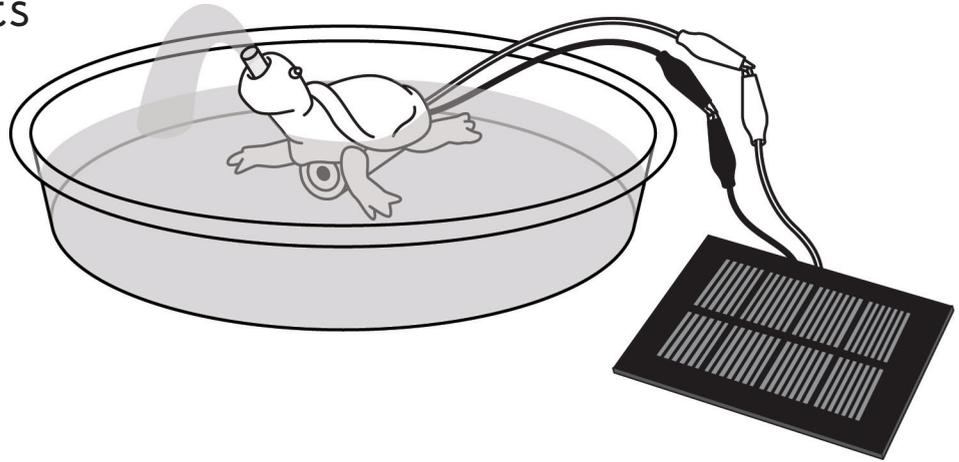


Materials for 5 Solar Fountains or 5–15 Students



Grades

- 2–12

Concepts

- Inquiry and Science Process
- Energy and Energy Transfer
- Forces and Motion
- Earth Science
- Engineering, Art, and Design
- Using Basic Tools
- Collecting and Interpreting Data

Time required

- One or two class periods

Objectives

At the end of the lesson, students will:

- Know the fundamental aspects of a solar panel and understand how placement and orientation affect its power output
- Be able to use the scientific method to isolate and adjust variables in a solar powered fountain
- Understand power measurement and energy concepts, using a small water pump
- Be able to use basic engineering, art and design skills to create a one-of-a-kind solar fountain

Your REcharge Labs Classroom Kit

The materials enclosed in this kit will help you bring engaging lessons about renewable energy into your classroom. Consider attending a REcharge Training, if you haven't already done so, to enhance your experience using these materials.

About REcharge Labs

We believe that responsible and informed students of today will become our innovative renewable energy leaders of tomorrow. At REcharge Labs, our mission is to provide the resources to encourage this generation of informed thinkers, involved doers, and curious life-long learners.

REcharge Labs provide everything you need to teach renewable energy.

- **Professional development workshops** that prepare you to teach fun, hands-on project-based wind and solar activities.
- **Scalable activities** for different age groups and time frames.
- **Kits and resources** that fit educational standards and your budget.

We recommend attending a REcharge Lab training workshop to enhance your experience using these kits.

REcharge Labs was born out of programming from the KidWind Project, and relies upon KidWind's resources and history to carry out its work. KidWind has been a leader in renewable energy education for over a decade. REcharge Labs, like KidWind, continues to be committed to bringing affordable, hands-on applications of our materials to teachers and students worldwide.

A note on reproduction

Reproduction of this activity guide and associated kit is prohibited except for student use in the classroom. For permission to copy portions or all of this material for other purposes, please contact REcharge Labs at info@rechargelabs.org.

Find kits and sign up for training workshops at www.rechargelabs.org

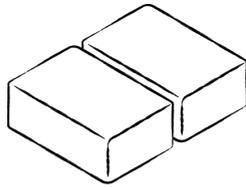


Materials

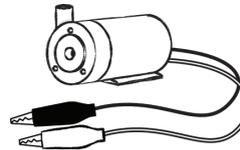
There are many ways to construct a Solar Fountain. The guidebook suggests some ways using the basic materials included in this kit, but that's just the beginning of the design possibilities.



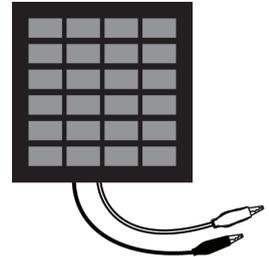
Trays



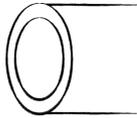
Plasticine



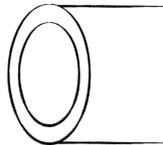
Water pump



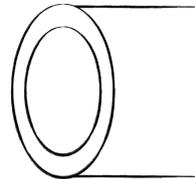
Solar panel
3V 500mA



Small Tube
1/8"



Medium Tube
1/4"



Large Tube
3/8"

You will need to supply the following materials:

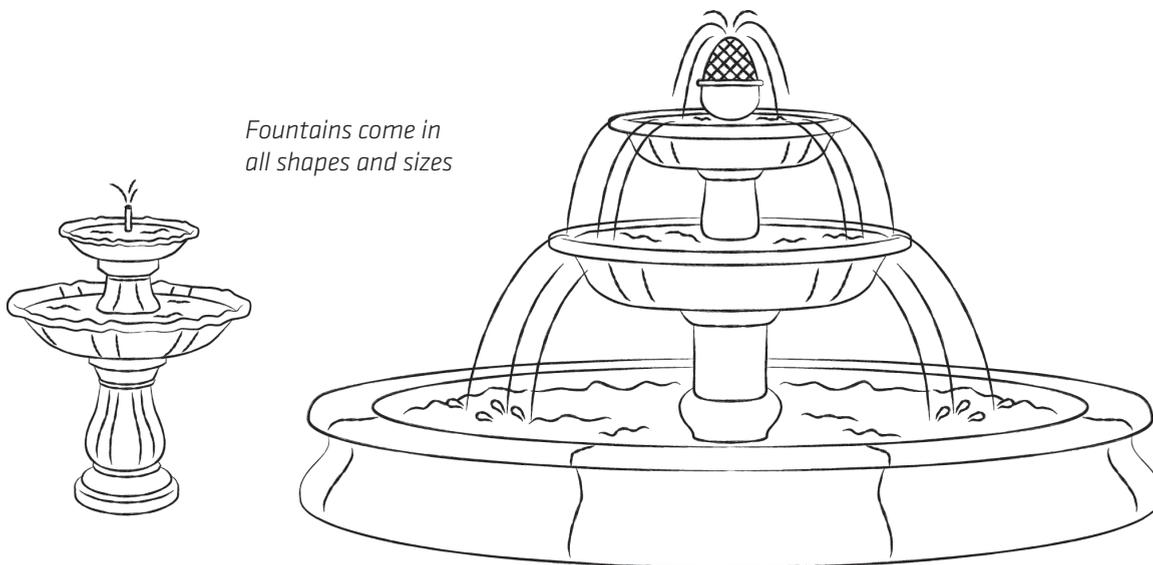
- Scissor
- Water
- Towel
- Lamp (if you do not have good sunlight)
- High wattage incandescent bulb (100 watts or higher)
- Compact fluorescent bulb (optional)
- LED bulb (optional)
- Ruler
- Protractor
- Color acetate sheets (optional)
- Alternative fountain building material such as plastic bottles, large basins for water, more plasticine, straws, etc.

Background

We see fountains everywhere, from the drinking fountains at school to the huge displays of the Bellagio in Las Vegas or the Trevi Fountain in Rome. Fountains have been an important part of human history for both their functional and decorative purposes, and still are today. Until the 19th century, fountains relied on gravity to move water, so were dependent on a nearby watershed or an elevated water tower. More recently, the invention of electricity and the steam pump have enabled fountains to be built in more places. During this lesson, students will use the power of the sun to build their own creative water fountain.

Learning Goals

This activity demonstrates how solar energy is transformed into electricity that we can use. Students will use solar panels to power a small water pump and build a functioning fountain. In doing so, they will learn how a solar panel works, collect data and test variables, and apply their observations to their engineering process as they improve their designs.



Getting Ready

- Build and test your own Solar Fountain before the class begins. This is a valuable preview to the challenges and problems that students will face. Your example will also help students conceptualize the final product of the lesson.
- Gather the tools and any additional items students will need to complete the activity.
- If you are working inside, prepare a work area that can get wet, and set up a lamp in a spot that is safe from water. **Warning: do not use water near electrical outlets!** Prepare a pitcher of water. You will need towels for clean up.
- Part of this activity is best done outside on a sunny day, although it can be done indoors under some very high wattage lamps. If possible, plan to do this lesson during days predicted to be sunny. Cold weather does not harm the electronics or the solar panels, although may be unpleasant when dealing with water!
- Gather some images of fountains from around the world. This will be helpful in starting the conversation with students on how to construct their fountains.
- Prepare the plasticine by warming it up. Since plasticine is an oil based clay that never hardens, it resists water absorption and will not dissolve or get gooey. It is easy to reuse and reshape plasticine as often as you like. But this also means that when the plasticine is cold, it is very difficult to mold. Warming the plasticine will make it much easier to use, especially for younger students. You can do this by placing the clay under the high wattage lamp (close but not touching it), by using a hair dryer, resting the plasticine on a radiator or heater, or by placing it in the sun. The plasticine will also soften the more it is handled. Once a desired shape is achieved, cold water can be run over the shape and the plasticine will harden quickly.



Activity Overview

During the first part of this activity, students learn how to wire the solar panel to their pump to move water. During the second part, students perform experiments to better understand how their design affects the performance of their fountain. This activity works best with groups of two or three students.

Step 1: Beginning questions for students

- What is the most interesting or memorable fountain you have ever seen? Why does it stand out in your memory? What could it do? What made it unique?
- Who has seen solar panels before, and where?
- Why are solar panels important?
- What variables do you think affect how much power a solar panel produces?
- How do humans harness energy from the sun?

Step 2: Distribute materials

Each group of students will need: one solar panel, one pump, some plasticine, three sizes of tubing, two water trays, scissor, towel, pitcher of water, and lamp station.

Step 3: Affix the pump

Students should use the following instructions to attach the pump. Set up the solar fountain materials on a flat work area with a high wattage lamp. Set one tray into the other; this fortifies the tray's strength. Attach the pump to the middle of

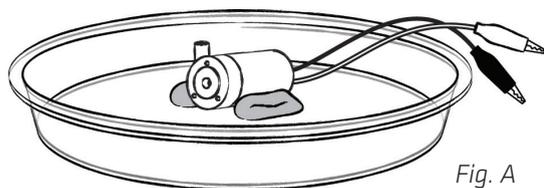


Fig. A

the tray using small pieces of plasticine like gum to stick the pump in place (Fig. A).

Step 4: Make a tube adapter

There are three tube sizes in the kit: small, medium, and large. In order for all three tube sizes to fit on the pump, an adapter needs to be made using the medium tube. To make the adapter, students should cut 1 inch off the medium tubing, and attach this piece to the nozzle on the pump. The fit should be snug (Fig. B). Now, test to see how the small and large tube sizes fit on the adapter (Fig. C.)

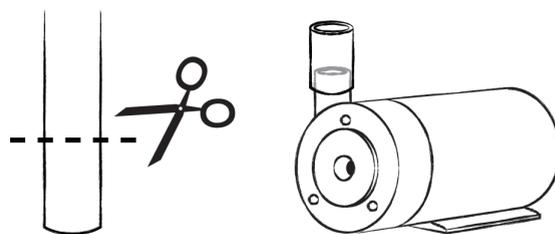


Fig. B Cut 1" inch off medium tube to make adapter

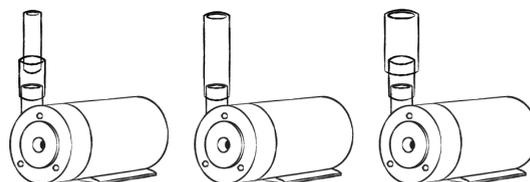


Fig. C Test and experiment with tube sizes

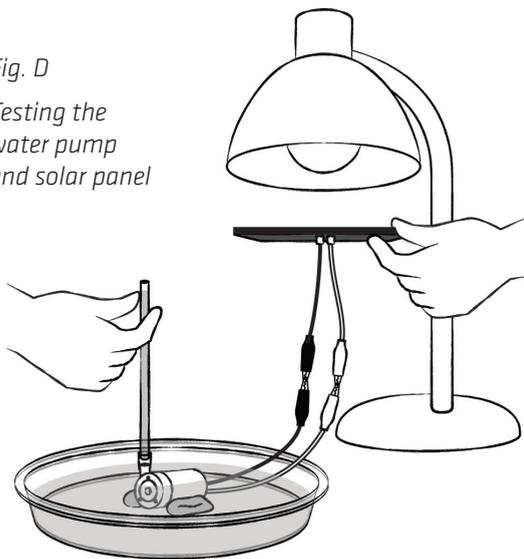
Step 5: Water pump and solar panel test

First, ask the students to make sure the adapter and tube fit tightly on the pump nozzle, starting with the small tube. The tubing will be too long to stand upright from the pump, and will need to be held upright by someone during testing.

Second, students should check to see that the pump is attached to the tray, and that the pump wires are hanging off the tray edge. Then they should fill the tray with an inch of water, enough to cover the pump intake hole.

Third they should attach the solar panel wires to the pump, red to red, and black to black. While it is attached to the pump, students should position the solar panel next to the lamp light (Fig. D). Water should be pumping up the tube. If it is not, students need to make sure all the wires are connected, that the water is above the pump

Fig. D
Testing the
water pump
and solar panel



intake hole, nothing is shading the panel, and the panel is close enough to the lamp. Students should work with the pump and the panel until water goes up the tube. Once the students have their system working, have them turn the lamp off and take a break to learn about the vocabulary and variables below.

Step 6: Vocabulary and variables

Many variables affect how much power the solar panel can produce, which in turn affects how much and how high water can be pumped. When designing a fountain, it is important to be familiar with certain vocabulary words and understand some important the variables. The way these variables affect one another will influence how students design their fountains.

Solar panel (photovoltaics): Solar panels convert light into electricity. In this activity, the electricity generated by the solar panel powers the water pump. A solar panel is made up of tiny photovoltaic (PV) cells. Photovoltaic comes from the words *photo*, meaning light, and *volt*, the measurement of electricity. Have students read the solar panel passage on page 14 for more information. Because solar panels require light to generate electricity, the intensity and the angle of the light affects how much electricity can be generated.

Solar panel variables:

- light source
- distance from the light source
- angle of the panel to the light source

Light source: A light source is an object or device that glows or produces light. There are different kinds of light sources in the world, natural and human made. The sun, fire, lightning, and glowing organisms are natural light sources. Human-made sources, like light bulbs, come in a variety of sizes, brightnesses, and types. Ask the students to name the types of lights located in the classroom, for example, fluorescent, incandescent, LED. If possible, try to define the wattage of the light bulbs, especially the one used in the lamp on the activity table.

Light source variables:

- type of light source
- wattage

Water pressure: Water pressure is the strength of water flow. In the example of solar fountains, if the water pressure is really high, the water will rise so high that it will overflow out of the top of the tube. If the water pressure is low, it will not rise very high in the tube.

Water pressure variables:

- solar panel electricity produced
- inside tube dimension

Indoors, this activity can be messy. Make sure lamp cords, power strips, and outlets, as well as



WARNING!

Keep water off wall powered electrical devices.

any other devices using wall power, remain dry during the experiment. Water can cause electrical devices to malfunction, and in extreme cases, can cause lethal shock or fire.

Important: The solar panel included in the kit does not produce enough current to cause any shock or harm while submerged in water. It is safe for the pump to be completely submerged in water.

Step 7: Solar Scavenger Hunt

The Solar Scavenger Hunt demonstrates how the variables listed earlier will affect solar fountains. This is important to understand: if students can control energy flow, they can reliably predict how their fountain will behave and can make design decisions based on this. Distribute meter sticks, protractors, and copies of the Solar Scavenger Hunt worksheet on page 15 of this guide. Students will also need the pumps they set up earlier. This activity is best done in groups. One student will hold the tubing upright and position the solar panel. Another student will hold the meter stick



Fig. E

Collecting data inside

and write down data (Fig. E).

First, identify a variety of light sources as a class. Encourage students to think about indoor and outdoor options. What are different types of light bulbs? Have the students list the light sources as they are discovered. For fun, prompt them to think about how additional variables affect the light, like colors from acetate sheets, reflective surfaces, shade, clouds or windows.

Data collection: Test the solar panel, light source, and water pressure variables.

To begin, ask students to replace the short adapter tube with the remainder of the medium tubing. While the students are setting up tests, it may be less messy to remove the panel from the pump and water tray until the test begins. Remind students to set the water-filled tray on solid, flat surfaces during testing, or the water might spill out.

Before the students collect data, they should think of the variables they will be testing:

- Choose at least three *light sources* to test.
- Choose at least three *distances* to test for the light sources.
- Choose at least three *angles* to test for the solar panel.

Groups will test each light source at the distances and angles they chose. Position the solar panel at the first light source. Using the meter stick, one student will measure the first distance variable, from the lamp or light source to the solar panel. Students should place the light source directly above the panel, to the best of their ability. Holding the panel in this position, another student



Fig. F

will place the panel at the first angle variable they chose, using the protractor as a guide. Make sure the flat bottom of the protractor is level or parallel to the ground. Have students begin their test by following these instructions. Hook the panel back up to the pump in the tray of water (Fig. F). Record the height the water reaches on the tube, using the meter stick, (It is helpful to tape the tube to the meter stick before testing.) On the worksheet, record the test

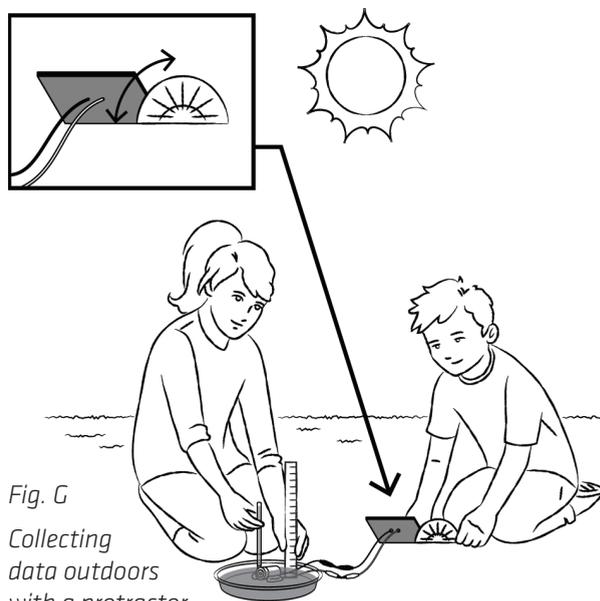


Fig. G

Collecting data outdoors with a protractor

number, light source, distance, angle, and height the water reaches (Fig. G).

For visual data collection, give students the option of marking the water height on the tube itself. Place a piece of clear tape on the tube and

The distance from the Earth to the sun is 149,597,870,700 meters (92,955,807 miles), which is the equivalent to flying around the Earth's equator 3,733 times! The distance from the Earth to the sun is called an **astronomical unit**, or AU, which is used to measure distances throughout the solar system. If students are using the sun as a light source, students can use one AU as the distance measurement.

write the test number on it. This helps students visualize the variables.

Continue to test the other two light sources with the same distances and angles.

Afterwards, reconvene as a class to discuss the data gathered. Invite students to come up to the board and write the most powerful and the least powerful light sources they tested, including angle and distance, and the height of the water in the tube. Once each group has added to the list, ask students to reflect on the data and discuss which areas they think are more efficient places to place solar panels, and why.

Step 8: Experiment with tubing

If the variables for the solar panel and light

source are constant, a comparison can be made between the difference in water pressure based on the tube size and length. With the small tube, the water pump has to pump harder to push the water up the tube, but has less water to pump through the narrow channel, so the water pressure will be high. The large tube will need more water to rise up the same distance as the small tube, so the water pressure will be less.

Students can test this by exchanging the different tube sizes on the adapter they made earlier. They can also affect the water pressure by splitting the stream or partially blocking the stream partially with plasticine. See what happens when their tube is not straight up and down, but angled or curving. Record the findings on the bottom of the Solar Scavenger Hunt worksheet.

Step 9: Develop a design for the fountain

Based on data they gathered, students can now design a fountain. Start the process by asking students some design questions: Do you want a fountain that shoots really high? Do you want a fountain that only works in direct sunlight? Do you want one that works in all kinds of light but does not shoot high? Do you want to move a little bit of water or a lot? Do you want one stream or multiple streams?

Have students brainstorm the technicalities of their design in groups, or individually. Ask students to draw out a solar fountain design that includes fountain height, tube size, and the location where their fountain will be placed. If it will be indoors, then the distance to the lamp and the kind of bulb are important, or if outdoors,

then the time of day and sun angle are important.

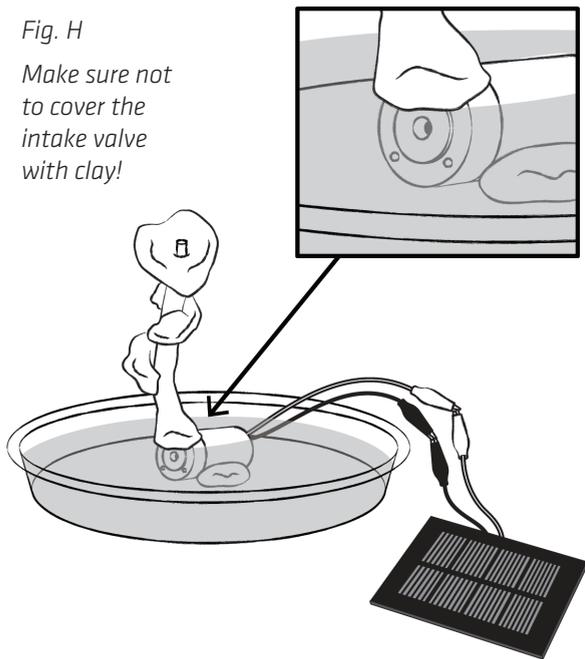
Step 10: Build a unique fountain

Using their design as a guide, students can start building! Make sure the plasticine has been prepared are ready for this step so that students can easily mold it. To make the tubing more secure on the pump, it can be covered in plasticine to offer it more support. Make sure not to cover the intake valve with clay (Fig. H)!

Students should continue to test and experiment

Fig. H

Make sure not to cover the intake valve with clay!



with different variables in order to improve the performance of the solar fountain.

RECYCLE! Use other materials not found in the kit. Look in recycling bins for plastic bottles and other things that can be cut up. Look for spoons and materials shaped in ways that can move, drip, hold, or spray water.

Step 11: Water fountain party

Once everyone has a functioning water fountain, have students go around and look at their peers' fountains. What do the fountains have in common? What is different? What aspects did students think were cool or creative? How did the construction process make them think about challenges faced when building real solar fountains?

Extension Activities

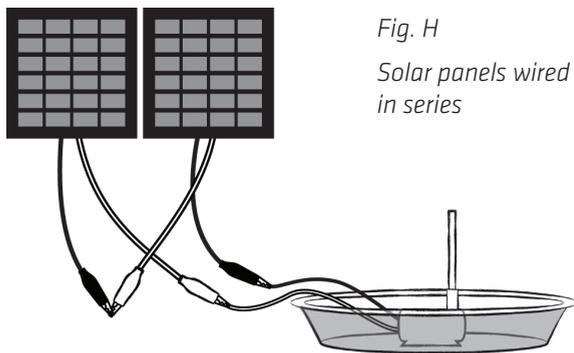
Introduce further experimentation with multiple solar panels.

Multiple panels

What happens to the water flow when multiple solar panels are hooked up? We can test the difference in water flow by hooking the solar panels in **series** or **parallel**.

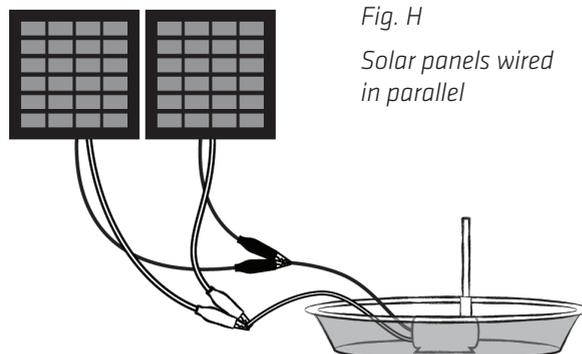
Step 1. Solar panels in series

Have students form a larger group so there are two solar panels per group. They should connect two panels in series by clipping the red wire from the first panel to the black wire of the second panel. Then they should connect the red wire of the pump to the open red wire of the panels, and the black wire to the black wire (Fig. H). What happened to the water flow? Did the water go higher in the tube? Was there a significant difference between one panel and two?



Step 2. Solar panels in parallel

Ask students to connect two solar panels in parallel by clipping the red wires of the two panels together, then clipping the red pump wire to this pair. Do the same for the black wires (Fig. I). Was there a difference in the **flow rate** between panels hooked in series or parallel?



Step 3. Calculate flow rate

One important variable of pumps is flow rate, the amount of fluid passing during a unit of time. Water pressure also affects flow rate. This means that if the water pressure is high, more water is moving faster. Ask students to design an experiment to calculate how many liters or gallons of water were moved per minute. What do they need to do it, and what is their process?

Vocabulary

We have listed some important vocabulary terms for students to understand as they work through the activities.

light source

A light source is something that glows or produces light. There are different kinds of light sources in the world, natural and human made.

water pressure

Water pressure is the strength of water flow.

astronomical unit (AU)

The distance from the Earth to the sun is an AU of 149,597,870,700 meters (92,955,807 miles). AU is used to measure distances throughout the solar system.

flow rate

Flow rate stands for the amount of fluid passing during a unit of time.

series

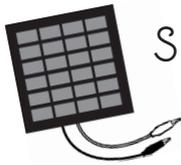
A way to connect components in a single path, like hands being held.

solar panel (photovoltaic)

Solar panels convert light into electricity. They are made up of photovoltaic (PV) cells. The term comes from the words *photo*, meaning light, and *volt*, the measurement of electricity. They convert light directly into electricity.

parallel

A way to connect components by like polarities, for example, all red positive wires connected, and all black negative wires connected.



Solar Panel Reading: How Does a Solar Panel Work?

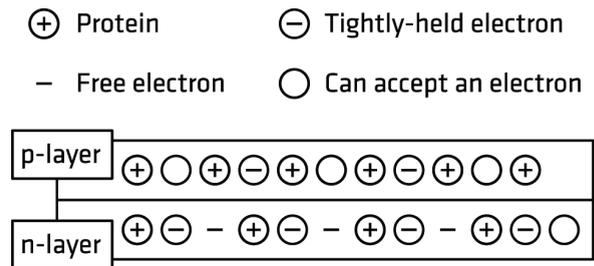
Given how prevalent solar panels are, it's surprising how little most people understand them. Give your students a brief overview of the process that happens inside each solar panel. Find a video or a diagram to supplement, this will give them a more tangible understanding of how this can be used as an energy source.

Each solar panel is made up of tiny photovoltaic (PV) cells. Photovoltaic comes from the words photo, meaning light, and volt, the measurement of electricity. They convert light directly into electricity. PV technology works any time the sun is shining, but the most electricity is produced when the light is intense and when sunlight is striking the PV modules at a perpendicular angle, which is the most direct.

Sunlight is composed of photons, or bundles of radiant energy. When photons strike a PV cell, a fraction of them are absorbed, and the energy from these photons is transferred to electrons in the atoms of the solar cell. With their newfound energy, the electrons are able to escape from their normal positions associated with their atoms to become part of the current in an electrical circuit. By leaving their positions, the electrons cause holes to form in the atomic structure of the cell into which other electrons can move, continuing the process.

Solar cells are usually made of two thin pieces of silicon, a semiconductor. One piece of silicon

has a small amount of boron added to it, which gives it a tendency to attract electrons. It is called the P-Layer because of its positive tendency. The other piece of silicon has a small amount of phosphorous added to it, giving it an excess



PHOTOVOLTAIC CELL CROSS SECTION

of free electrons. This is called the N-Layer because it has a tendency to give up negatively charged electrons. When the two pieces of silicon are placed together, some electrons from the N-Layer flow to the P-Layer and an electric field forms between the layers. The P-Layer now has a negative charge and the N-Layer has a positive charge. When the PV cell is placed in the sun, the radiant energy energizes the free electrons. A circuit is made connecting the layers, forcing electrons to flow from the N-Layer through the wire to the P-Layer. The flow of electrons means the PV cell is now producing electricity!

Solar Scavenger Hunt Worksheet

Go on a Solar Scavenger Hunt to find where the solar panel makes the pump push water the highest, and where it pushed the water the least. Use three sources of light at three different distances and angles.

SOLAR PANEL AND LIGHT SOURCE EXPERIMENT				
Test number	Light source and wattage	Distance to light source	Angle to light source	Height reached

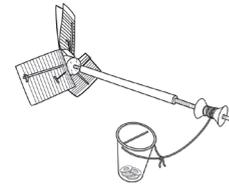
WATER PRESSURE EXPERIMENT			
Test number	Describe tube size	Describe tube orientation and position	Height reached



Did you like the **Solar Fountain Class Pack**? Then you might be interested in these REcharge Labs classroom kits.

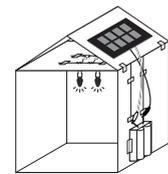
MacGyver Windmill Class Pack

Students will use a limited amount of materials to design and build functioning windmill models. They will use these models to convert wind into mechanical energy in order to lift weights. Using the scientific method, they will conduct trials, change variables, and work to improve the performance of their windmills.



Solar Town Class Pack

Build a small solar powered house, then learn basic circuitry to wire it with lights, a motor, switches, power storage, and a solar panel. Use the model house to learn about energy consumption, efficiency, and conservation in an average household. A great activity to model real world applications. Connect with your neighbors to build a town!



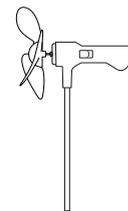
Sail Car Class Pack

Build a Sail Car using inexpensive materials to demonstrate how wind can be used to propel an object. Gather measurements, record changes in variables, and use simple engineering design concepts to build sails that can push the car as far as possible..



firefly™ Class Pack

This activity explores basic wind turbine design. Learn how to make an efficient wind turbine by designing a pinwheel shape to catch wind and illuminate an LED bulb. Experiment with materials and get creative with design.



Visit **www.rechargelabs.org** for more.

2010 East Hennepin Ave Building #2, Suite 101

Minneapolis, MN 55413

Phone: 877-917-0079 | Fax: 208-485-9419 | Email: info@rechargelabs.org

© REcharge Labs 2014 All Rights Reserved