

# Solar Energy: Racing with the Sun

TechXcite: Discover Engineering

Pratt School of Engineering  
Duke University



## Activity 1: What Does a Solar Panel Do?

Name: \_\_\_\_\_

Date: \_\_\_\_\_

### Materials List

- Solar panel (from SolGear solar car kit)
- Digital multimeter
- Motor (from SolGear solar car kit)
- 1 AA battery
- 2 alligator clip leads

### Remember!

- Do not lose any of the parts. Other classes will be using them.
- Be careful with your solar panel. Do not drop or bang it on something. Your solar car will not be able to go as fast if the solar panel is damaged.

### Background

We discussed earlier that the sun could be used to power electrical devices. However, some devices require more solar energy than others to work. In this activity, you will use a multimeter to determine how much voltage your solar panel is generating. The wires connected to the multimeter are called leads. The red lead is positive (+) and the black lead is negative (-). The metal tip on the end is the probe.



**Procedure**

1. Turn the dial of the multimeter until it points to 20 VDC (or 20V $\overline{\text{---}}$ ). In this position, up to 20 volts (DC) can be measured.
2. Measure the voltage across the AA battery by touching the red probe of the multimeter to the positive (+) terminal of the battery and the black probe to the negative (-) terminal of the battery. Make sure the probes are held firmly against the battery terminals to get a stable reading of the voltage. Record the voltage displayed on the multimeter in the table provided below.
3. Measure the battery again, this time with the black probe on the positive terminal and the red probe on the negative terminal. What changed? (The voltage reading should now be negative.)
4. Connect the battery to the motor using the alligator clip leads to make sure the motor works.
5. Now use the multimeter to measure and record solar panel voltage for three different lighting conditions: darkness, bright indoor lighting, and sunlight.

	Voltage
Battery	
Solar Panel: Darkness	
Solar Panel: Indoor Light	
Solar Panel: Sunlight	

6. Let's do a quick experiment!

How much light do you think you'll need to power the motor?

Connect your motor to the solar panel by clipping the solar panel leads onto the motor's terminals as shown. Be sure that the positive and negative solar panel alligator clips don't accidentally touch each other while connected to the motor terminals. That would create a short circuit causing the electric current to bypass the motor and go straight back to the solar panel without being used. A short circuit won't hurt this small solar panel, but it would cause major problems if it happened on a battery or a more powerful source of electricity.



Test the 3 lighting conditions in your table and find out which ones, if any, have enough voltage output to run your motor.

### Exploration Questions:

What factors affected the voltage output from your solar panel(s)?

Explain what a solar panel does:

Engineers always pay attention to the benefits & limitations of a particular technology. What are some of the positive benefits to using solar panels as a source of energy?

What are some of the limitations to using solar panels as a source of energy?

## Activity 2: Multiple Solar Panels

Name: \_\_\_\_\_

Date: \_\_\_\_\_

### Materials List (Combine 2 groups from Activity 1)

- 2 solar panels (from SolGear solar car kit)
- Digital multimeter
- Motor (from SolGear solar car kit)
- 2 AA batteries
- 4 alligator clip leads

### Remember!

- Do not lose any of the parts. Other classes will be using them.
- Be careful with your solar panel. Do not drop or bang it on something. Your solar car will not be able to go as fast if the solar panel is damaged.

### Background

In the last experiment, we learned that the amount of light we exposed to the solar panel affected how much voltage the panel generated. Now, we will experiment with two solar panels to see how much the voltage is affected by connecting multiple solar panels in various ways. You will use a multimeter to determine how much voltage your solar panel system is generating. Adjust the dial until the indicator points to 20 VDC. In this position, up to 20 volts of direct current can be measured.



## Procedure

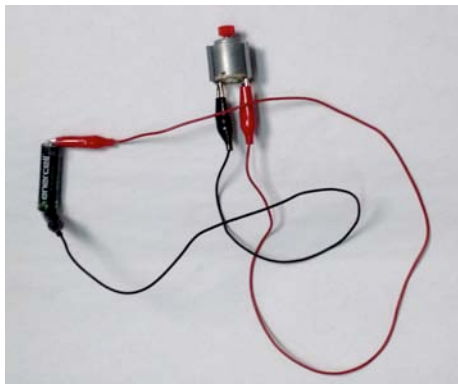
1. There is more than one way to connect multiple solar panels together. How do you think you would connect them in order to *increase* their total voltage? Try connecting the panels in at least two different ways and draw how you connected them in the spaces provided below. Measure and record the voltage of each.

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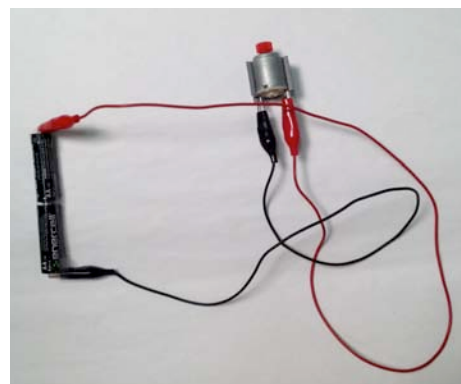
Voltage: \_\_\_\_\_

Voltage: \_\_\_\_\_

2. When you connect the panels together and their total voltage is the sum of the voltage generated by each individual panel, the panels form a **series** connection. In comparison, the voltage measured across panels connected in **parallel** remains the same and the current increases instead. If you haven't already, connect the motor to the solar panels in both series and parallel and make a note of the difference
3. Now connect the batteries in series, as you did with the solar panels, and measure the combined voltage across the batteries with the multimeter. How does the voltage across one battery compare to the voltage across two batteries in series? How about when the batteries are in parallel?
4. Test the motor with the batteries connected in series and in parallel. You may need to use tape to secure the wires to the batteries.



Motor connected to single battery



Motor connected to two batteries in series

## Activity 3: Building a Solar Car

Name: \_\_\_\_\_

Date: \_\_\_\_\_

### Engineering Design Problem

Your design challenge is to build a car that will move as fast as possible over a flat surface using only power from the sun. Your SolGear instructions provide a starting point for designing the car.

### Materials List

- Masking tape
- SolGear solar car kit, including:
  - Solar panel
  - Motor
  - Plastic motor mount
  - 4 wheels
  - 4 rubber tires
  - 4 eyelets
  - Small gear
  - Large gear
  - 2 wooden dowels
  - Plastic tubing
  - 2 square wooden sticks
  - SolGear Instructions

### Remember!

- Do not lose any of the parts. Other classes will be using them.
- Be careful with your solar panel. Do not drop or bang it on something. Your solar car will not be able to go as fast if the solar panel is damaged.

### Exploration Questions:

What design considerations did you make when constructing your solar car?

What factors do you think will affect the racing performance of your solar car?

How fast do you think your solar car will go? How might you test its speed?



### Activity 4: Mini Solar Challenge

Name: \_\_\_\_\_

Date: \_\_\_\_\_

In this activity, you are going to test your solar car. You will be examining different factors that affect the racing performance of your solar car.

#### Materials List

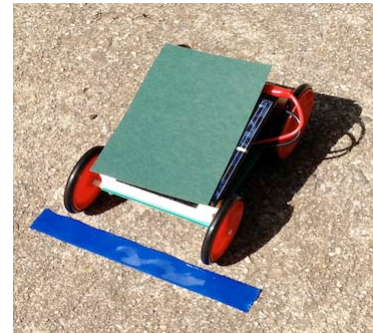
- Solar car (built in Activity 3)
- Sun blocker (file folder, book, etc.)

#### Remember!

- Do not lose any of the parts. Other classes will be using them.
- Be careful with your solar panel. Do not drop or bang it on something. Your solar car will not be able to go as fast if the solar panel is damaged.

#### Procedure

1. Examine your solar car to make sure it is ready to be raced. Check:
  - Solar panel has not been cracked or damaged
  - All components (solar panel, motor, wheels and axles) are securely attached to the chassis
  - Wheels and axles don't slide from side to side
  - Motor and solar panel are connected
2. As a class, you'll determine how you want to conduct the race and make the necessary preparations.
3. Decide with your partner which one of you will hold the car at the starting line and who will wait at the finish line to catch the car.
4. Once your car is in position at the starting line, make sure the solar panels are secure and pointing toward the sun. When the start signal is given, remove the sun blocker from the solar panels to power the car.
5. Record the length of the racecourse (distance from starting line to finish line) and your race time in the table below.
6. After the race is completed, make any necessary changes to your solar car that would help it go faster.



Length of the racecourse	
Race time of your solar car	
Race time of <i>fastest</i> solar car	

### Exploration Questions

How did you conduct your race? How might you change the racing procedure?

What factors affected the performance of your car?

Did your solar car move as fast as you thought it would? What changes would you make to your solar car to increase its performance?