

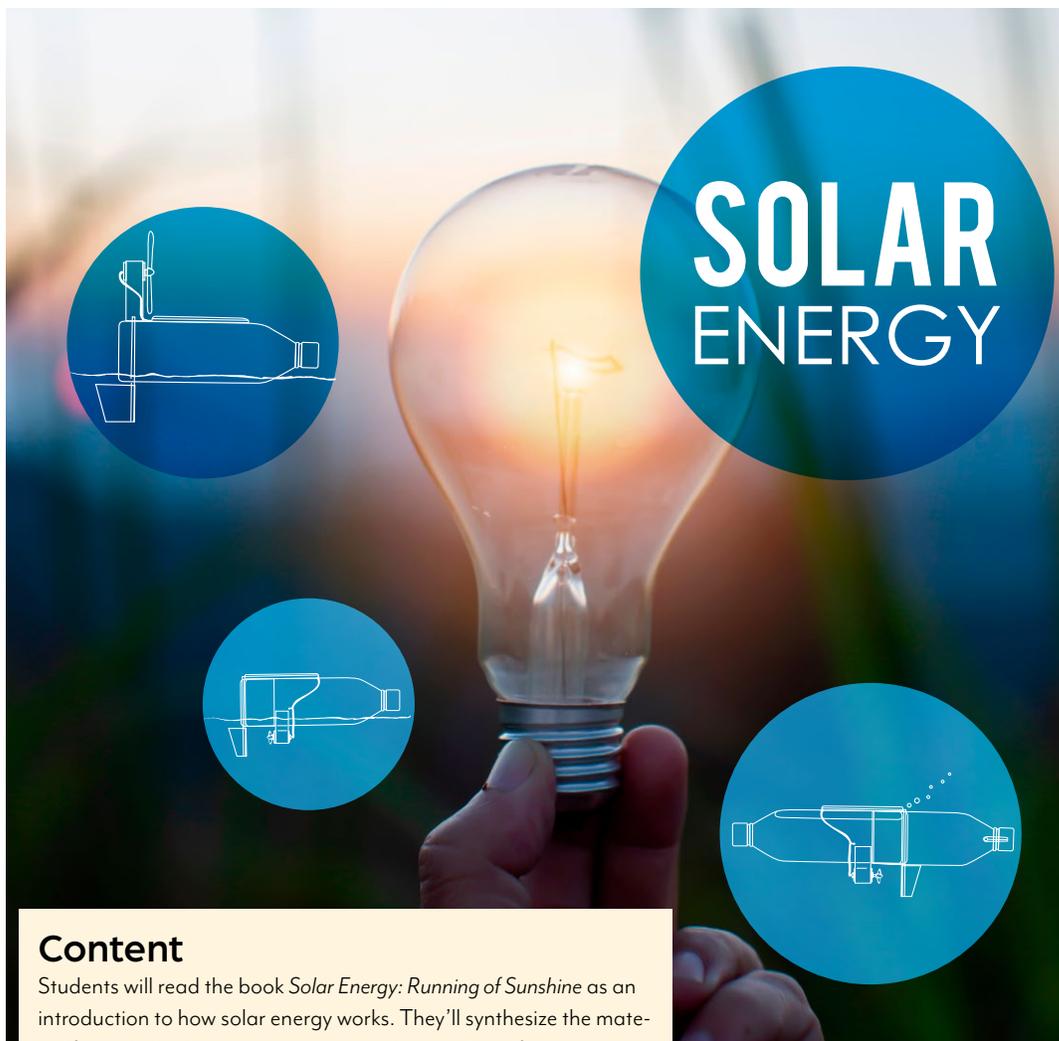


Developed with Kristin Hotter

Solar energy: Real world use

Volume 6 | Gr. 3-5

Time: 3 hours



Content

Students will read the book *Solar Energy: Running of Sunshine* as an introduction to how solar energy works. They'll synthesize the material from the book to gain a working understanding of how energy is transferred from one energy source (the sun) to another. Students will then be broken into small groups (2-4 students per group) and presented with three types of boats to build (speed boat, air boat, and surface submarine). They'll learn basic terms, such as rudder, propeller and motor, as they are introduced to each type of boat. Using their knowledge, they'll select one type of boat to build with a small group. Following step-by-step directions, they'll build their boat and troubleshoot any issues they may encounter along the way. Once the boat is built, students will test its ability in a kiddie pool or Raingutter Regatta[®] filled with water. When the initial test run is complete, students will brainstorm changes they can make to their boat to improve it. Each group will make one change to their boat. After making that change, the group will evaluate how much, if any, change occurred.

Objectives

Students will...

- Be able to follow step-by-step directions to build a solar powered boat
- Be able to evaluate the performance of their boat and make appropriate modifications to improve the boat's performance
- Be able to explain how energy is transferred from one energy source to another

Learning standards:

3-5-ETS1-1 — Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2 — Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

4-PS3-2 — Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS3-4 — Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

STEAM connections

Science: Students will develop an understanding of how energy is transferred from one source to another.

Technology: Students will explain how photovoltaic panels work. They will also view a video that explains solar energy.

Engineering: Students will follow step-by-step directions to build a solar powered boat. They will make one modification to the boat to evaluate the modification's effect on the boat's speed.

Art: Student groups will paint and name their boats.

Math: Students will measure the length of the bin in which their boat will travel. Students will then test the speed of their boats multiple times. They'll determine the average time it takes for their boat to travel a given distance.

Introduction (20 mins.)

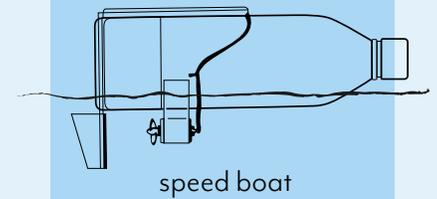
Provide each student with a copy of the double-sided worksheet. Direct their attention to side 1. Tell students the three images on the sheet are three different models of solar-powered bottle boats. Each boat is made from the same type of materials. Show students the contents of a kit and two of the recycled plastic bottles. Each is a model of a common type of boat: air boat, speed boat, and surface submarine. The three boats may look quite different, but they all share three common features: motor, propeller, and rudder. Provide students with a working definition of each feature.

Motor: A machine that uses energy to provide a vehicle with power

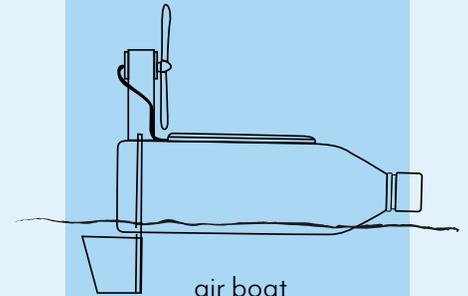
Propeller: A revolving device that uses blades to move a boat

Rudder: An underwater blade near the back of the boat that aids in steering

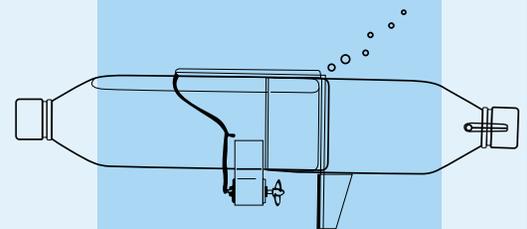
- Circle each part on the speed boat. Then ask students to circle the three parts on the submarine and air boat and what they know about each particular type of boat. (Sample responses: You can take an air boat ride in the Everglades. People can water ski or tube behind a speed boat. A submarine is one of the boats in the game Battleship.)
- Put students in groups of 3 or 4. Ask them to talk about the similarities and differences between the three types of boats. Bring the group back together and facilitate a discussion about each small group's findings.
- Explain to students that each group will build one type of boat. The boats will be solar-powered. Before deciding which type of boat a group wants to build, students will need to learn a bit more about solar power.



speed boat



air boat



surface submarine

Activity 1 (40 mins.)

Prior to determining which type of boat a group wants to build, students will read sections from *Solar Energy: Running on Sunshine* and watch some videos on solar power.

Students will complete the back of the worksheet during Activity 1. They will use these sections to complete the worksheet:

(*Our Shining Star*; *What is Solar Power?*; *Zip! Zap! Electricity*; *Ups and Downs of Solar Power*). Either provide students with a copy of each section or display a copy to read as a whole group.

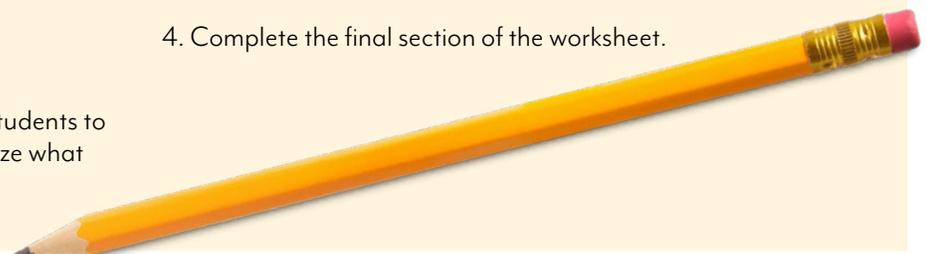
1. Read through *Our Shining Star* and *What is Solar Power?* As you complete each section ask students to summarize and answer the two questions included on the worksheet.
2. Watch the video. It provides a brief description of what solar energy is and how it works.

Video: <https://youtu.be/L5jpCY3BO4k>

1. Either discuss questions as a large group or ask students to complete the questions. Ask students to summarize what they saw in the video.

2. Read *Zip! Zap! Electricity* and follow the same procedure.
3. Direct students back to the boat models on the front of the worksheet. Remind them that the video and previous section discussed photovoltaic panels. Where are the photovoltaic panels on each boat? Ask students to mark them on the diagrams on worksheet's front side.
 - Why are the panels in those locations?
 - What would happen if the panels were in a different spot, like on the bottom or side of the boat?
 - Take it one step further and ask students about the cell's patterns. (Tell students the pattern is an array. Where else have they heard about arrays?)

4. Complete the final section of the worksheet.



Activity 2 (90 mins.)

1. Break students into groups of 2-4.
2. Once students are in their groups, direct them to the front of the double-sided worksheet. Explain that they will have the opportunity to build one of the three boats. They'll follow step-by-step directions, paint their boat, name their boat, and most importantly, test their boat. Show them where they'll test their boat.
3. Ask each group to take a few minutes to figure out which type of boat they want to build. Tell them to take a look at the features of each boat and use the knowledge gained during the solar power discussion to determine which type of boat they think will run the fastest. Remind them the boats run solely on solar power.
4. Once a group has determined the boat it will build, the group needs to record the type and explain why in the space below the Venn diagram.
5. Provide each group with an adult volunteer, the materials needed to build a boat, an instructional sheet for the boat, and a troubleshooting sheet.
6. Once students have finished building their boats, consider giving them time to paint, decorate, and name their boats before the official launch.
7. Take students outside to conduct races. You'll have two boats race at a time. Have each group keep its boat's "official race times." Students can use the recording sheet to keep their times. There is space on the sheet for each boat to race up to 4 times. These race times can be compared to additional race times in Activity 3.

You can run the races however you choose. You could set up a tournament bracket, have boats of the same type race one another, or have different types of boats race one another.

Activity 3 (45–60 mins.)

In this activity, groups will be able to make a modification to their boats.

1. Start a discussion with students by asking question such as these:
 - How do you think your boat performed?
 - Why did your boat perform well (not well)?
 - If your boat did not perform as well as you'd hoped, is there a change you would make?
 - Do you think a different bottle size or shape would make a difference in your boat's performance?
 - What about the solar panel placement?
 - What about the motor?
 - If you could make just one change to your boat, what would it be?
2. Tell students they have the opportunity to make that one change to their boats.
3. Tell them you have some additional materials, such as different bottles, pieces of plastic, etc., that they can use to make one modification. Emphasize that each group is to only make one change. Explain that when multiple changes are made, it can't be certain which of those changes actually had an effect on the boat's performance.
4. Give groups 20 minutes to complete the modification. As students are working, circulate and ask what change they're making and why they chose to make that particular modification.
5. Reconvene outside and have each group retest their boat's performance. This can be done in a race format (as in Activity 2) or have each group independently run its boat and time it with a stopwatch. The recording sheet includes a table for up to four races.
6. When retests have been completed, ask students to complete the remainder of the recording sheet to bring the lesson to a close.

Materials list

- Solar Bottle Boat Class Kit (**SB53392**)
- Solar Bottle Boat Kits (**SB40881**) – 1 kit for each small group of 2-4 students
- One to two 16 oz. recycled plastic bottles with caps for each group (depending on model being built)
- Various other 16-18 oz. recycled plastic bottles (students can use these when making modifications)
- School Works!® Safety Point Scissors (**9729183**)
- Electrical tape, 3/4" x 60' (**SB50541**)
- Heavy-duty awl (to poke holes in the bottles) (**9723871**)
- Large plastic tub, kiddie pool, or Raingutter Regatta® (**NA10268**) filled with water
- *Solar Energy: Running on Sunshine* by Amy S. Hansen
- *Solar Energy 101* video: <https://youtu.be/L5jpCY3BO4k>
- Nasco budget yardstick (**9704372**)
- All-purpose digital stopwatch (**TB14784**)
- One set of laminated step-by-step directions and troubleshooting sheet for each group. (Make several sets of each type of boat as each group of students will select their own boat to build.)
 - *The directions and troubleshooting document contain the same information as the blue booklet found in the kit. It's given in a separate form for better student accessibility.
- Double-sided worksheet (included in this lesson). The front activity corresponds with the introduction and the back activity corresponds with Activity 1 (included with lesson)
- Analysis sheet (included with lesson)
- Recording sheet (included with lesson)
- Adult volunteers to help each group of students as they build their boats
- A sunny day (preferably at a time close to noon with little to no wind)

Optional:

- Painting supplies:
 - Brushes (**9727731**)
 - Acrylic paint [**9714725(A-Z)**]
 - Paint cups (**9729701**)