Activity 2: Building a Solar Car

Time Required: 90 minutes

Materials List

Group Size: 2 students per group

Each group needs:

- Solar Car kit including:
  - Solar Panel
  - Motor bag (motor with small gears, motor mounting bracket, and small screws to mount motor)
  - Wheels and Axle Bag (4 wheels, 4 rubber tires, gear options for axles)
- 4 eyelets
- Balsa Wood - 4 x 12 inch board
- Wood Glue
- Colored Markers to draw on balsa wood
- 1 drinking straw
- 2 wires with Alligator Clips

Each class needs:

- Small Saw or Utility Knife (These should only be used by the instructor.)
- Balsa Wood - ½ x ½ x 36 inch pieces
- 5/64” drill bit (or similar sized nail))
- Clothespins
- Masking Tape
- Rubber Bands
- Nuts and Washers (for the eyelets)

Youth Worksheets

Design – Build a Solar Car Worksheet

Learning Objectives

After this activity, students should be able to:

- Design and build an electric car which has a motor that is connected to a solar panel.
- Identify factors that affect the performance of a solar car including friction, position of the axles, and weight of the car.

Introduction:

In the last activity, you explored how solar panels generate electricity. Now it’s time for you to design and build your solar car. What would be some advantages of owning a solar car you could drive?

[Provide students time to brainstorm a few potential advantages of driving a solar car.]

Keep these advantages in mind as you build your cars. After constructing your solar cars, we will discuss how you would build a real solar car. One such car that has been

built by an inventor from Switzerland is a Solar Powered Taxi. He has driven this taxi all over the world <http://www.solartaxi.com/> to show what a car powered entirely by the sun can accomplish.

College students participate in national and international competitions each year in which cars powered entirely by solar power race hundreds of miles. The two main competitions are the American Solar Challenge <http://americansolarchallenge.org/> and the World Solar Challenge <http://www.wsc.org.au/>. Once your solar cars are built, you will race them against each other.

The main components required to put together your model solar car are the chassis, a 4x13 inch solar panel, 2 axles, 4 wheels, a motor, and gears for the motor. The chassis is the frame of the car and it supports the weight of the motor and solar panel. The chassis should be designed bearing in mind that it needs to be stable and it should not break when the motor, panel, and wheels are connected to it. When designing the chassis, the placement and alignment of the wheels need to be planned carefully. Also, you should think about the placement of your solar panel. You might want to consider tilting your solar panel (placing it at an angle to the chassis), but if you do this you might want to consider the effect of the extra material required to tilt your solar panel on your cars performance.

Why might you want to tilt your solar panel? [Answer: To point the panel more directly at the sun.]

What might be a problem with tilting a solar panel on a car that drives in many different directions? [Answer: There are many answers to this question that may be valid, but it is specifically important for students to recognize that if the panel is fixed and pointed at the sun while the car drives in one direction, it would be pointed somewhat away from the sun as the car drives in other directions.]

Vocabulary

Word	Definition
Voltage	Electrical energy that causes current to flow.
Current	Flow of electricity.
Solar Cell	Converts sunlight into electrical energy
Conductor	A material through which electricity flows easily. Metal is a good conductor.
Chassis	Component of a car that supports the body, wheels and motor. Pronounced “chass-ee”
Axle	Shaft on which a wheel can rotate.

Procedure

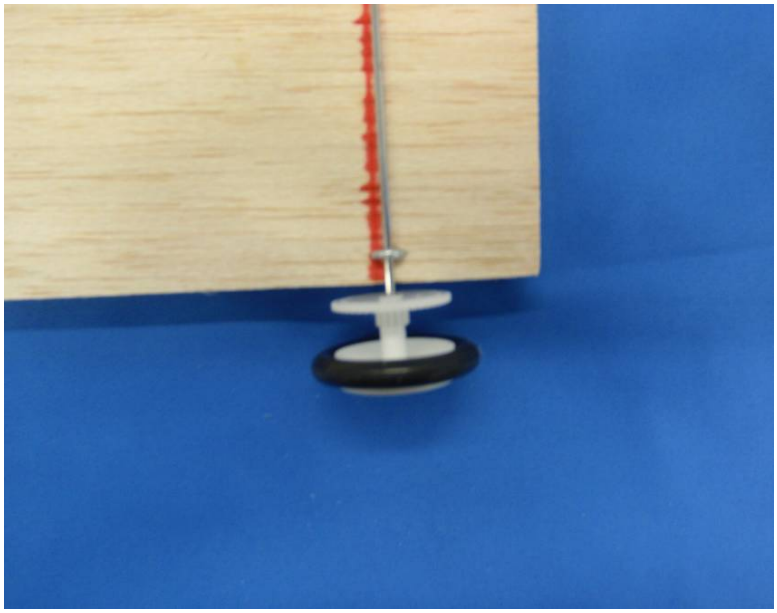
Before the Activity: (Optional 30 Minutes)
If your class would like to participate in a regional solar car competition, please visit the NC Solar Center website (http://www.evchallenge.org/schools/middleschool/index.html) for background information, rules, and an application.

During the Activity:

1) Split the students into pairs.
2) Provide each group with an activity sheet and this activity's materials.
3) Have the students examine their solar panel:
   a. Warn the students that the solar panel is fragile and can easily be cracked or broken. Care must be taken not to drop, bend, or twist the panel. The solar panel can still be used if there are cracks, but its efficiency is reduced. Have the students examine their panel for cracks and record any cracks they see on their activity sheet. If the panel is broken, care must be taken to properly discard the pieces (the pieces will be sharp like pieces of glass).
   b. Students should verify that their panel is clean (dirt on the panel will block sun absorption and reduce efficiency). If the panel needs to be cleaned, the student should use a soft rag and rub the panel gently.
   c. Warn the students to not remove, pull, or twist the conductor tabs (the two silver tabs on the solar panel).
4) After the students have their materials and have examined their solar panel, ask the students to brainstorm what the main parts of the solar car will be. Write these on a board if possible. If they are missing any of the following, help them think about what they are missing:
   - Chassis/Body
   - Motor
   - Wheels
   - Solar panel
   - Gears
   - Axles
5) Discussing the components will help the students begin thinking about the necessary parts as a group. For gears, tell students to utilize a small gear for the motor and a large gear for the axle. Ask students why they think that might be important. [Answer: Going from a small gear to a large gear increases the torque (mechanical advantage) from the motor to the axle. This provides good acceleration like when you use a low gear on a bicycle. Without this mechanical advantage, the car would start very slowly and might not start at all. It would be like trying to start moving a bicycle in a high gear.] Note: If you have more time, including a lesson on gears would be appropriate. It is difficult to change the gears once a gear ratio has been selected with these cars. For that reason, it is not the ideal activity for students to experiment with gear ratios.
6) At this point, the students may work in their pairs on their projects. Instruct them to follow the directions on their worksheet and begin building their cars. This is an

open-ended activity. Some groups will move at different paces from other groups. This is expected.

7) Walk around and help the pairs design and build their chassis and then connect their motor, gears, and wheels to complete their solar car. When designing their solar car you should help the students think about:
   a. What affects the solar panel efficiency? You have already discussed cracks and dirt on the panel surface, but the angle of the solar panel to the sun and amount of sunlight are other factors that the students should identify. They should discuss the impact of trying to operate their solar car inside where the only light source is overhead light bulbs, outside, in the shade, and at different times of day (which determines the amount of sunlight and angle of the sun).
   b. What aspects of the chassis design will affect the performance of the solar car? Students should discuss how the weight of the vehicle (if the car is too heavy there will not be enough power for it to move), friction, the stability of the chassis, and the wheel placement/alignment affects performance. They may also identify that momentum (car already in motion), inertia (car starting from stand-still), gravity, and drag (friction of wheels rotating on axle) will affect the performance of the car.
   c. Axles can be mounted in any way the students can think of. The eyelets provide one method. Below is one way to mount the axle. The students do not have to mark the location of their axles but it can help in keeping them parallel. The axles may be mounted above or below the chassis.



8) By the end of the activity ask the pairs to verify that their solar car is working properly. If it is not, help them think about what might be causing problems. If the solar car is not running properly and you cannot figure out why, try the following:
   a. If the motor is running backward, try reversing the wires.
   b. If the acceleration seems to be very slow or the motor is not producing enough torque to get it started from rest, try changing the gear ratio.

9) Once completed and the solar car is working, tell the students, “Congratulations! You have built a solar car and are ready to test and race it in the next activity.”
10) Collect and store each group’s solar car between sessions.

Processing and Activity Closure:

1) Ask two to three groups who seem to have particularly good solar cars to come forward and explain their design solutions. In the next activity additional groups will have an opportunity to describe their solar car designs and performance.
2) As the students are presenting their design solutions, ask them to explain their design process. Specifically, they should describe their chassis construction process, the solar panel placement, and how and where the different components were attached to the chassis. Also, ask them if they would have done anything differently.
3) Let the students know that in the next activity they will be testing (racing) their solar cars and evaluating their performance. Ask them how they would evaluate the performance of the cars and generate a list of their ideas.

Additional resources can be found at:

http://www.solar-world.com/JuniorSprint.htm (Junior Solar Spring Kit from Solar World)

http://www.cstv.com/cstv/programming/solarcar/

Resources about Junior Solar Sprint competitions:
http://www.nrel.gov/education/jss_hfc.html

http://www.nrel.gov/education/rules_regulations.html

http://www.evchallenge.org/schools/middleschool/index.html

Embedded Assessment

Please collect and copy page 20 of the student handout. Questions are included in the student activity worksheet.

See if you can answer this question now that you have designed and built a solar car: What design factors did you take into consideration when building your solar car and what factors will affect the performance of your solar car when you race it? [Some examples of possible answers include wheel placement & spacing, solar panel placement, angle, & efficiency, motor placement, and chassis weight.]

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Engineering Design Activity – Building a Solar Car Worksheet

Name: _____

Date: _____

In this activity you are going to use engineering design principles to design and build a solar powered car. The Junior Solar Sprint (JSS) kit from Solar World provides a solar panel that produces 4 watts at 3 volts (as you measured during activity 1), a motor, wheels, axles and drive gears. A chassis must be built using balsa wood. The testing of your solar car culminates in a solar race that will occur in Activity 3.

Materials List

- Solar Car kit including:
  - Solar Panel
  - Motor bag (motor with small gears, motor mounting bracket, and small screws to mount motor)
  - Wheels and Axle Bag (4 wheels, 4 rubber tires, gear options for axles)
- 4 eyelets
- Balsa Wood - 4 x 8 inch board
- Wood Glue
- Colored Markers to draw on balsa wood
- 1 straw
- Clothespins
- Masking Tape
- Rubber Bands
- Nuts and Washers (for the eyelets)
- 2 wires with Alligator Clips

Rules

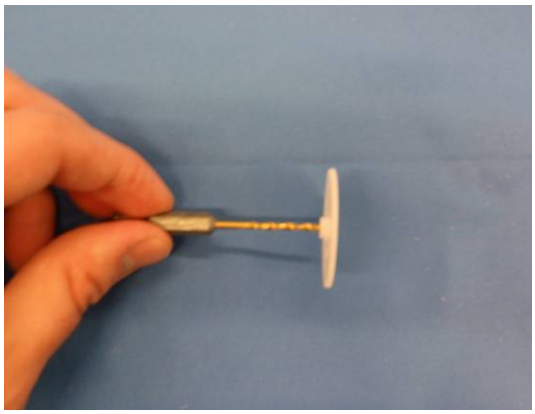
- Do not lose any of the parts. These parts will be used by future classes.
- Do not bend, drop, or damage your solar panel. Cracks and damage to the solar panel will reduce the efficiency of your panel. Your solar car will not be able to go as fast when you are racing it if the solar panel is damaged.
- Do not remove or damage the two silver conductor tabs attached to your solar panel.

Engineering Design Problem

Engineers design systems within specific design constraints. Whenever we provide you with an engineering design challenge, we will give you constraints that are specific. For the solar car design challenge, the problem you are trying to solve is to build a vehicle that moves as fast as possible over a flat surface utilizing only power from the sun. This will be tested in the next activity. Your available materials are the ones that have been provided to you. Below are some things to think about as you design your cars.

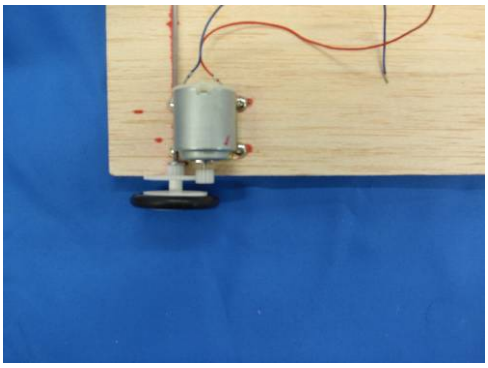
Guidance

1) Think about the design of your solar car chassis. You will be using balsa wood to construct the chassis so think about the overall dimensions of the car as well as the weight that the chassis must support (the motor and solar panel), and the overall weight of the car. You want the car to be light in order to make the car go as fast as possible. When engineers are solving problems and designing devices they often start by drawing a diagram. On a separate piece of paper sketch your solar car design making sure to label each component (i.e. the motor, the wheels, etc).
2) Start to build your solar car chassis. Use wood glue to connect your balsa wood pieces if necessary.
3) Add the axles, gear, and wheels. One way to do this is to use the eye hooks to connect the axles to the balsa wood chassis (see image below). The eyelets can be pushed into the wood so that only part of the eye sticks out of the wood (The nuts and washer's can be used to secure the eyelets if this is done). The wheels can be pushed onto the axles. Be careful not to break the wheel or bend the axle. If the wheel hole or gear is too small to fit the axle through, push the drill bit or nail through the wheel hole or gear to make the hole larger (see image below). Be careful not to drill into it too much or the gear won't grip on the axle. You can cut a piece of straw to slip over the axle in order to keep the wheels from slipping back and forth.



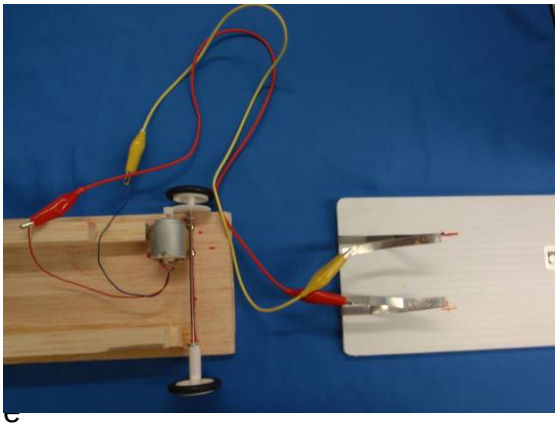
Drill Bit to Make Gear Hole Large

4) Add the motor. Use the metal motor holder and four screws to mount the motor to the balsa wood chassis (see image below). Think carefully about motor placement before securing the motor. Remember that the gear teeth on the motor must touch and mesh with the gear on the axle. You may need to utilize a straw on the axle or some other method to keep the gears from slipping away from each other.



Motor Mounted to Chassis (use screws to secure)

5) Mount the solar panel. Make sure your panel will point towards the sun and that it is secure (Rubber Bands work. Glue should not be used). Before attaching the solar panel make sure you have carefully considered how the cell should be positioned to maximize the power created by it.
6) Connect the motor and solar panel using the wires with alligator clips.



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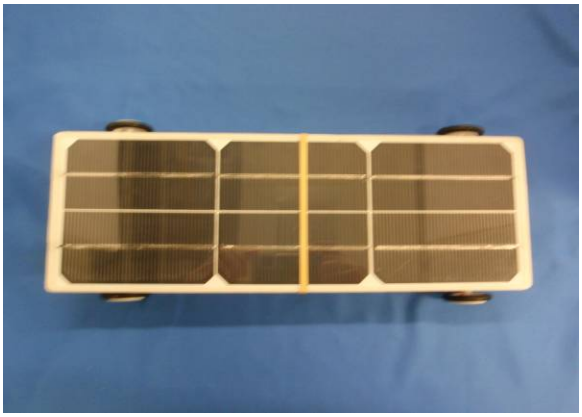
Solar Panel Connected to Motor



Solar Panel strapped on chassis

7) Once the car is completed, verify that it works. If your solar car is not working properly, try the following:
    a. If the motor is running backward, try reversing the wires.
    b. If the wheels are sliding from side to side, try using pieces of a straw as a spacer.
    c. If the car turns significantly rather than going straight, check the axles to make sure they are parallel to each.
8) Decorate your chassis as you like using markers, stickers, etc.
9) Store your solar car until the next session when you will test and race your solar car.

Exploration Questions:
What design considerations did you take into account when constructing your solar car?

What factors do you think will affect the performance of your car in the next activity?

How fast do you think your solar car will go? How would you test this?
(How can you find out how fast your solar car will go?)