Parts of a Solar Panel – Part II

Suggested Level: Grades 4 through 6

LEARNING OUTCOME

After reverse engineering a mini–solar panel to determine how it was constructed physically and electrically, students are able to describe how fragile solar cells are packaged to form a durable solar panel and how the series and parallel electrical connections that were used relate to the output voltage of the device.

LESSON OVERVIEW

Students use observation, critical thinking, and deductive and inductive reasoning to determine how a mini–solar panel is constructed.

MATERIALS

Per class

- Digital multimeter or analog voltmeter
- Lamp with 100-watt incandescent bulb
- AA battery
- Broken piece of solar cell or pop clear plastic cover off solar cell to expose cell, but ***be careful not to break fragile exposed cell***

Per work group

- Student handout
- One mini–solar panel or solar cell. (A panel is composed of two or more cells.)

SAFETY

- Broken pieces of a solar cell have sharp edges. Instruct students to handle the small pieces as they would any sharp object such as a piece of broken glass. Light bulbs get hot enough to burn. Instruct students not to touch the light bulb.

TEACHING THE LESSON

This lesson is designed to follow the lesson *Parts of a Solar Panel – Part 1*.

Show students a solar panel and identify it. Then, show them a piece of solar cell and tell them that solar panels are made up of solar cell pieces such as this. Challenge them to figure out how a panel is put together. Explain that when engineers want to learn how someone else put together a product, they behave like detectives and look up, examine the product, and draw diagrams that show how they think the product works.

Distribute the student handouts and have students look at the graphic for Fact 1. Define *voltage* and then demonstrate how to use a multimeter to measure the voltage across a battery and then a solar cell under a bright light. (If no bright direct sunlight is available, use a lamp with a 100-watt incandescent bulb.) Tell students that most small household batteries will measure about 1.5 volts and that most solar cells will measure about 0.5 volts.

Have students look at the graphic for Fact 2. Describe what it means to connect solar cells “in series” and then ask students how many solar cells would have to be connected in series to make the same voltage as a household battery. Discuss with them why this is so.

Have students look at the graphic for Fact 3. Describe what it means to connect solar cells “in parallel.” Tell students that connecting two solar cells in parallel is the same as using a bigger solar cell and that a bigger solar cell can collect more light energy than a smaller one.

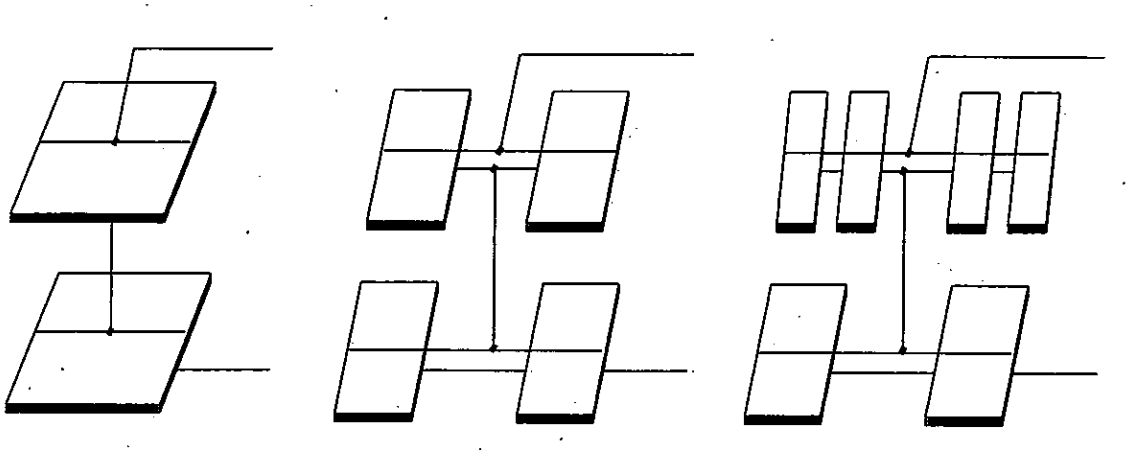
Form the class into teams of two and distribute the mini–solar panels. Have students complete Question 1 of the handout as you go around to each team and help them measure the open-circuit voltage of their mini–solar panel and demonstrate once more how to measure the open circuit voltage of the solar cell. Students will need these measurement values to complete Question 2 on the handout.

Extension activity: Provide a workstation with a selection of solar panels, a light source (the best light source is a sunny window), and a digital multimeter. Let student teams use the workstation in turns. Have students connect the solar panels in different combinations, predict the voltage output they expect, and then use the multimeter to check their prediction.

ACCEPTABLE STUDENT RESPONSES

1) Expect a drawing showing a clear plastic top to let light in and a rigid, shallow, plastic, open- topped box to hold the cells firmly in place. Two wires, one red and one black, extend from one end of the box. Some astute students may show the red wire marked with a plus (+) sign and the black wire marked with a minus (-) sign.

2) Expect a drawing showing two to eight cells. In this drawing, two groups of one to four cells should be shown connected in parallel and these two groups should be shown connected in series with each other. Typical drawings may look like this:



BACKGROUND INFORMATION

By placing metal contacts on the top and bottom of a photovoltaic cell (solar cell) and connecting these to an electric circuit, we can draw electrons off the top of the cell to form a current that we can use externally. Electrons from the top of the cell move through the electric circuit to replace the missing electrons in the bottom of the cell. This movement will continue as long as the cell is exposed to light having photons with high enough energy to excite the photovoltaic crystal's electrons. In this way, a solar cell works like a battery in that it provides a circuit with direct current.

Each silicon PV cell produces about 0.5 volts when exposed to light. The amount of current PV cells produce is related to their surface area. Larger cells produce more current. Current multiplied by voltage equals power, so larger cells produce more power. The unit output of a PV cell is measured in watts per square meter.

To produce more current, you can connect two or more PV cells in parallel (negative terminals all connected together and positive terminals all connected together). The effect of this is to give you a larger solar cell.

To produce higher voltage, connect two or more PV cells in series (positive terminals are connected to the next cell's negative terminal). The total voltage is the addition of each PV cell's individual voltage.

Parts of a PV Cell

The top of a PV cell contains a grid of metal contacts. The metal contacts must be thick enough and close enough together (low resistance) to allow for the required current to flow through them, but thin enough and spaced far enough apart to let sufficient light into the cell. The cell is covered with an anti-reflective coating that enables maximum penetration of light into the cell. This is necessary because silicon crystals are highly reflective.

The bottom of a PV cell is covered with a metal plate that allows electrons to move back into the cell with minimum resistance. The metal plate also acts to reflect light back through the cell.

PV cells are packaged in panels of several cells connected in series or parallel to produce the desired voltage and current. A panel of cells is covered by protective glass or other transparent material and encased in a protective receptacle.

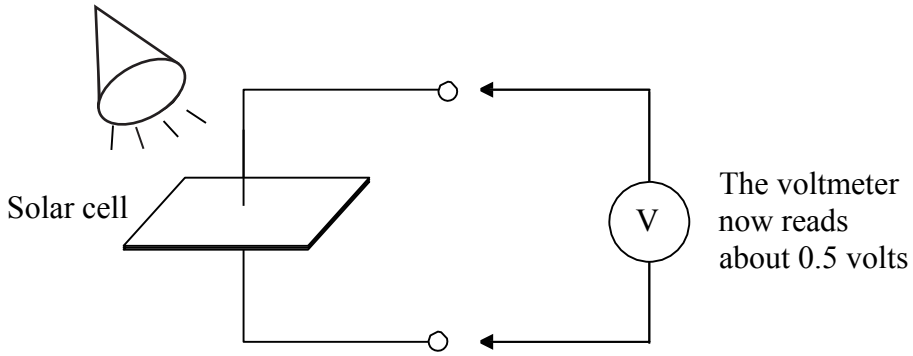
(STUDENT HANDOUT FOLLOWS)

Name _____ Date _____

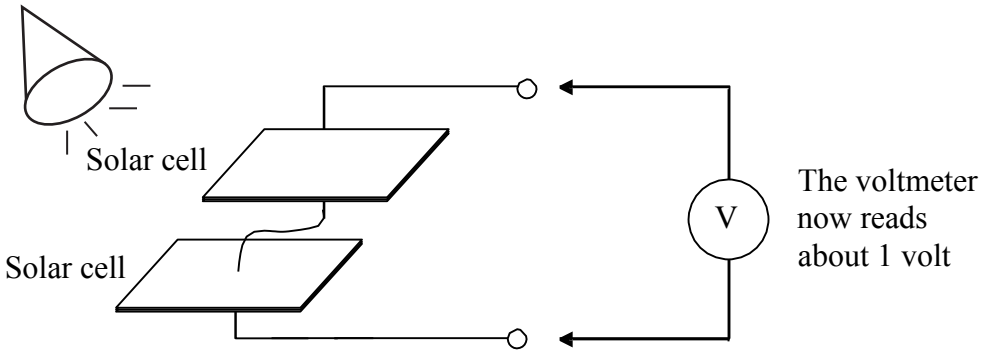
Parts of a Solar Panel – Lesson II

Sometimes engineers behave like detectives. This happens when they try to understand how someone else designed and constructed a product. That is what you will be doing today. By the time you finish, you will be able to explain in detail how a mini–solar panel was put together. You will start with a few given facts, find your own clues, and then record your ideas.

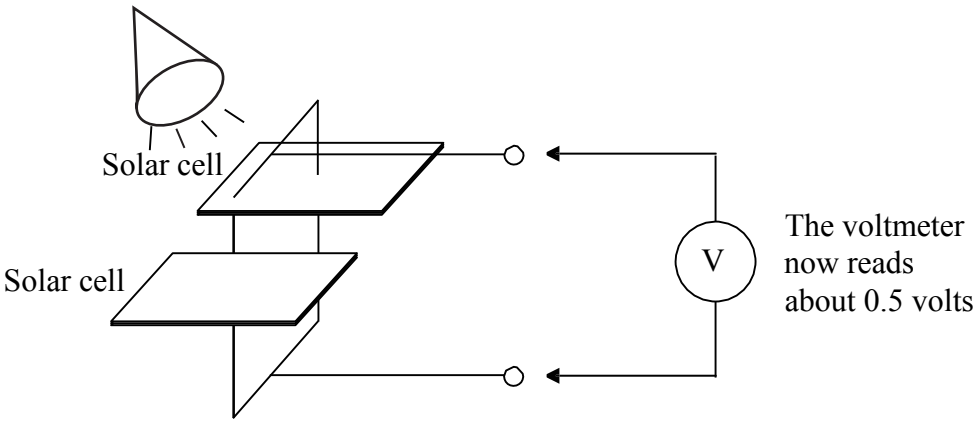
The facts:



Fact 1: A single solar cell produces about 0.5 volts when placed under a bright light.



Fact 2: Two solar cells connected front to back (also known as "in series") add voltages together to produce about 1 volt while under a bright light.



Fact 3: Two solar cells connected side by side (also known as "in parallel") do not add their voltages together. They produce about 0.5 volts while under a bright light.

In order to discover important clues, you are to carefully examine an actual solar panel. Use drawings to describe what you observe. With your teacher's help, measure the solar panel's voltage and use this information to help explain how you think the solar panel has been put together.

1) **Examine your solar panel:** How are the cells protected from being broken? How does the panel let light into the cells? How do we get electricity from the panel? Draw the panel showing how the panel was put together to accomplish each of these things. Label and describe each part.

2) How many cells are in your panel? How are they wired together? After your teacher helps you measure the voltage of your panel, draw a diagram that describes how you think the cells have been wired together. Explain why you think this.