Nasco education LESSON PLAN

K TO Career solutions

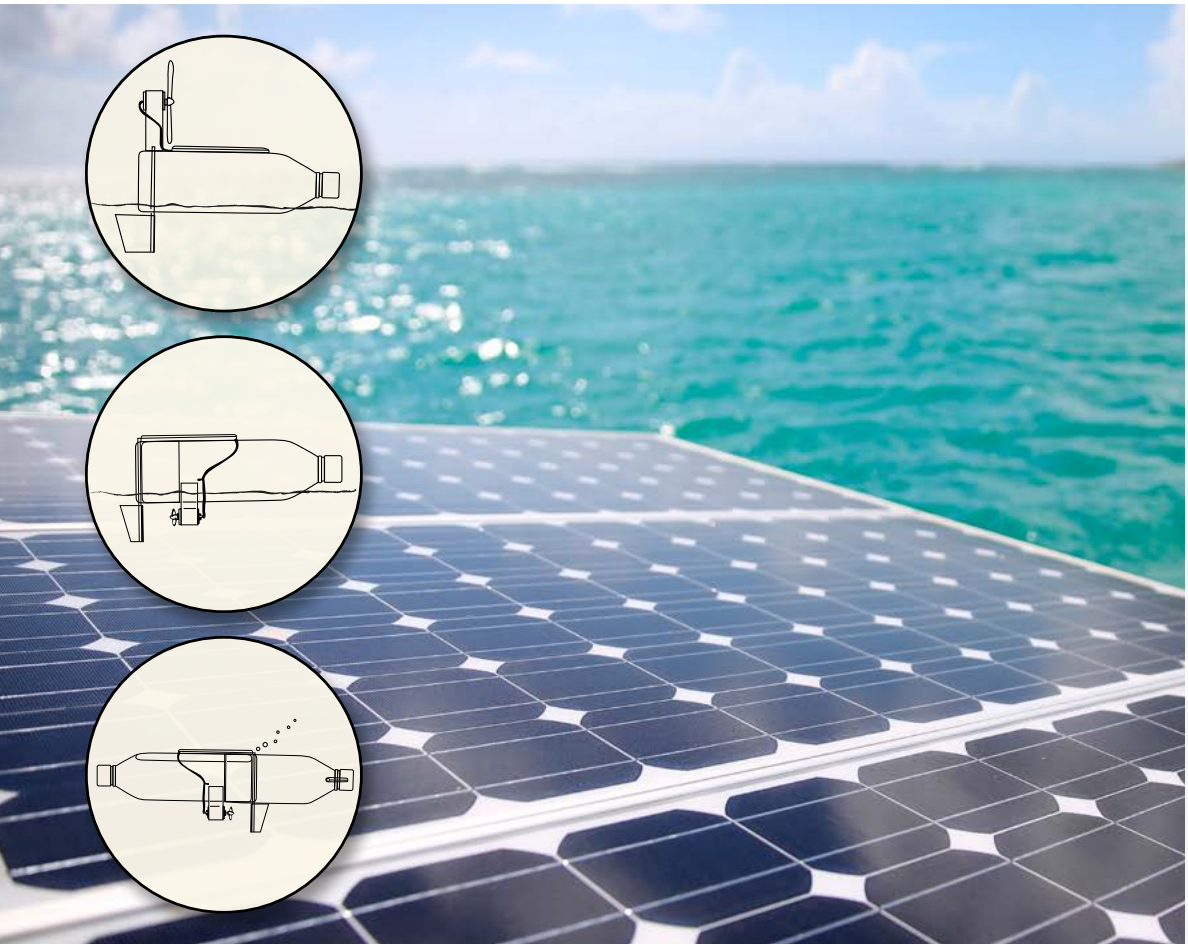
steamworks

SOLAR ENERGY: DESIGN AND ENGINEER

VOL. 6

Developed with Kristin Hotter
Grades 6–8

Time: 3 hours



STEAM CONNECTIONS

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

Technology: Students will explain how photovoltaic panels work. They will also use the EIA website to learn more about solar energy.

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

Art: Student groups will paint and name their boats.

Math: Groups will compete in head-to-head races. Each student will record each competing boat's race time and calculate the time differential between the winning and losing boat. Students will also measure the length of the Raingutter Regatta® and determine the amount of time it takes their boats to travel from one end of the regatta to the other. Using that information, they'll be able to calculate the speed at which their boats traveled.

OBJECTIVES

Students will...

- Be able to explain how solar energy provides electricity for a boat
- Be able to build a solar-powered boat using limited materials
- Be able to make one modification to improve the performance of a solar- powered boat

LEARNING STANDARDS

MS-PS-3 — Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-ETS1-2 — Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Problem: Design a solar-powered boat that travels the length of the kiddie pool or Raingutter Regatta® the fastest.

Criteria: You must use all provided materials. You cannot touch the boat once it is placed at the starting line.

CONTENT

In this lesson, students will explore how solar energy can provide enough power to move a boat from one end of a kiddie pool or Raingutter Regatta® to the other. They will start out by exploring what solar energy is, how it has been used, and what a solar cell is. They will use that knowledge to work in a small group to brainstorm and build a solar-powered boat from a provided kit. Once each group's boat is built, students will compete in timed races. Each group will evaluate their boat's performance and suggest one modification that could be made to improve it.

INTRODUCTION

Why is the sun so important? (It's the center of our universe. It provides heat. It provides light.) Since the sun provides us with both heat and light, it's a source of energy. Here's how that energy gets to us.

> Deep in the sun's core, nuclear fusion converts hydrogen to helium, which generates energy. Particles of light called **photons** carry this energy through a spherical shell called the radiative zone to the top layer of the solar interior, the convection zone. This is where hot plasmas rise and fall like the ooze in a lava lamp, which transfers energy to the sun's surface, called the photosphere. It can take 170,000 years for a photon to complete its journey out of the sun, but once it exits, it zips through space at more than 186,000 miles a second. Solar photons reach Earth about 8 minutes after they're freed from the sun's interior, crossing an average of 93 million miles to get here—a distance defined as one astronomical unit (AU).
>
> Source: https://www.nationalgeographic.com/science/space/solar-system/the-sun/#close

Solar energy can be used to make electricity. Here's a house that uses solar panels for electricity. What are some things you notice about these panels? (They're on the roof. They're arranged in arrays. There are a lot of them.)

Solar panels similar to these are soon going to play a very important role.

You're going to be tasked with building a boat that uses solar energy that has been collected by a solar panel. That solar-powered boat will have to travel across a kiddie pool or Raingutter Regatta®.

Before we can get to that, we need to understand solar energy a little bit more.

Have students work independently or in small groups to complete the Diving Into Solar Energy worksheet. When completed, facilitate a discussion about students' findings.

ACTIVITY 1: BOAT BRAINSTORM

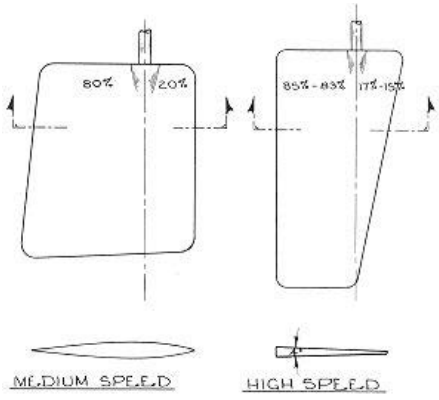
1. Divide students into groups of 2-4. Give each group the materials included in a solar-powered boat kit (minus the blue booklet) and two 16-18 ounce plastic bottles. Explain that each group will use all of the materials provided to build a boat. That boat will go through a series of races that span the length of a kiddie pool or Raingutter Regatta®. The goal is to have the fastest boat.

2. Before students start brainstorming and building, discuss the materials included in the kit. Start with the propeller. Facilitate a discussion around student observations. What are its features? What is its function? What purpose will it serve?

3. Facilitate the same discussion about the motor. When students discuss the red and blue wires coming out of the motor, explain those will help create the electricity that flows through the boat. What other item in the kit has the same wiring? (Solar panel)

4. Ask students what they know about the electrical wiring. If they do not come to the conclusion on their own, explain that the red wire from the motor will need to connect to the blue wire on the solar panel. Conversely, the blue wire on the motor will need to connect to the red wire on the solar panel. Explain that without those connections, the energy collected from the solar panel cannot be transported through electricity to the motor.

5. Show students these rudder images. Ask about features, function, and purpose. Ask what they notice about the two different types of rudders shown in the image. You may choose to explain that since rudders are used to help steer the boat, they are traditionally located on the underside of boats.



Source: https://www.glen-l.com/weblettr/webletters-4/wl38-rudders.html

6. Provide each group with a blank sheet of paper for brainstorming. Explain that one plastic bottle must be included as the body of the boat. The second can also be used in the body, used for parts, or a combination of the two.

7. Ask groups to sketch an image of the boat they will create. Sketches should include all necessary parts—solar panel, rudder, motor, at least one of the plastic bottles, and propeller. Students should also explain why they have chosen to include that part in a particular location on their boat.

8. Once students have brainstormed and sketched their idea, they are ready to build. In addition to the materials provided in Step 6, students will need electrical tape and scissors to work on their vessels. You may also want to provide them with a copy of the Troubleshooting Sheet.

9. Provide students with ample time (at least 30 minutes) to build their boats. Once construction is complete, be sure each group names its boat. You can also have students paint and decorate their group's boat.

Note to Teachers: It is your discretion how much or how little you provide students with in regards to creating their boats. You may choose to skip steps 6-8 and provide one of the following modifications to the activity.

Modification 1: The kit provides specific ways to build a speed boat, air boat, and surface submarine. Use these pictures to tell students they can create one of these three types of boats. Point out the features—motor, rudder, and propeller—in each type of boat.

Air Boat

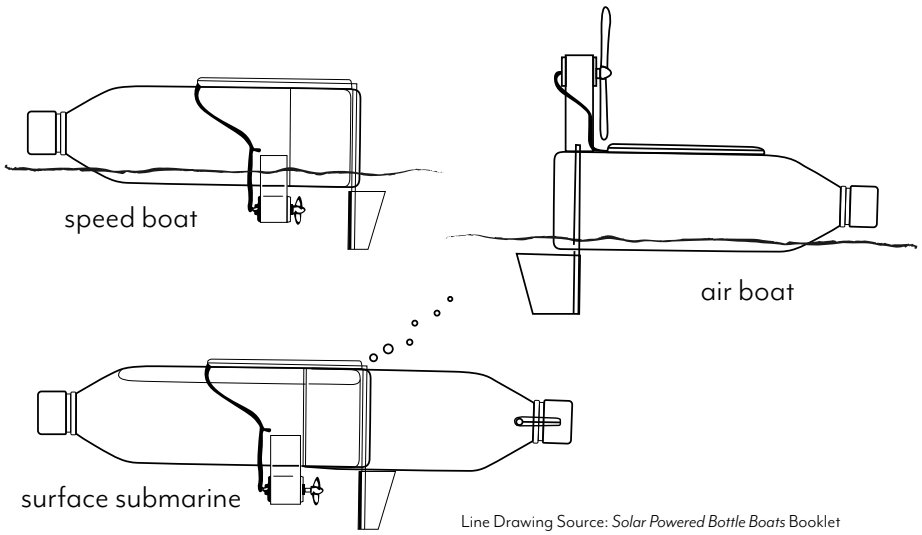
Speed Boat

Surface Submarine

Modification 2: Show students the images on the front of the blue booklet included in the Solar Bottle Boats Kit. These images can serve as a guide as students decide how to construct their own boats.

Modification 3: Provide students with the booklets. Each booklet includes step-by-step directions and diagrams that aid in the construction of the boats.

Modification 4: Provide students with handouts (included with lesson) that further break down how to assemble each type of solar-powered boat.



Line Drawing Source: *Solar Powered Bottle Boats* Booklet

ACTIVITY 2: OFF TO THE RACES

1. Once students have completed construction of their boats, it's time to race them. Give each student or group a copy of the Race Sheet. Set up head to head competitions. You'll want each boat to race at least twice.
2. Explain to students the rules of the race are simple. The two racing boats will start at one end of the kiddie pool or Raingutter Regatta®. When you say go, each group will release its boat and start timing. Time stops when their boat touches the opposite side of the kiddie pool or Raingutter Regatta®. To keep everyone engaged, have all students record all race times on the Racing Sheet.
3. Once the races are complete, have students complete the time differential column to determine how much time the winning boat won by. Have them also calculate their group's boat speed for at least one of the races.
4. For additional challenge, have students rank the boats from fastest to slowest.

ACTIVITY 3: REFLECTION & MODIFICATION

1. Ask each group to reflect on what worked well with their boats construction. Ask them to reflect on what improvement(s) they could have made.
2. Tell each group they have the opportunity to make a single modification to their group's boat. What modification do you want to make? Explain that modifications can only be made using provided materials (plastic bottles and electrical tape).
3. If time allows, ask each group to make its proposed modification to their boat.
4. If further time allows, let each boat race one more time so groups can determine if their modification did in fact improve the performance of their boat.

MATERIALS:

- Solar Powered Bottle Boat Kits **(SB40881)** – 1 kit for each small group of 2-4 students
- Two 16-18 oz. recycled plastic bottles with caps for each group
- Various other 16-18 oz. recycled plastic bottles (students can use these when making modifications)
- School Works!® Safety Point Scissors - 7" **(9729183)**
- Electrical tape, ¾" x 60' **(SB50541)**
- Heavy-duty awl (to poke holes in the bottles) **(9723871)**
- Kiddie pool or Raingutter Regatta® **(NA10268)** filled with water
- Diving Into Energy worksheet
- Laminated troubleshooting sheet for each group
- All-purpose digital stopwatch **(TB14784)**
- Nasco budget yardstick **(9704372)**
- Race sheet (included)
- A sunny day (preferably close to noon with little to no wind)

Optional:

- 1 set of laminated step-by-step directions for each group (You'll provide these if you are utilizing Modification 4 in Activity 1)
- Painting supplies:
  Brushes **(9727731)**
  Acrylic paint **(9714725 A-Z)**
  Paint cups **(9729701)**

Nasco education
1.800.558.9595
NascoEducation.com

steamworks handout

RACE SHEET

Volume 6 : Gr. 6–8

Race	Boat Name/Time	Boat Name/Time	Time Differential
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

The length of the Raingutter Regatta® is _____.

It took my boat _____ to reach the end of the regatta.

My boat traveled at a speed of _____.

My group's proposed modification: _____

_____

Why we decided on that modification: _____

_____

Was the modification successful? Why or why not?

_____

_____

steamworks handout

DIVING INTO SOLAR ENERGY – WORKSHEET

Volume 6 : Gr. 6–8

Name: _____ Class: _____ Date: _____

Use this website to complete the outline about solar energy: https://www.eia.gov/kids/energy-sources/solar/

I. Two Kinds of Solar Energy

A. _____

B. _____

II. Ways People Have Historically Used Solar Energy

A. _____

B. _____

C. _____

III. Benefits and Limitations of Solar Energy

A. (Benefit) _____

B. (Limitation) _____

IV. Factors that Affect Insolation (Two factors on each line)

A. _____

B. _____

C. _____

V. Two States with the Highest Direct Normal Solar Irradiance

A. _____

B. _____

Why do southern states tend to have higher global horizontal solar irradiance than northern states?

_____

_____

_____

VI. Two Types of Solar Radiation Used by Photovoltaic (PV) Collectors

A. _____

B. _____

VII. PV Collectors

A. Function: _____

B. What Happens When the Light Hits a PV Collector?

_____

_____

C. Cause of Imbalance in the Collector _____

_____

D. Effect of Electron Absorption _____

_____

VIII. Facts About PV Systems

A. _____

_____

B. _____

_____

C. _____

_____

steamworks

DIVING INTO SOLAR ENERGY – ANSWER KEY

(Answers May Vary)

Volume 6 : Gr. 6–8

Use this website to complete the outline about solar energy: https://www.eia.gov/kids/energy-sources/solar/

I. Two Kinds of Solar Energy

A. heat

B. electricity

II. Ways People Have Historically Used Solar Energy

A. solar ovens

B. dry meat, fruit, and grains

C. warmth

III. Benefits and Limitations of Solar Energy

A. (Benefit) Don't pollute

B. (Limitation)

The amount of sunlight in any given spot on any given day is not consistent.

IV. Factors that Affect Insolation (Two factors on each line)

A. latitude and climate

B. weather and clouds

C. volcanic ash and pollution

V. Two States with the Highest Direct Normal Solar Irradiance

A. Arizona

B. New Mexico

Why do southern states tend to have higher global horizontal solar irradiance than northern states?

They are closer to the equator.

VI. Two Types of Solar Radiation Used by Photovoltaic (PV) Collectors

A. diffuse solar radiation

B. direct solar radiation

VII. PV Collectors

A. Function: convert sunlight into electricity

B. What Happens When the Light Hits a PV Collector?

Photons hit the PV cell. Some of the photons are absorbed by the PV cell. When enough photons are absorbed, electrons move to the surface to the cell creating electricity.

C. Cause of Imbalance in the Collector

the movement of electrons

D. Effect of Electron Absorption

Electricity

VIII. Facts About PV Systems

A. Can power things as small as a calculator

B. Typically arranged in arrays

C. Can provide electricity where other sources, such as power lines, are unable to be placed