



Shedding Light on Solar Energy

Submitted by: Jennifer Tyrell, AP Biology, Jefferson County High School, Dandridge, TN

Grade: 8-12

Lesson Duration: 90 minutes

Background Information

Students should be able to describe the characteristics of solar energy. Ideas for lecture topics include the electromagnetic spectrum, light as a wave vs a particle, photovoltaic cells and p-n junctions, or properties of light. Students should understand how solar energy can be harnessed, as well as applications of solar technology such as solar thermal and solar photovoltaic systems.

They should also understand the limitations of using solar energy as a renewable resource, particularly the expense and conversion efficiency, so they understand why it is not widely used. Whole class demonstrations of PV cells, thermoelectric generators, or Stirling engines would be appropriate for this lesson.

Lesson Objectives

- Students will be able to describe how solar energy can be captured and used by humans.
- Students will be able to assemble a solar cockroach and use it to explore properties of solar cells.
- Students will be able to build and use a solar oven to cook food.
- Students will be able to construct a graph to represent data collected.

Instructional Process

Activity 1 will be done in about 30 minutes. Activity 2 requires about 50 minutes to be performed correctly. The activities would be best suited for integration into a multiple day unit on solar energy.

Activity 1: Solar Cockroach

Materials needed:

Solar cockroach kit from <http://www.browndoggadgets.com/products/solar-cockroach-2-0-kit>.

Kit includes: solar panel, motor, resistor, paperclips, magnet wire, and googly eyes **OR**

- 1x [Vibrating Motor](#)
- 2x Big Paper Clip
- 2x Googly Eyes
- 6 inches of Magnet Wire
- 1x [2V Solar Cell](#)

Hot glue guns

Hot glue

Lamp with various types of bulbs

Wire cutters

Solder and soldering iron

Note: Prior to the lesson, teacher may choose to solder the resistor wires to the motor and the solar panel to avoid having students use solder. The student instructions below assume this has been done.



20 minutes

Students construct solar cockroaches using the kit and hot glue. Each student should have his or her own cockroach to assemble. Glue the legs, eyes, and antennae to the solar cell. Special attention can be paid to cockroach legs because different placement of legs will create different movement in the bug.

10 minutes

Students will test the cockroaches' movement by placing them beneath lights of varying wattage. Students can block light using different materials to see how much light is needed to operate the cockroach.

Activity 2: Solar Oven

Materials needed:

- Poster board or double thick construction paper
- Mylar sheets
- Packing tape
- Shredded newspaper
- Thermometer or temperature probe
- Heat lamps if it is a cloudy day
- S'mores ingredients
- Shoe box
- Saran wrap
- Scissors
- Cardboard pieces
- Wooded skewer
- Kite string
- Nail

Pre-Activity Prep Work

Mylar sheeting should be glued to one side of the poster board. On the other side, the outline of a large cone should be drawn. The ideal cone will have a small opening diameter that is $\frac{1}{9}$ the size of the large opening. A support structure that is pictured in the instructions below should be cut from cardboard.

30 minutes

In groups of 3-4, students construct solar ovens following the instructions below.

5 minutes

Students go outside with their solar ovens. Students place s'mores ingredients in their ovens, directly beneath the plastic wrap window. Students position a thermometer inside of the oven, beneath the window and another outside of the oven. Students should align the large end of their cone with the sun and may adjust it throughout the experiment to maintain alignment.

10 minutes

Students begin collecting data. Students will record the temperature inside and outside of their solar oven every 30 seconds for at least 10 minutes. Students will use their data to construct a graph showing the temperatures inside and outside of their ovens.

5 minutes

Students will eat their s'mores.

Assessment/Follow-up



Students will answer questions on solar energy in a written assignment. Sample questions:

1. *How do solar panels work?*

Example response: Solar panels are made up of solar cells. Solar cells are made of silicon, which is abundant on Earth. It is also the same substance that sand is made of. When the silicon gets heated, chemicals are introduced. These chemicals make silicon atoms unstable. When sunlight hits the solar panel, some photons of sunlight stick to the solar cells while other photons of sunlight make some electrons jump off the solar panel.

These electrons that jump off the solar panel travel through wires that have been inserted in the cell. The flow of electrons through these wires creates electricity. Whatever the wires are connected to will be provided power by the electrons within the solar panel. In our case, the wires are connected to our solar cockroach, allowing the cockroach to move.

2. *What are solar panels used for?*

Spacecrafts, water heaters, iPod and cell phone chargers

3. *How do clouds affect solar panels? How do you know?*

Clouds block the solar rays from reaching the panels and so the panel is unable to make electricity. This was demonstrated using the solar cockroaches. When I used my hand to make a shadow over the solar panel, the cockroach stopped moving.

4. *When sunlight shines through the window and makes you feel warm, is this an example of passive or active solar heating?*

Passive solar heating

5. *After 10 minutes, what is the difference in temperature inside and outside of your solar oven? What caused this difference?*

Specific temperatures will vary. Example: The difference between the inside and outside of the solar oven after 10 minutes was 51°F. The cause of this difference is the concentration of solar energy into the box by the Mylar cone. The temperature difference is maintained by the insulation of the box and the shredded newspaper

6. *If solar energy is a very clean and renewable resource, why don't more people don't use it more often for energy?*

Even though sunlight is everywhere, the amount of solar energy hitting the ground at one time is very small, so having enough light intensity to power houses, for example, is very small. On average, about 10 square feet receives 300 watts of energy from the sun. This equals about 600 volts, which is enough to power a bright light bulb. A lot of empty terrain would be needed to heat large spaces using solar energy. In addition to this, solar technology is extremely expensive. These are limitations researchers are trying to overcome regarding solar energy being used as a renewable resource.

Key Vocabulary

1. Solar energy
2. Renewable resource
3. Solar panel
4. Thermal energy
5. Photovoltaic cell

Safety and Cleanup Required

1. Soldering should be performed by an adult in a well ventilated area.
2. Students should use caution with hot glue guns to avoid burns.
3. Students should use caution with scissors and nails to avoid cuts.



Extension/Project:

1. Build and compare different solar cookers for efficiency.
2. Design a solar cooker for a particular location or country.
3. Compare a variety of solar cookers for a variety of foods. Which work better for each type of food.

Alignment with TN Science and Math Standards

Algebra I

- CLE 3102.1.5 Recognize and use mathematical ideas and processes that arise in different settings, with an emphasis on formulating a problem in mathematical terms, interpreting the solutions, mathematical ideas, and communication of solution strategies.
- CLE 3102.1.7 Use technologies appropriately to develop understanding of abstract mathematical ideas, to facilitate problem solving, and to produce accurate and reliable models.
- CLE 3102.5.1 Describe and interpret quantitative information.

Algebra II

- CLE 3103.1.2 Apply and adapt a variety of appropriate strategies to problem solving, including testing cases, estimation, and then checking induced errors and the reasonableness of the solution.
- CLE 3103.1.4 Move flexibly between multiple representations (contextual, physical, written, verbal, iconic/pictorial, graphical, tabular, and symbolic), to solve problems, to model mathematical ideas, and to communicate solution strategies
- CLE 3103.1.5 Recognize and use mathematical ideas and processes that arise in different settings, with an emphasis on formulating a problem in mathematical terms, interpreting the solutions, mathematical ideas, and communication of solution strategies.
- CLE 3103.1.7 Use technologies appropriately to develop understanding of abstract mathematical ideas, to facilitate problem solving, and to produce accurate and reliable models.
- CLE 3103.2.3 Use appropriate technology (including graphing calculators and computer spreadsheets) to solve problems, recognize patterns and collect and analyze data.
- CLE 3103.2.4 Understand the capabilities and limitations of technology when performing operations, graphing, and solving equations involving complex numbers.
- CLE 3103.5.1 Describe, interpret, and apply quantitative data.

8th Grade Science

- GLE 0807.Inq.2 Use appropriate tools and techniques to gather, organize, analyze, and interpret data.
- GLE 0807.Inq.3 Synthesize information to determine cause and effect relationships between evidence and explanations.
- GLE 0808.Inq.5 Communicate scientific understanding using descriptions, explanations, and models

Biology

- CLE 3210.Inq.2 Design and conduct scientific investigations to explore new phenomena verify previous results test how well a theory predicts, and compare opposing theories.
- CLE 3210.Inq.3 Use appropriate tools and technology to collect precise and accurate data.
- CLE 3210.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.
- CLE 3210.Inq.6 Communicate and defend scientific findings.

Chemistry

- CLE 3221.Inq.2 Design and conduct scientific investigations to explore new phenomena verify previous results test how well a theory predicts, and compare opposing theories.
- CLE 3221.Inq.3 Use appropriate tools and technology to collect precise and accurate data.
- CLE 3221.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.
- CLE 3221.Inq.6 Communicate and defend scientific findings.

Solar Cockroach Kit Instructions

From browndoggadgets.com

GOAL

Today you will learn how to instruct a solar cockroach from a solar cell and vibrating motor.

SUPPLIES

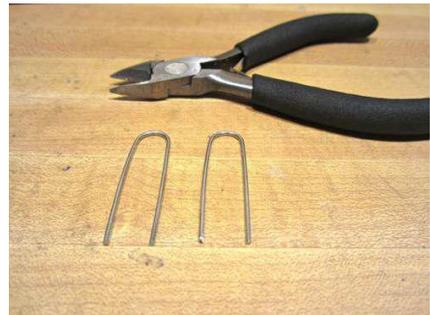
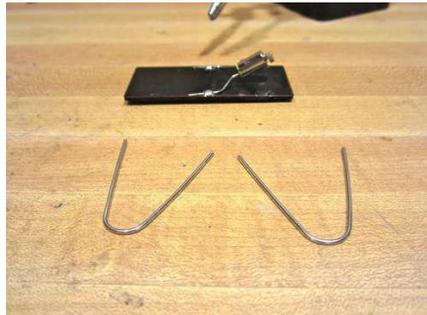
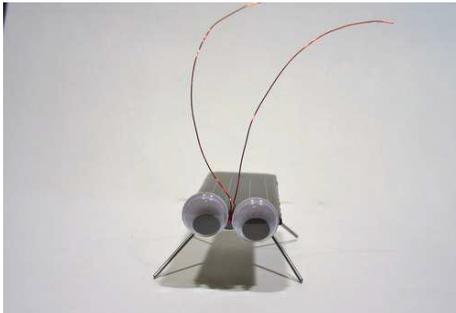
A list of the materials which have been provided for you include:

- A. One 2V solar cell
- B. One vibrating motor
- C. One resistor (we will only use the scrap wire from the resistor)
- D. Two eyes
- E. Two paper clips for the legs
- F. One magnet wire for the antenna

TOOLS

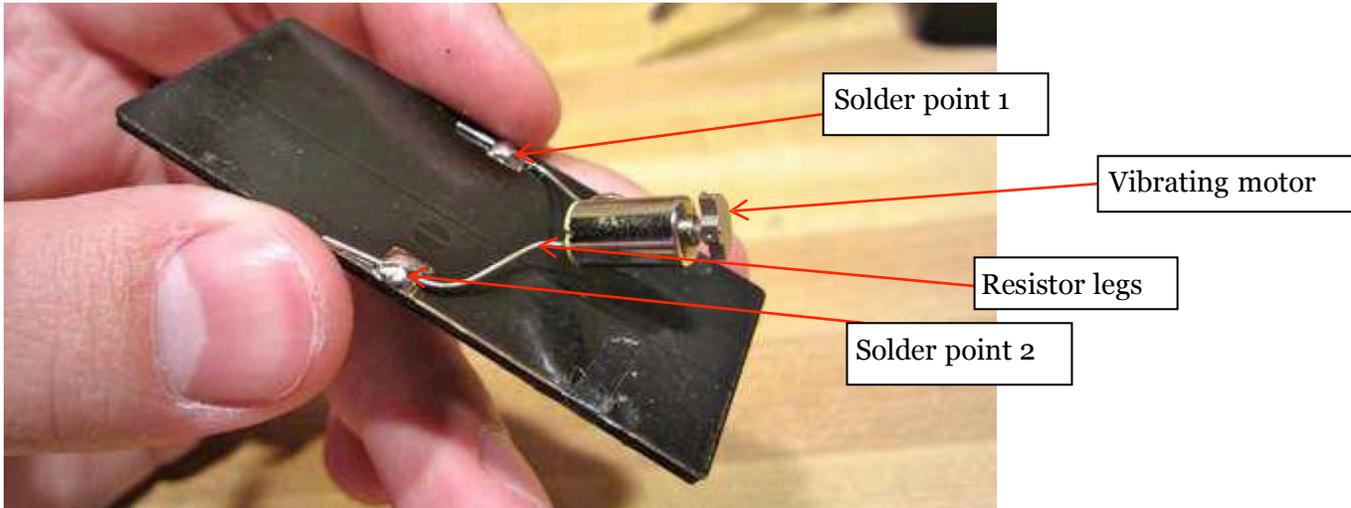
A list of tools which have been provided for you in order to build the cockroach include:

- A. Hot glue gun and hot glue sticks
- B. Wire cutters for cutting the resistors and paper clips
- C. A helping hand from a friend

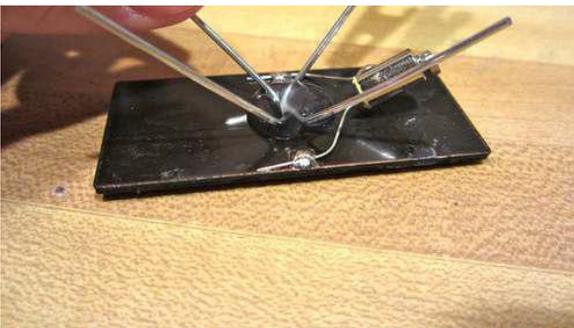
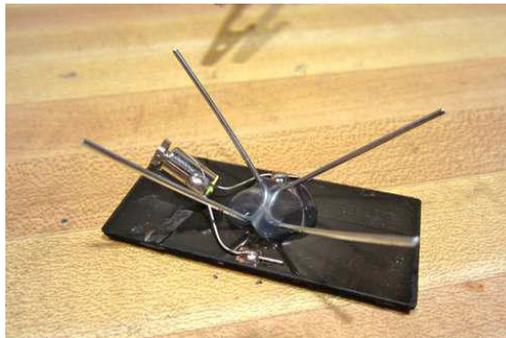
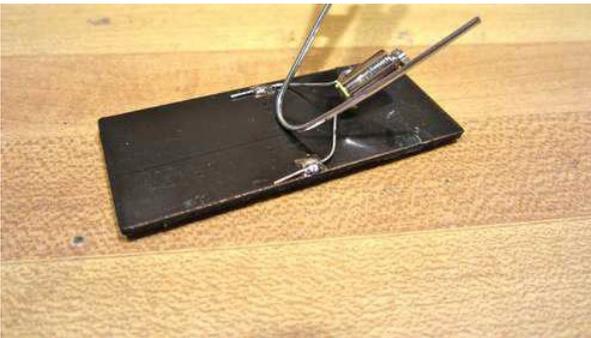


STEP TWO: GLUE THE LEGS

- As you can see, the resistor wires have already been cut with a wire cutter and the middle of the resistor has been thrown away. The resistor legs were bent at a 90 degree angle using pliers and soldered to the motor. One resistor leg went to the positive solder point while the other went to the negative solder point. Soldering the motor to the solder points allows us to have electrical contact. When the solar cell is exposed to sunlight, this enables the motor to vibrate.

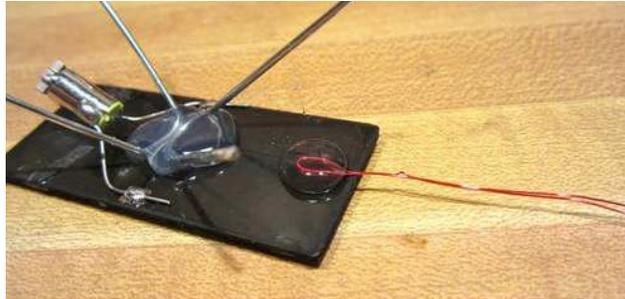


- To glue the legs, place the solar cell face down so the motor is facing you
- Use a helping hand to hold a set of legs at an angle
- Use your hand to hold a second set of legs at an opposite angle
- Apply a fair amount of hot glue to hold the legs in place and wait for it to harden



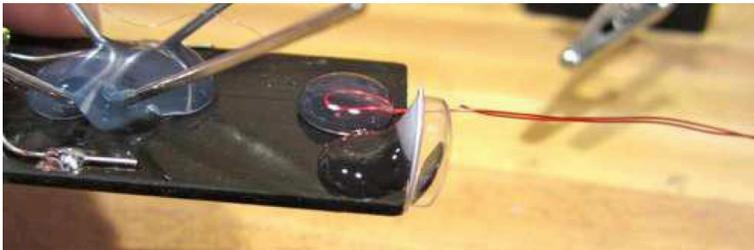
STEP THREE: ATTACH THE ANTENNAE

- Fold your magnetic wire in half
- Place the wire in the front, middle of the solar cell
- Apply hot glue and wait for the glue to dry
- Once the glue dries, you can bend the antennae however you like



STEP FOUR: APPLY THE EYES

- Place hot glue on the bottom of one eyeball and place the eye to the right or left of the antenna
- **Be careful not to get hot glue on your finger
- Do the same thing for the other eye and place it on the other side of the antenna, as close to the eye as possible
 - Apply some pressure to the eyes by pressing on them a little bit until the glue dries



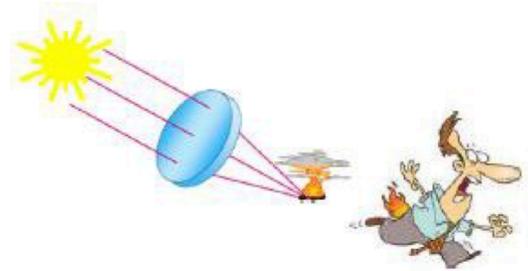
STEP FIVE: TEST THE COCKROACH!

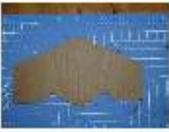
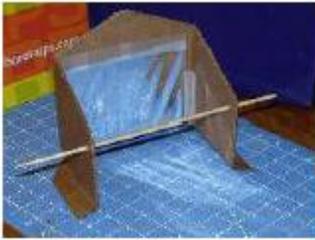
- Now that your cockroach assembly is complete, take it to a heat lamp to test it out. Place the cockroach under the light and see how it moves!

Additional Resources:

<https://www.instructables.com/id/Solar-Cockroach-20/step2/Video-Instructions/>

Concentrating Solar Cooker



Cone	Box	Support
<p>The cone is drawn on a large sheet of double-thick construction paper with the pattern on one side and a reflecting mylar coating on the other side. Cut out the pattern but DO NOT CUT THE DASHED LINE! The dashed line is the overlap that makes tape-up easier.</p> <p>Roll the cone to shape with the reflective side in and use packing tape along the seam. This takes more than one person - do not let some hero try it alone. Reinforce both ends with tape.</p> <p>Use the nail to punch a hole close to the large end and attach a 3-foot length of string.</p>	<p>Cut a 3" x 3" square hole one inch from the center of the narrow end of the lid of the box.</p> <p>Cut a piece of plastic wrap to cover the hole and tape it to the inside of the lid.</p> <p>Fill the box with shredded paper for insulation. Keep the mess to a minimum - it would be nice if we were invited to come back.</p> <p>Use the nail to punch a hole in the side of the box to allow the thermometer to be inserted.</p>	 <p>The support structure has been pre-cut from cardboard but must be bent into shape.</p> <p>Cut a piece of mylar 4"x6" and tape it to the back of the structure, shiny side out</p> <p>Use nail to punch holes in the sides as illustrated in the picture and insert the skewer.</p>
		

Assemble the pieces

Align the support structure with the hole in the top of the box and tape it in place. The back of the support structure will hang over the edge of the lid.

Remove the skewer, hold the cone in place and puncture with the skewer as you slide it back into place. The pivot point should be about an inch from the end of the cone. It may be helpful to use one of the nails to punch the holes.

Support the cone at an angle by inserting the string into the slits in the support structure. You may have to tie some knots in the string.



This one is missing the mylar back reflector

Solar Oven Data Sheet

Using your thermometers, record the temperature of the air inside and outside of your solar oven every 30 seconds for at least 10 minutes. Plot the data on the graph below.

Time (m:ss)	Temperature Outside (C)	Temperature Inside (C)
0:00		
0:30		
1:00		
1:30		
2:00		
2:30		
3:00		
3:30		
4:00		
4:30		

Time (mm:ss)	Temperature Outside (C)	Temperature Inside (C)
5:00		
5:30		
6:00		
6:30		
7:00		
7:30		
8:00		
8:30		
9:00		
9:30		

Solar Oven Heating

