Nasco Education™

LESSON PLAN

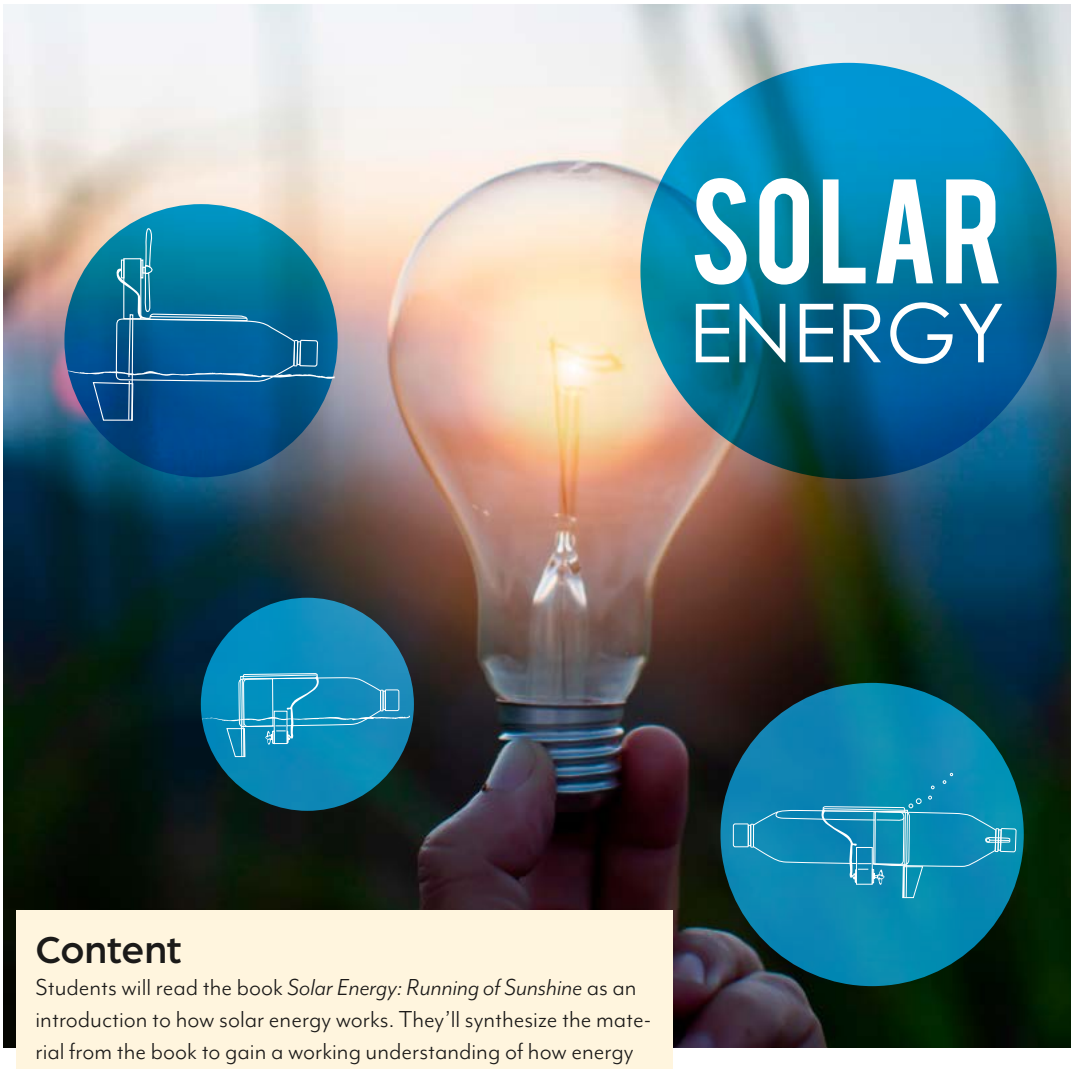
STEM/ STEAM

Developed with Kristin Hotter

Solar energy: Real world use

Volume 6 | Gr. 3-5

Time: 3 hours



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.

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.

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.)

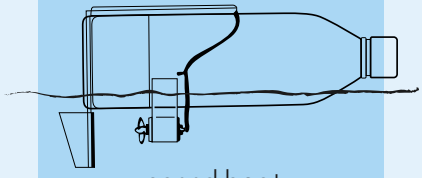
Provide each student with a copy of the double-sided worksheet. Direct their attention to side 1. Tell students the three images on the sheet are three different models of solar-powered bottle boats. Each boat is made from the same type of materials. Show students the contents of a kit and two of the 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

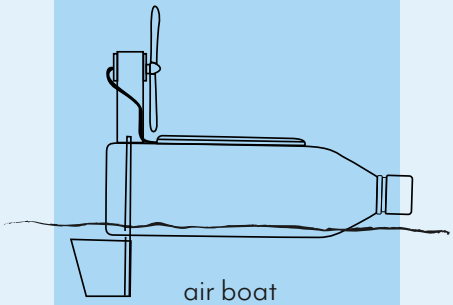
Propeller: A revolving device that uses blades to move a boat

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

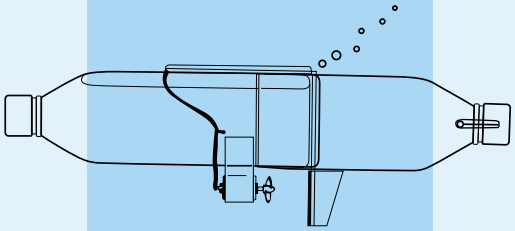
- Circle each part on the speed boat. Then ask students to circle the three parts on the submarine and air boat and what they know about each particular type of boat. (Sample responses: You can take an air boat ride in the Everglades. People can water ski or tube behind a speed boat. A submarine is one 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:

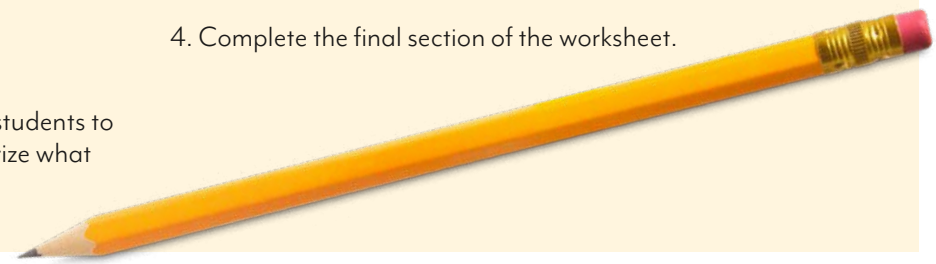
(*Our Shining Star*; *What is Solar Power?*; *Zip! Zap! Electricity*; *Ups and Downs of Solar Power*). Either provide students with a copy of each section or display a copy to read as a whole group.

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.

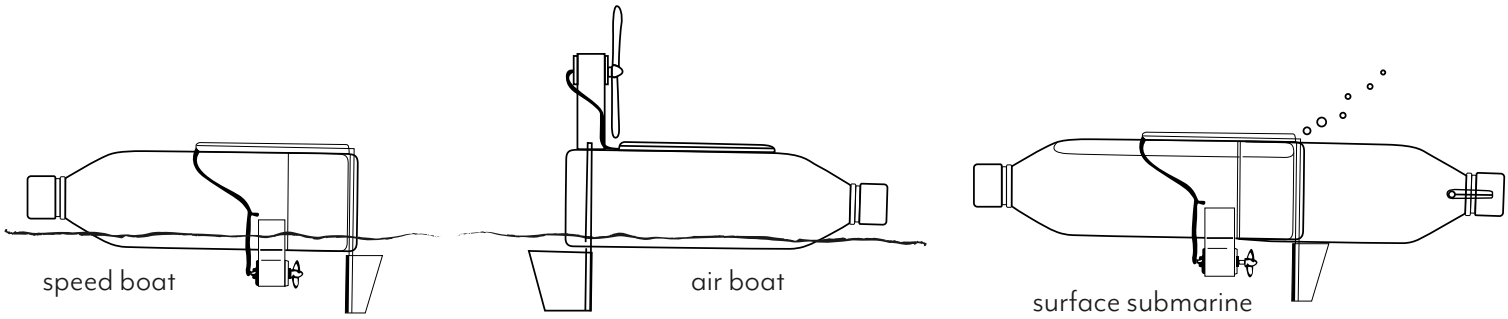
Materials list

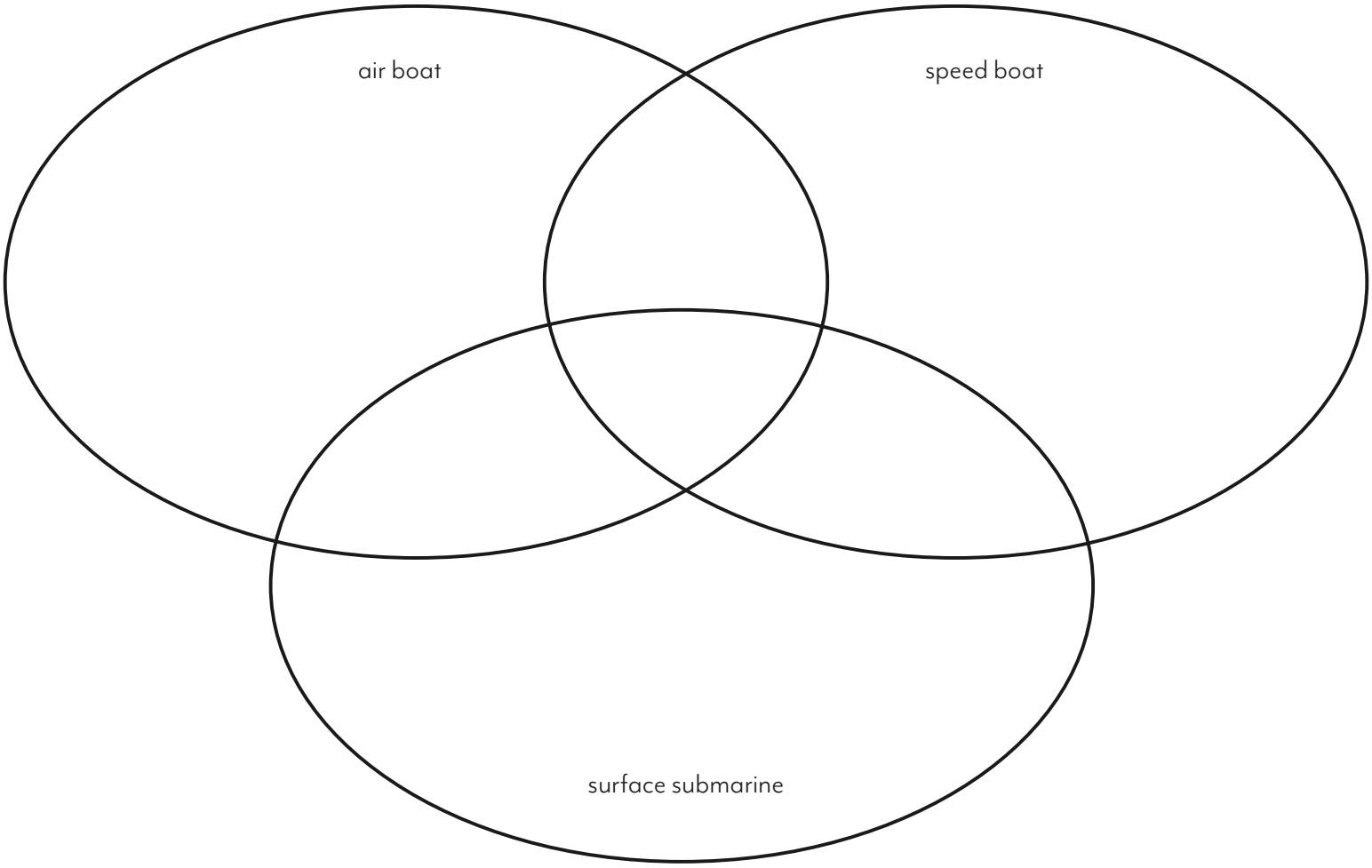
- Solar Bottle Boat Class Kit **(SB53392)**
- Solar Bottle Boat Kits **(SB40881)** – 1 kit for each small group of 2-4 students
- One to two 16 oz. recycled plastic bottles with caps for each group (depending on model being built)
- Various other 16-18 oz. recycled plastic bottles (students can use these when making modifications)
- School Works!® Safety Point Scissors **(9729183)**
- Electrical tape, ¾" 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)**

Name: _____ Class: _____ Date: _____





My group will build a _____ (kind of boat) because _____

_____

_____

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Section 1: Our shining star

1. What causes the sun to release such a large amount of energy?

2. How does the sun's energy make its way to Earth?

Section 2: What is solar power?

1. What are two example of solar power?

2. What makes solar power a renewable resource?

Video:

1. How much sunlight is needed to provide the world's energy for one year?

2. What do photovoltaic panels do?

3. Explain how a photovoltaic panel works?

Section 3: *Zip! Zap! Electricity*

1. Why are photovoltaic panels made of silicon?

2. Why are photovoltaic panels often found on roofs?

Section 4: Ups and downs of solar power

1. What is one positive thing about solar energy?

2. What is one negative thing about solar energy?

3. What are **two** new things you learned about solar energy?

4. What is **one** question you still have about solar energy?

Name: _____ Class: _____ Date: _____

	Race 1	Race 2	Race 3
My boat's time			
Opponent's time			

Activity 3:

1. What modification will your group make? _____

2. Why did you decide on this change? _____

	Race 1	Race 2	Race 3
My boat's time			
Opponent's time			

1. Did your modification improve your boat's time? _____

2. Why do you think it helped or hurt your race time? _____

3. If you could make one more modification, what would it be? _____

Let's troubleshoot

You may run into a few problems as you build your boat. Here are a few problems and some possible solutions to help you solve those problems.

Problem: The propeller doesn't spin.

1. Use your finger to make sure the propeller spins freely. If not, adjust until it does.
2. Make sure the wires are connected between the motor and the solar panel.
3. Be sure you're working under direct sunlight.

Problem: The boat leans to one side.

If the boat is leaning, it's not balanced and the solar array and motor need to be realigned.

1. Remove the solar array.
2. Reattach on top in the opposite direction that the boat is leaning.

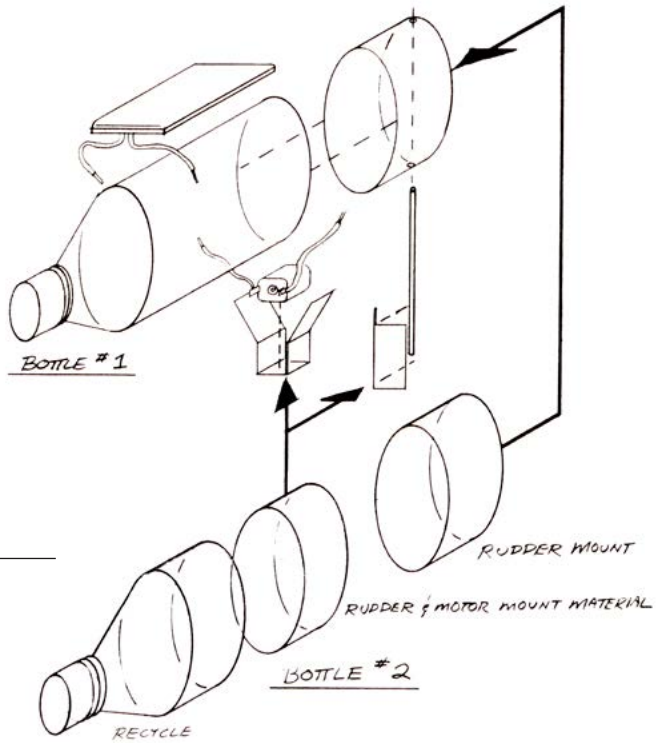
Problem: The propeller is turning in the wrong direction.

1. Disconnect the wire leads.
2. Reconnect them in the opposite way.

To make the speed boat, you'll need two plastic bottles. They must be the same size and shape.

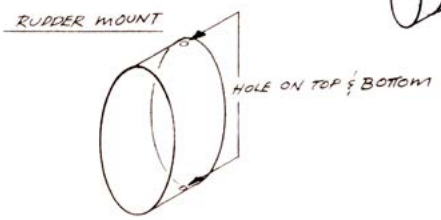
Bottle 1: This bottle needs to be kept air tight. That means you need to keep the lid on tight. Make sure there are no holes in this bottle.

Bottle 2: You'll use this bottle to make the rudder, the rudder mount, and the motor mount.



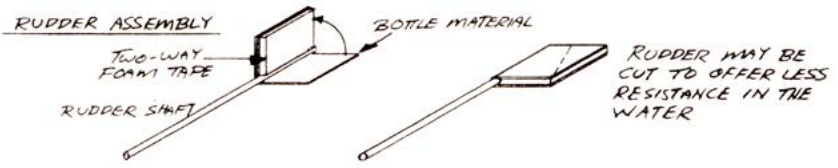
Making the rudder mount

1. Cut the bottom portion of bottle 2 off. Before cutting, make sure it's long enough to fit over the end of bottle 1.
2. Punch two holes into the portion of bottle 2 that you cut off. One hole will be on the top and the other on the bottom. Make sure each hole is centered and as close to the edge of the bottle as possible.

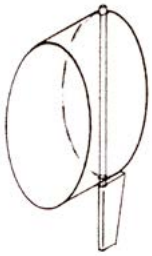


Making the rudder

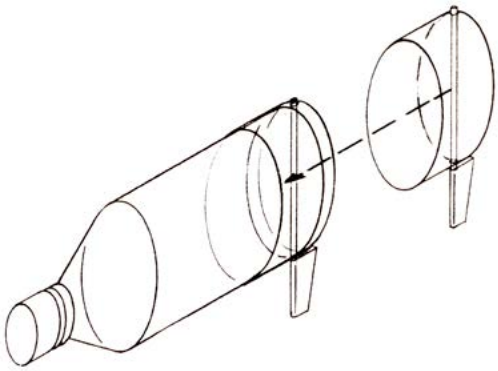
1. Cut a 2" x 2" square from bottle 2.
2. Fold the square in half. Lift it at the fold and place a piece of tape inside. Put the tape as close to the fold as possible without the tape actually touching the fold. You don't want it to touch the fold because that's where the rudder shaft needs to go.
3. Put the rudder shaft inside the folded square. Be sure to keep it flush (straight) on the bottom of the rudder.



4. Put the completed rudder into the rudder's mount. To do this, place it into the two holes you punched earlier.



5. Slide the rudder and rudder mount onto bottle 1.



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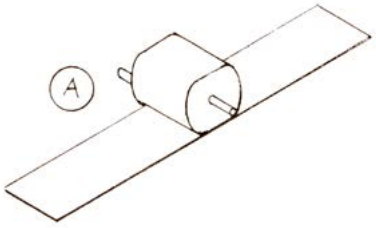
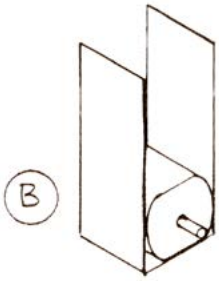
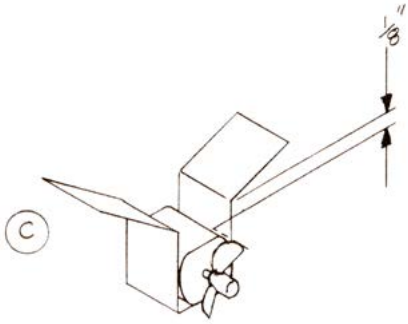
Making the motor mount



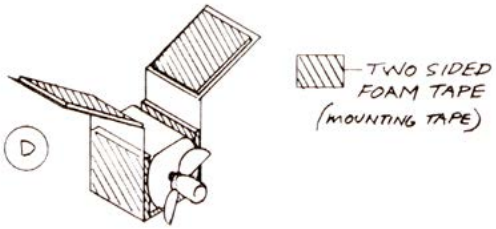
1. Cut a 5" x 1" strip of plastic from bottle 2.
2. Place the motor on the center of the strip.



3. Bend and slightly fold the sides up and around the motor.



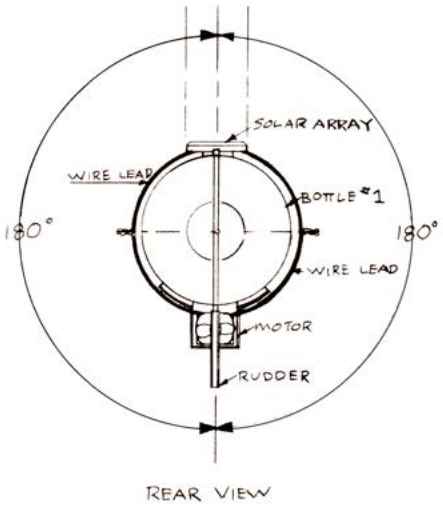
4. Place the propeller onto the motor shaft to figure out the clearance from the top of the prop to the bottom of bottle 1.
5. When you figure out the level, bend and slightly fold the plastic on both sides of the mount. You don't want the prop to hit the bottom of bottle 1.



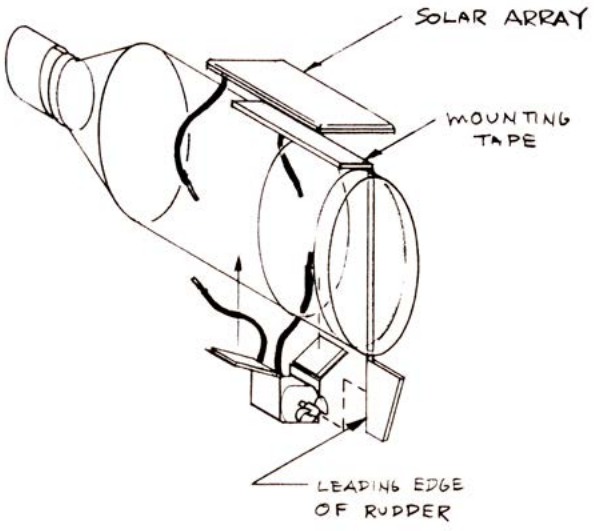
6. Cut mounting tape and place it around three sides of the motor and two surfaces of the mount and place the motor into the mount.

Put it all together

1. Take the completed motor mount assembly and put it on the bottom of bottle 1. Make sure to line up the center of the prop to the leading edge of the rudder.



2. After the motor and rudder are aligned, mount the solar array.
3. Place a strip of mounting tape on the back side of the solar array.
4. Center the array on the top of bottle 1.



1. Use the one **gray** wire nut to connect the **blue** wire from the solar array to the **red** wire of the motor.
2. Use the other **gray** wire nut to connect the **red** wire of the solar array to the **blue** wire of the motor.
3. If necessary, tape the wire leads to the side of bottle 1.

Your speed boat is ready for the water!

To make the surface submarine, follow the directions to make the speed boat. Then, you'll need an additional bottle that is the same or similar in size and shape to those used on the speed boat.

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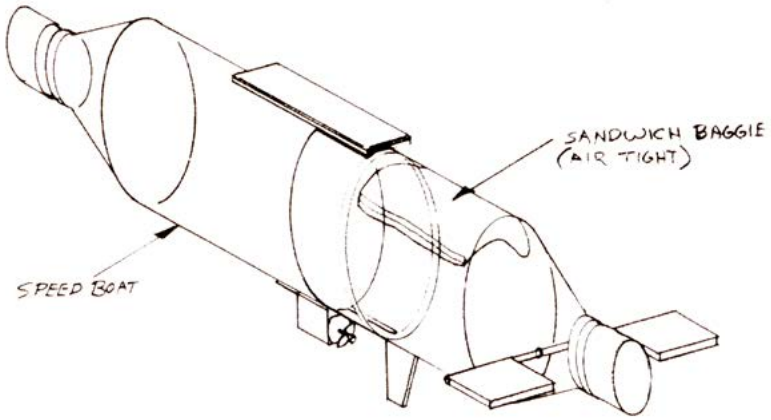
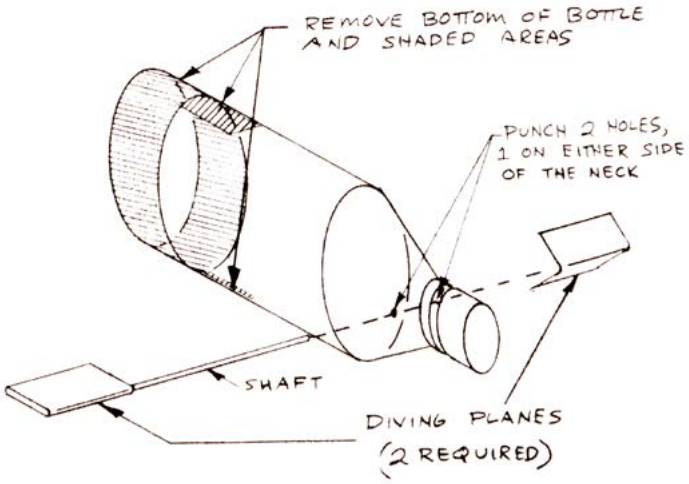
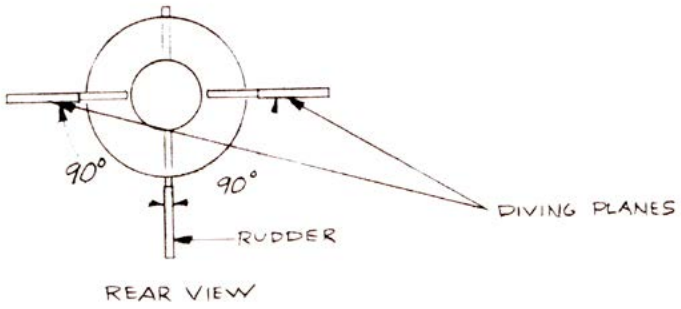
1. Cut the bottom off the bottle.
2. Place what's left of the bottle onto the rear of the speed boat to figure out where slots will need to be cut for the rudder shaft and the solar array. (You may need to remove these areas so the bottle will slide partially onto the back of the speed boat.)
3. You'll use the second shaft from the kit and the leftover plastic to make the horizontal diving planes. You'll make these planes the same way you made the rudder for the speed boat.



4. Punch two holes, one on either side of the neck of the bottle you took the bottom off of, and run the shaft through these two holes. If you're confused, look at the image above this step.
5. Fasten a diving plane onto both ends of the shaft. Be sure to keep the diving planes square to the rudder like in the illustration below.



6. Slide what you've made onto the rear of bottle 1 until it comes close to or touches the motor mount. If it seems loose, secure it with electrical tape.

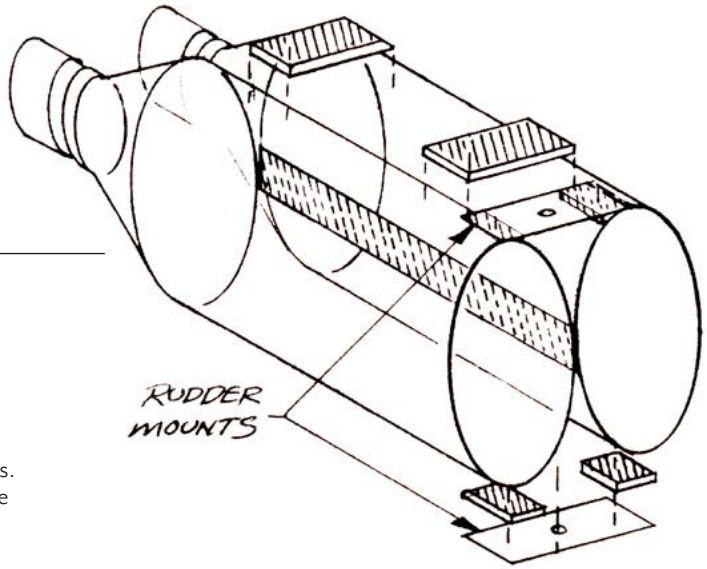


Now that you have the submarine assembled ...

Put it in the water and remove the cap from bottle 1 to partially fill with water and submerge the submarine. Secure the cap onto the bottle. Some air needs to stay in bottle 1 to maintain buoyancy. You may need to experiment with how much air and water you need to keep your submarine balanced.

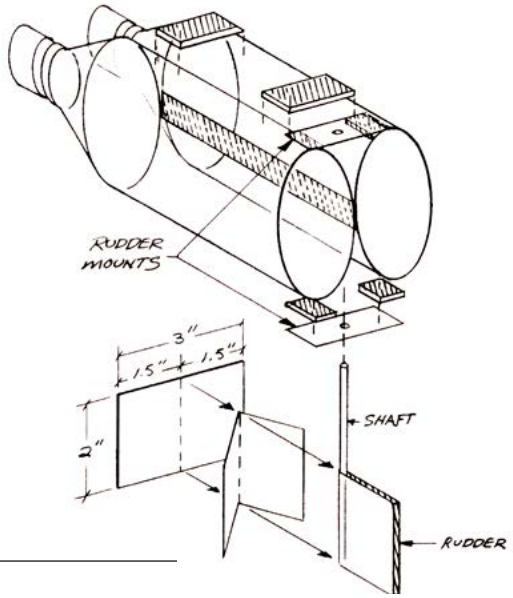
To make the air boat, you'll need two bottles of the same size and shape. You'll also need a third bottle for material.

1. Place the two similar bottles side by side. Put a piece of mounting tape along the side where the two bottles touch. Make sure the caps are securely fastened on the bottles.



Making the rudder mounts

1. Cut two 1" x 4" strips from the third bottle. These are your rudder mounts.
2. Use mounting tape to secure the rudder mounts to the back of the two bottles. One will go on top and one will go on the bottom. If you need help, look at the image above to see exactly where the rudder mounts go.
3. Punch a hole in the top and bottom mount for the rudder shaft.



Making the rudder

1. Cut a 3" x 2" rudder from bottle 3.
2. Fold the rectangle in half on the 3" side. Lift it at the fold and place a piece of tape inside. Put the tape as close to the fold as possible without the tape actually touching the fold. You don't want it to touch the fold because that's where the rudder shaft needs to go.
3. Put the rudder shaft inside the folded square. Be sure to keep it flush (straight) on the bottom of the rudder.
4. Put the completed rudder into the rudder's mount. To do this, place it into the two holes you punched earlier.

Making the motor mount

1. Cut a 1" x 10" strip from the third bottle.
2. Place the motor in the center of the strip.
3. Bend and slightly fold the sides up and around the motor.
4. Cut mounting tape to place onto three sides of the motor and place into the mount.
5. Stand the motor upright and fold each side of the mount at about 1" from the bottom. The folds will determine how the motor and propeller will be from the tops of the bottles when they're mounted.
6. Make sure the propeller won't hit the top side of the bottles.
7. Use mounting tape to secure the motor mount to the top side of the bottles or the top of the rudder mount.
8. Use mounting tape to attach the propeller and mount the solar array to the center of the sop side of the bottles.
9. Use the one **gray** wire nut to connect the **blue** wire from the solar array to the **red** wire of the motor.
10. Use the other **gray** wire nut to connect the **red** wire of the solar array to the **blue** wire of the motor.