor come from?

4) How fast is the motor spinning, or how bright is the lamp operating? On a scale of one to five, circle the appropriate number.

LAMP	MOTOR
1 2 3 4 5	1 2 3 4 5
Dim ... Bright	Slow ... Fast

5) How long do you predict the motor or lamp will remain on, if left as you have it connected? Back up your claim by explaining your prediction.