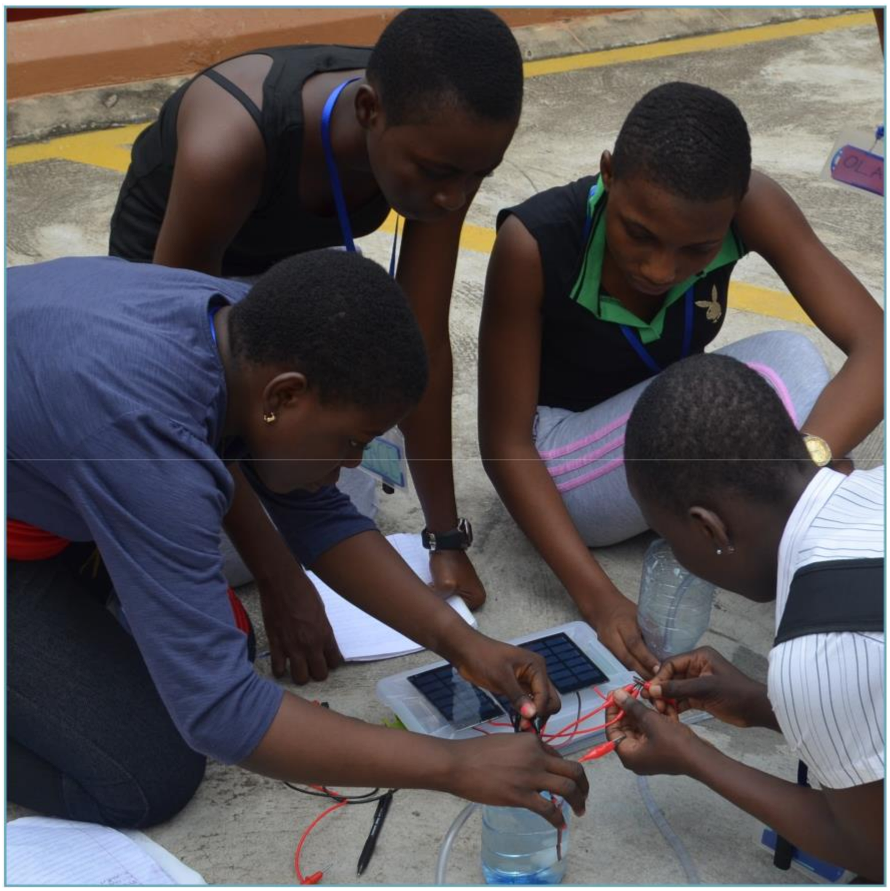
Solar Energy– Photo Voltaic

Outreach Program Lesson Plan



WAAW foundation

Working To Advance STEM Education for African Girls

WAAW Foundation is non-profit organization dedicated to bringing hands-on STEM education to girls all over Africa.

Our Mission: To increase the pipeline of African women in Science, Technology, Engineering and Math (STEM) disciplines and to ensure this talent is engaged in African innovation.

Our Vision: To eradicate poverty in African through female education and science and technology innovation.

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Class Description-

In this class, students will explore how solar panels work using a large model. They will experiment with small solar panels to find out what makes them operate efficiently, and how they can be used to run elec-tronic devices, like a water pump.

Total class time: 90 minutes

Class Outcomes-

- Students will be able to describe how a solar panel can be used to generate electricity.
- Students will understand how sun angle effects the efficiency of a solar panel.
- Students will be able to create both series and parallel circuits, and will be able to compare the performance of each.

Materials List-

The kit to teach this class should include:

-sidewalk chalk

-masking tape

-ping pong balls (about 20)

-SUN Angle Science Kits from KidWind (3 or 4?)

-bowls or cups for water pumping (6- 2 per team)

-scrap cardboard

-clear plastic protractors (one per team)

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Pre-Class Preparation and Set-Up (5 Minutes)

To prepare for class, it is most important to try out the experiments that the students will be doing. Get familiar with the equipment and material so that you will be able to anticipate student questions. Check equipment and make sure that there are complete sets for students to use.

Visit http://solardat.uoregon.edu/SunChartProgram.html and look up the optimal sun angle for your location and the date you will be doing the experiment. Bring the information with you to class to compare with student results.

Introduction (5 minutes)

Ask the students– Where does earth's energy come from? From the sun! There are many different ways that we can capture and use this energy, and the way that we are going to explore today is through photo voltaic (PV) cells. Who has seen a solar panel before? Solar panels use PV cells to convert the sun's energy into electricity that we can use

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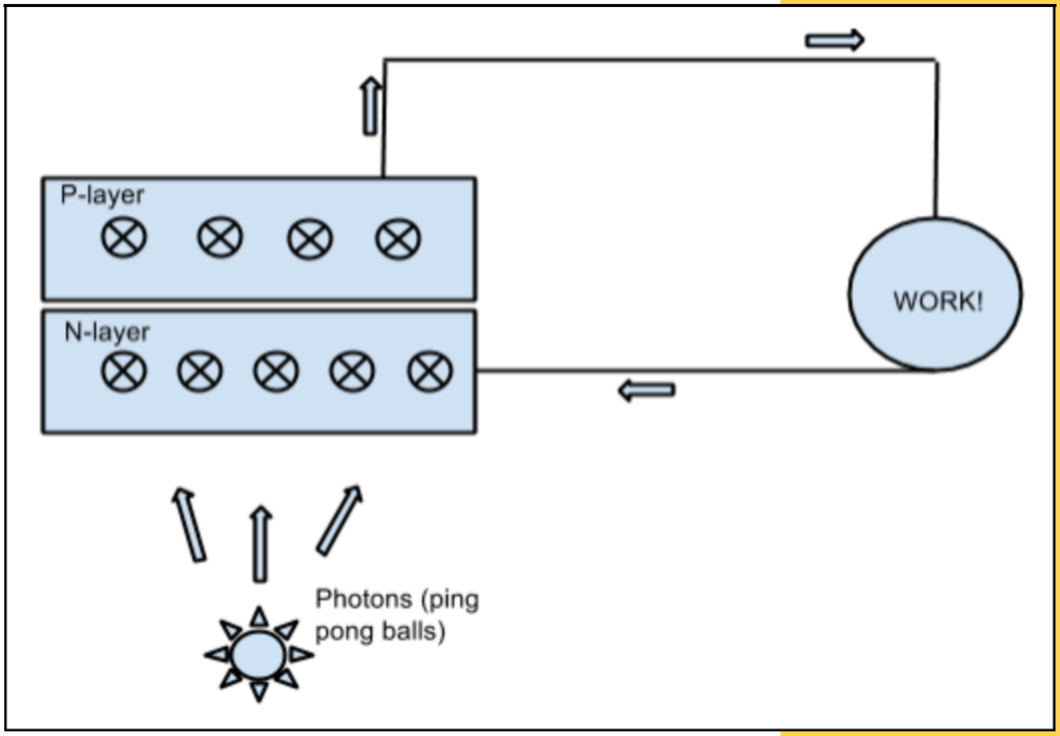
Human Solar Panel (30 minutes)

Before we start using these solar panels, we should try to understand a little bit about how they work.

[Side bar is for additional teaching notes.]

In this activity, we will create a huge model of a PV cell using our bodies, sidewalk chalk (or masking tape on the floor if playing indoors), and ping pong balls. Using the sidewalk chalk, draw the following playing court:



Have some students stand in the 'p-layer' and some in the 'n-layer'. Both layers are made of silicon, which is a semiconductor (electrons can flow through the material, but not extremely easily. The 'n-layer' of silicon has phosphorus added to it, an element that gives it extra electrons (n for negative charge). The 'p-layer' has some boron added to it, which gives it a tendency to attract electrons (p for positive).

The students are all electrons- there should be more students in the n-layer than in the p-layer to start the activity. Those in the n-layer should be a little squished- they are anxious to get moving! But because silicon is a semiconductor, they can't move yet. They need more energy in order to move. Those in the p-layer should have plenty of space- not super excited... yet.

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Human Solar Panel (continued…)

To start the activity, have a student (or you, the teacher) stand and be the sun. The sun throws solar radiation or photons (ping-pong balls) towards the n-layer of the solar panel. Just throw one photon to start. The students (electrons) in the n-layer should try to catch the photon as it is thrown in their direction. If a student catches the photon, it boosts their energy just enough to jump from the n-layer to the p-layer. When they jump to the p-layer, the student will 'bump' one of the existing p-layer electrons. This student then gets bumped out of the p-layer and must travel through the wire back to the n-layer. We have a flow of electrons, which means we have electricity!

Now that we have a circuit, we can add in a load- a motor, a light bulb, a pump, etc.- to get WORK out of the circuit. When the students reach the work circle, they should do some 'work' (a dance, jumping jacks, etc) before moving on down the wire back to the n-layer.

Now that we have our model, we can use it to explore some concepts:

1. We can't catch 100% of the photons that come our way. The same is true with a real solar panel. Some are absorbed (caught) and can be used, but others are reflected (bounced away) just like in our model. Comparing the amount of solar radiation that is available vs. what is actually absorbed allows us to find efficiency. Run the activity again, this time recording how many photons are caught and calculate the efficiency of the model.

2. What would make it harder to catch photons? What if the sun was at a different angle? (Have the sun throw photons from off on the side.) How about if there was something in between the sun and the n-layer? (Have one student be a cloud and try to get in the way of the photons.) Run different experiments to see how these things might affect the efficiency of the model.

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PV Experiments (45 minutes)

*This section of the lesson designed using the KidWind "SUN Angle Science Kit" supplies and instructions.

Divide your students into groups of 3-4 and distribute materials. Each team should receive 3 solar panels with alligator clips, a protractor, cardboard, a multi-meter, a pump, a section of clear hose, and two water containers. The next experiments need to be done outside so we have sunlight!

Have students start by connecting one solar panel up to their multi-meter. Make sure the voltmeter is set to read the lowest range of DC Voltage. Have students lay the panel flat on the ground and read the voltage being produced. Have students record this 0 degree voltage.

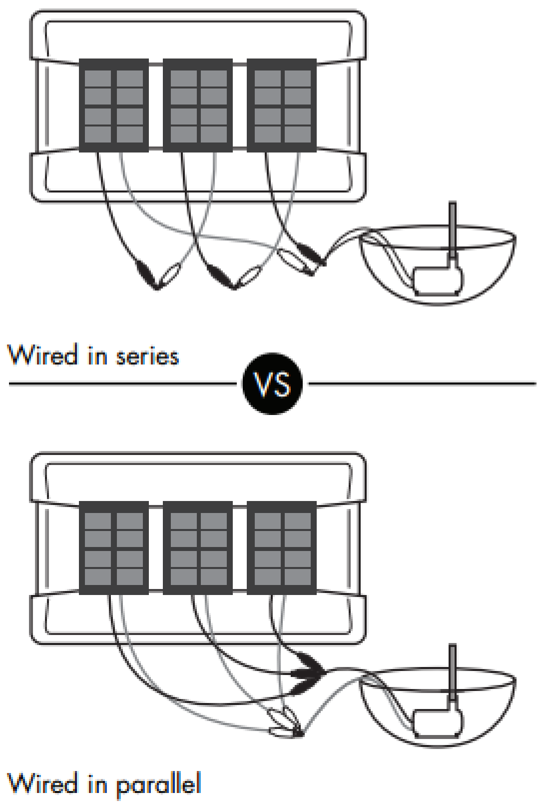
Now, just like in our model, we want to achieve the highest efficiency that we can with our panels. We want to try out different tilt angles to determine what the best angle to use for future experiments is. Have students use the pieces of cardboard and their protractors to tilt the panels to different angles. Students should record the voltage they get from one panel at 4-5 different angles. What was the best angle? Whichever angle produced the highest voltage should be used for the rest of the experiments. Let's be careful though: What will happen if we spend a long time on our experiments? Will the sun stay in the same location? No! Our perfect angle will change as the sun moves.

*When observing the voltage at different angles, make sure your students are paying attention to shadows. Will clouds make a difference? Sometimes the students themselves block the sun and change the results!

*Before class, you can visit http://solardat.uoregon.edu/SunChartProgram.html and find out the optimum sun angle at your location, on a specific date and at a certain time. Print this out (or if your students have computer access, they can do this too) and compare the actual optimum sun angle to their data.

So far, we've connected our solar panels only to our voltmeter: Do we have electricity? Not yet. Voltage is only a measure of energy potential! We need a complete circuit to create a flow of electrons, or current (measured in amps) and generate electricity. Let's complete our circuit and put in a load– the water pump. Have students fill one of their water containers, attach the hose to their pump, and submerge the pump in the container. Now attach the wires to the wires from a solar panel, and see if it runs! If it doesn't we may need more power. It's time to attach more panels, but how?

Next, we are going to try wiring the panels in two different ways: parallel and series.



In any good experiment, we want to only explore the change in one variable– In this case, the wiring configuration. Everything else should be kept constant. For example: The pumps used in this activity have a direction– make sure they are wired in the same way for both trials, or results will be inaccurate. Also, the hose should be kept at a constant level: Increasing the height of the hose will require more power to pump.

For the first trial, have students wire their solar panels in series. Have them time how long it takes the pump to fill their second water container to a predetermined mark. Have them record the number. Groups should also use their multi-meters to measure the voltage through the pump, and the current running through the pump for the trial.

Next, repeat the process, this time with the panels wired in parallel. Have students record the same three things: pump time, voltage, and amps.

*A hint for your students: To start and stop trials, it is easiest to cover the panels with something like a notebook. It's more accurate and easier than trying to quickly disconnect the pump from the panels.

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Conclusion ([time allotment])

Once students have completed their trials, ask them to take a look at their data, and ask some questions:

- How much power was generated by the solar panels in this situation? (Power = Voltage * Current)
- Which was the best way to wire the solar panels for the pump? (Which was able to pump faster?)
- From your data, which wiring configuration results in higher voltage? Which results in more current?
- With this in mind, are the pumps we are using more dependent on current or voltage? Do you think this is the same for all loads?

References-

KidWind Project: "SUN Angle Science Kit Instructions" http://learn.kidwind.org/files/manuals/SUNANGLE_MANUAL.pdf