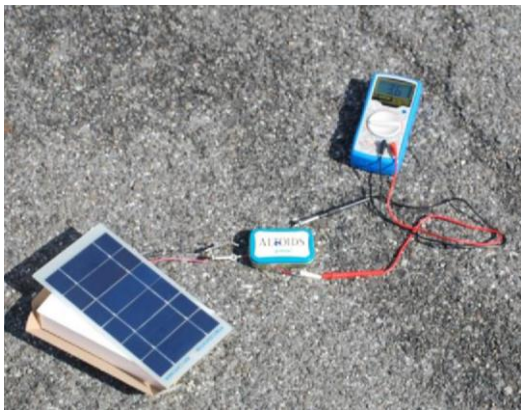
Solar Power!

Grade(s): 6-8



Learning & Activity Goals/Objectives

- How does the sun move across the sky
- How does a solar panel work
- Does the angle of the solar panel relative to the positioning of the sun impact the efficiency of the panel

Overview

Does the angle of my solar panel really impact the power output that much? Find out with this lesson that is designed to test that exact question. We will review the basics when it comes to solar energy generation; the distance from the earth to the sun, the path of the sun across the sky, how a solar panel works, and how to choose the best angle when looking to use solar power on a stationary object.

Utilizing a solar panel, multimeter and a protractor students will investigate how the angle of the solar panel, relative to the sun's position, impacts the output of the solar panel. By taking measurements at different angles the students will get to see the importance of being able to move their solar panel towards the sun during the races.

Curriculum Standards

Health & Physical Education

- 2.1.8.A.3
- 2.2.8.A.2
- 2.2.8.B.2
- 2.2.8.C.1

Mathematics

- CCSS.Math.Practice.MP4
- CCSS.Math.Practice.MP7
- CCSS.Math.Content.6.NS.B.3

Science

- 5.1.8.A.2
- 5.1.8.B.[1&2]
- 5.1.8.D.[1-3]
- 5.2.8.C.2
- 5.2.8.D.2
- 5.2.8.E.1
- 5.4.8.C.3

Life & Career Skills

- 9.1.8.A.1
- 9.1.8.A.4
- 9.1.8.B.1
- 9.1.8.C.[1-3]

Solar Power Lesson Plan: 2020

Objective: Students will understand how to efficiently capture the rays of the sun to power their Junior Solar Sprints vehicles.

Time: 30-45 minutes

Materials: Solar Power PowerPoint, Solar Panels, Multimeters

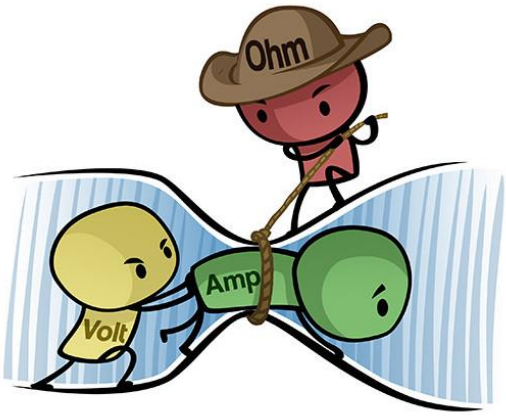
Procedure:

1. Ask the students if they know what a solar panel is. If anyone answers correctly follow-up with does anyone know how a solar panel works? Slide #2 and Slide #3 are the basics of how a solar panel works. You do not need to explain what any of the layers actually are as long as the students understand that electrons are being excited by the sunlight and moving through the metal material to whatever it is powering.
2. Slides #4-6 talk very generally about the pattern the Earth has when rotating around the sun. How it is at a different angle depending on the season and how this may impact testing conditions vs. race day conditions.
3. Slide #7 is a map of the race location, Kingwood Township School, and how the sun moves across the sky during the race. Ask the students if they think they will get the same power output from their panel at 9:00 am and at noon. What is different? How does this change impact my car? What do you think you can do to remedy this issue?
4. Slides #8 & 9 are a quick introduction to types of electricity so that the students understand what the mulitmeter they are using is telling them. First ask the students if they know the two types of current, AC and DC, and what they do. The chart below will define a few of the terms for you:

Term	Meaning
DC Current	“Direct Current” which is a flow of electricity in one direction only.
AC Current	“Alternating Current” reverses the direction many times per second at regular intervals.
Amp	Amperage is the flow of electricity, the amount
Volt	Voltage is the pressure of the electricity moving through the circuit
Ohm	The resistance of something on the flow of electricity

5. Ask the students if they know what type of current we will be dealing with, AC or DC. AC current is what comes into our homes, businesses, schools, etc. It is great for this type of service because then you don’t need to make a large circuit from every place the electricity flows. However, most electronic devices do not work well with AC current. Ask the students if anyone can tell you why they think

it doesn't work well. Electronic devices do not like having the electricity flowing in different directions. This is why all electronic devices that use DC current have that "brick" that plugs into the wall. The AC current from the wall is transformed into DC current for the electronics. This process also creates heat, which is why the brick is usually hot if it has been plugged in for a long time.



Activity:

For the activity you should put students in groups depending on how many solar panels and multimeters you have. Each group will need one of each for this activity.

The first thing that the students will have to do is plug in the wires into the correct ports. Remind them that everything in electricity is color coded so black always goes to black and red always goes to red. The black lead goes into the **COM** port and the red lead goes into the **VΩ** port on the front of the multimeter. They will then need to set up their multimeter to see the voltage in DC current. They should set the dials to **20** $^{V}\overline{\overline{\cdots}}$ **.**

This is the symbol for Direct Current Voltage $^{V}\overline{\overline{\cdots}}$. They will then need to connect the leads from the multimeter to their solar panel.

Once they have everything connected you can go outside and begin collecting data. You can use the following information to make a worksheet for them to fill out, or just instruct them to move the panel around and watch the voltage and note how it changes depending on how it faces the sun.

Solar Angle Matters Worksheet

Materials Needed:

- Solar Panel
- Multi-meter
- Worksheet
- "Solar Bug"
- Clipboard
- Pen/pencil

Safety Note: DO NOT look directly into the sun! If you need to know if your solar panel is facing the sun directly for a measurement, use your best estimate!

Solar Panel Tilt	Multi-meter Reading
Facing the Sun	
Lying flat	
10° (Small tilt)	
45° (Medium Tilt)	
Directly Facing	
Away from the Sun	
10° (Small tilt)	
45° (medium tilt)	
Directly Away	
Student Choice (Remember to write down the direction and the tilt you are taking a measurement for)	

***Note: The solar panel holder will need to hold the angle as steady as possible to allow the multimeter to settle on a number. Use the piece of paper to cover the back of your solar panel. On the readings facing away from the sun the back of the solar panel can take in some energy giving you a false reading.

Extension Activity – [Math Heavy]

What to the numbers actually mean on their worksheets? How does this equate to the power generated for their solar car. Well we can figure out how many kilowatts (kW) are being generated from their solar panel depending on the angle of the panel to the sun.

*NOTE: To do this the students will need to have taken the measurements for both Voltage AND Amperage as determining kW requires both. So if you want the students to take amperage measurements as well have them change the dial to 200 mA. Depending on the time of day, and how strong the sun is that day the students may be able to use the 10A setting. If the students are using the 10A setting make sure that they change the red lead on the multimeter to the 10A port.

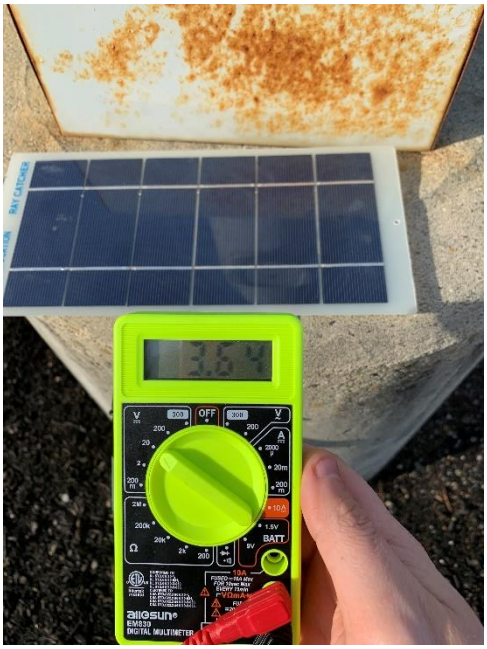
Once you have this data you can evaluate the amount of power (kW) the solar panel is creating and apply it to your car. Things you may be able to answer with this information are:

a) How does my torque and speed change with a change in kW?
b) What is the optimal gear ratio to use in different types of sunlight?
c) How does the amount of light impact my car?

For example, I took a solar reading on January 30, 2020. Here is what I got:

Volts: 3.64

Amps: 0.45



Using this data we can now find out how many kilowatts(kW) of power are being generated by the solar panel. We will use the following formula:

$$kW = 1000\ [V * A]$$

This works out to be 1,638 kW.

$$kW = 1000\ [3.64 * 0.45]$$

Once we have kW we can use our equation for power to see

$$Power(kW) = \frac{Torque\ (Nm) * Speed\ (RPM)}{9.5488}$$

$$1{,}638(kW) = \frac{x\ (Nm) * 5200\ (RPM)}{9.5488}$$

Solve for *x*, and we get 3 Nm of torque. This makes sense because we used the highest RPMs that the motor can handle for our equation which, when compared to the highest torque of 12.4 Nm, we see a very small amount of torque.

Utilizing this type of information you can see how the different Volt to Amp numbers change the ratio.