Solar Bug 2.0 Lesson/Extensions

Content Area: Engineering/Science/Energy

Topic: *What are the factors that affect solar cell output?*

Context: *Using your Solar Bug 2.0 to investigate how light interacts with solar cells.*

Solar cells are all around us…keep an eye peeled and you will find them on anything from bus stops to calculators to garden lights and rooftops. Solar cells are part of an array of technologies and materials that humans currently use to create electricity. What are the ideal conditions for their function? With a Brown Dog Gadgets Solar Bug 2.0 kit you and your child/student(s) will first assemble a fun, solar-powered circuit together. They will also use this critter afterward in a couple of short scientific investigation aimed at learning more about how light interacts with solar cells & factors that impact cell output and what the limits of its' use are!

Age/Grade: 4th grade and up

Duration: 40-60 minutes

Materials: 1x Solar Bug kit, 1x long table, 1x meter stick, paper, writing utensils, digital thermometer (optional), a variety of household lighting sources, printable data sheets, making tape, Digital Scale (optional), handful of rice or cheerios.

Central Questions/Brainstorm:

This activity begins with some central questions…things that you and your child/student(s) will investigate and answer through your use of an assembled Bug.

- *Is it possible to change the energy of light into electrical energy?*

Have your children tell you what they know about turning light into electricity. What they assemble will be verification that it can be done!

Educator Background: *Law of Conservation of Energy*

The natural world around us may seem chaotic at times. Although, through careful testing and observation, scientists HAVE described understandings of patterns in the chaos and randomness that have held up to repeated independent checks over the course of our scientific history. Science refers to this type of understanding as a "law" and one important natural law called the **Law of Conservation of Energy** is at play in the use of solar cells. There are many different types of energy that each have their own characteristics. Different energy types often behave in their own specific ways. However, one characteristic of ALL energy is that it is never truly being created from scratch…it is and always will be changing from one form of energy to another. If we consider the single daily experience of driving in a gas- powered automobile, we are experiencing the effects of the energy contained within the bonds of the fuel being changed into heat, pressure and motion. The energy locked within the **fuel** in most cars came from the decomposed and pressurized remains of **prehistoric organisms** that absorbed THAT energy from their food sources that, somewhere down the line on the food chain, acquired THEIR energy by converting sunlight into sugar. That **sunlight**, in turn, came from intense reactions happening at the **sun**…and on and on and on back to the original materials and processes that allowed the universe to take shape. In solar cells of today, current sunlight is being absorbed by materials called semiconductors in the form of heat which causes temporary changes in them. Based on how we arrange these materials in the solar cell, those changes can cause electrons to move from atom to atom which is, by definition, what electricity is. Once created at the solar cell, this electrical energy can be used to power circuits where it continues to change forms of energy as it does work.

Student Activity: *Assembly of Solar Bug* (10 minutes)

Have your kids follow the steps on the printed card included in your kit or via our online resources in order to complete this circuit. Decorate, Assemble, Place in the light... Watch it go!

Central Questions: Brainstorm

- *Do all light sources produce the same KIND of light?*
- *Does the distance of a light source from a solar cell affect a solar cell's output?*
- *Is there a relationship between temperature of light and solar cell output?*

Ask your kiddos to brainstorm and offer ideas related to how they could test to find factual evidence related to those questions with household materials. After this, they will conduct a few easy experiments using common household materials listed along with their assembled solar critter. What they observe, measure, record, organize and analyze will help them answer the three questions above.

Student Activity: *Testing light type & distance between light source and solar cell* (20 minutes)

Assemble the following materials: several different household light sources (cell phone flashlight, desk lamp with different size/types of bulbs, flashlights, ceiling lights etc…), printable data sheet, writing utensil, meter stick. ***The goals of this activity are twofold:***

1) to try to determine if all light sources have the same amount of energy

2) to try to determine the max distance that a given light source can be from the solar project in order to cause the motor to turn on.

Your student(s) will need to use one of the following two, simple methods in order to test a given light source. They will either slowly move the solar project TOWARD a light that cannot be moved (ceiling light) or they will keep the solar project in a stationary position and slowly move the LIGHT toward IT. This will depend on whether the light is too heavy or fixed in place OR something they can pick up safely. In either case, every effort should be made to eliminate ANY light sources that are **not** being tested so that, if and when the project motor turns on, students know that the light being TESTED is responsible for doing it and not other lights. They should also try to position the bug directly below the light source to be tested. This will mean that the light from varying sources will be hitting the solar cell on the back of the bug at a similar angle in all trials. Unless the light source is an unusually powerful one, it is unlikely that the project will turn on from further than a meter away. Slowly move either the light source toward the project or the project toward the light until the project's motor begins to vibrate. Position a meter stick between both the project and the light source in order to measure the max distance that the light is effective from. Your kids should note the distance between the two and record it on their data sheets. If the light source didn't make the motor work no matter how close they got to the solar cell, simply record it as "not powerful enough". In this simple investigation, point out to your participants that they kept a number of things the same in their experiment. **Ambient light, the solar cell, motor, and the angle that the test light was hitting the solar cell at were all constant.** When set up this way, the variety of outcomes that can be observed must either be caused by the **LIGHT TYPE** and/or the **DISTANCE** that it was from their project. If only some of the lights were able to power up the motor while others did not, there is sufficient evidence that not all light sources produce the same type of light. If an individual light source had to be at a certain distance in order to produce enough electricity to power the motor, there is sufficient evident to suggest that the distance between source and destination can impact the amount of energy carried by light to its' final destination.

Student Activity: *Testing Temperature of light source & Solar Cell Surface* **(10 minutes)**

Using the same array of lights and bulbs from the light distance/type investigation, use either one's hand or a digital thermometer to determine relative temperature of each. Instruct your children to allow each light to warm up for a standard amount of time before taking any reading so that any differences between light sources cannot be caused by differences in warm up time allowed. If a thermometer is used, kids should simply touch the thermometer to the surface of the light source and record the temperature in the appropriate place on their data sheets. If a thermometer is not available, hands can be used from 3" away. Instead of having a temperature to record, students will have to put the light sources in order from hottest to least hot. Although this may be a bit less accurate, it is still useful enough data to be used for comparison to their distance and light type data set. Ask your students to look over the data from the first investigation and what they found out about the temperatures right now. Do they see any patterns? Were the light types that turned the motor on from the furthest distance usually hotter or cooler by comparison? Were the light types that had a hard time turning the motor on (the lights that either didn't turn the 'bot on OR had to be super close in order to do so) hotter or cooler? Which temperature of light seems to cause the solar cell to produce more electricity?

Extension Activity 1: *How do the angles of the light and solar cell impact electricity output?* **(5 minutes)**

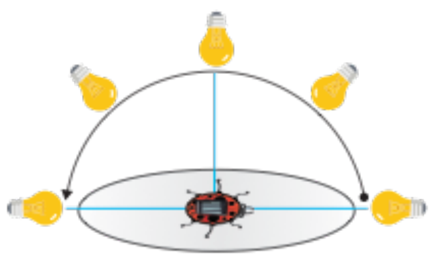
Many outdoor solar panels are held at certain angles facing certain directions.

Some REALLY fancy outdoor solar panels are even able to CHANGE that position throughout the year and day! This is because the angle at which the sunlight hits a solar panel can greatly impact the amount of electricity it is producing. Ask your students:

- Does the Sun's angle stay the same throughout a given day or does it change?
- Does the angle that a surface is positioned at, affect how sunlight hits it?
- Do these angles affect the output of the panel & why is that important to know when using solar cells outside?

To investigate the answers to these questions, place the solar bug in a stationary position on a long table. Using a single light source already determined to be able to turn the motor on from a distance, your students can mimic the daily arced path the sun follows from sunrise to sunset over the solar cell. To do this, pick one of the light sources that tests have confirmed to be able to turn the motor on with (preferably the one that could do so from farthest away). Ask your kiddos to recall the furthest effective distance measured (it should be on their data sheet) to still turn the motor on with. With the meter stick, they should measure this distance in opposite directions on the table from where they have decided to place their solar project. They can place a piece of masking tape down to mark these positions and use a writing utensil to mark one as East and the other as West. Use the "East" tape mark to represent where the sun first becomes visible, along with the imaginary point directly above their solar project as where the sun is at noon and the remaining tape mark as sunset.

Instruct your children to move their selected light source in an arc that starts at one of those tape marks, goes above the solar cell that same distance above and then over to the other tape mark (fig 1). They should do so in an effort to find, through observation, the positions along that arc where the motor turns on and turns off. They will likely see that the same light that turned the motor on from directly above, will not when at the sunset and sunrise positions even though those points should be just as far from the surface of the cell.


(fig 1)

Extension Activity 2: *Are Solar Bugs as strong as real bugs?* **(5 minutes)**

According to studies, actual bugs are insanely strong. Some species have been seen carrying things that are 10-50 times their own body weight! They do, however, have their limits…and so do the motors that are creating the vibrations that cause your solar bugs to skitter around in the sunlight. To test to see how much weight these small paper creations can move, have your students each snip a three-inch-long section of Maker Tape and tape it to the underside of the paper bug template's posterior (rear) so that it drags behind the bug with its' sticky side up. Stick kernels of rice, dried beans, or cheerios one by one onto the adhesive of the tape while letting the solar bug operate in full sunlight until the bug struggles to drag the total and move around or forward in any way. Once this limit has been found, they can remove the tape and weight and use a digital scale to see what its' weight actually is!

Extension Idea 3: *How might rattle foot placement impact movement?* **(5 minutes)**

Your students had the choice to use three or four rattle feet (googly eyes) on the underside of their solar bugs when they first assembled their projects. This means that your group is likely to have an assortment of foot arrangements to observe. Put your students in a position to view each of the configuration types in action under full sunlight on same or similar surfaces. This may mean switching with a partner if your class is physically together or sharing video for observation. Allow students to share their observations and possible explanations to account for any differences. Most of the observable differences in performance will be related to the direction of travel/resulting motion.

For more projects, guides and templates, find us at: BrownDogGadgets.com