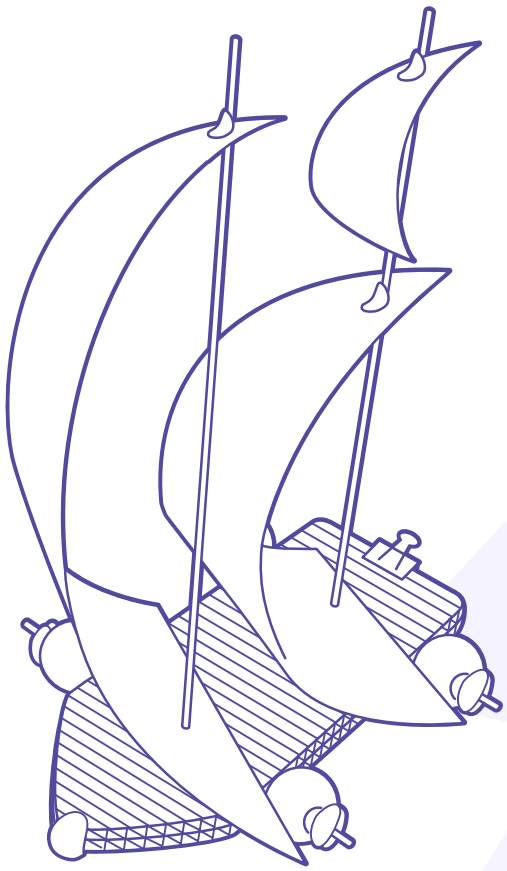
Sail Car Activity



Grades

- K-12

Concepts

- Inquiry and Science Process
- Energy and Energy Transfer
- Forces and Motion
- Earth Science
- Engineering, Art, and Design
- Using Basic Tools
- Collecting and Interpreting Data

Disciplinary Core Ideas

- PS2-A, PS3-A, PS3-B, ETS1.A, ETS1.B, ETS1-C

Time Required

- 45 minutes to 1 hour. Learning time is between 30 seconds and 45 minutes, depending on how much time is spent exploring different variables.

Science and Engineering Practices

- Planning and carrying out investigations
- Constructing explanations
- Analyzing and interpreting data
- Asking questions and defining problems

Cross Cutting Concepts

- Cause and effect
- Energy and matter
- Patterns

Objectives

At the end of the lesson, students will:

- Design and build a functional Sail Car that moves as far as possible in the wind.
- Be able to use the scientific method to isolate and adjust variables to design a sail car that travels as far as possible.
- Understand how sails capture energy from the wind and transfer it into usable energy to propel a car forward.

This activity guide was adapted from a prior REcharge lesson.

Click to check out the NGSS Website, Full NGSS Standards, or Science and Engineering Practices in the NGSS

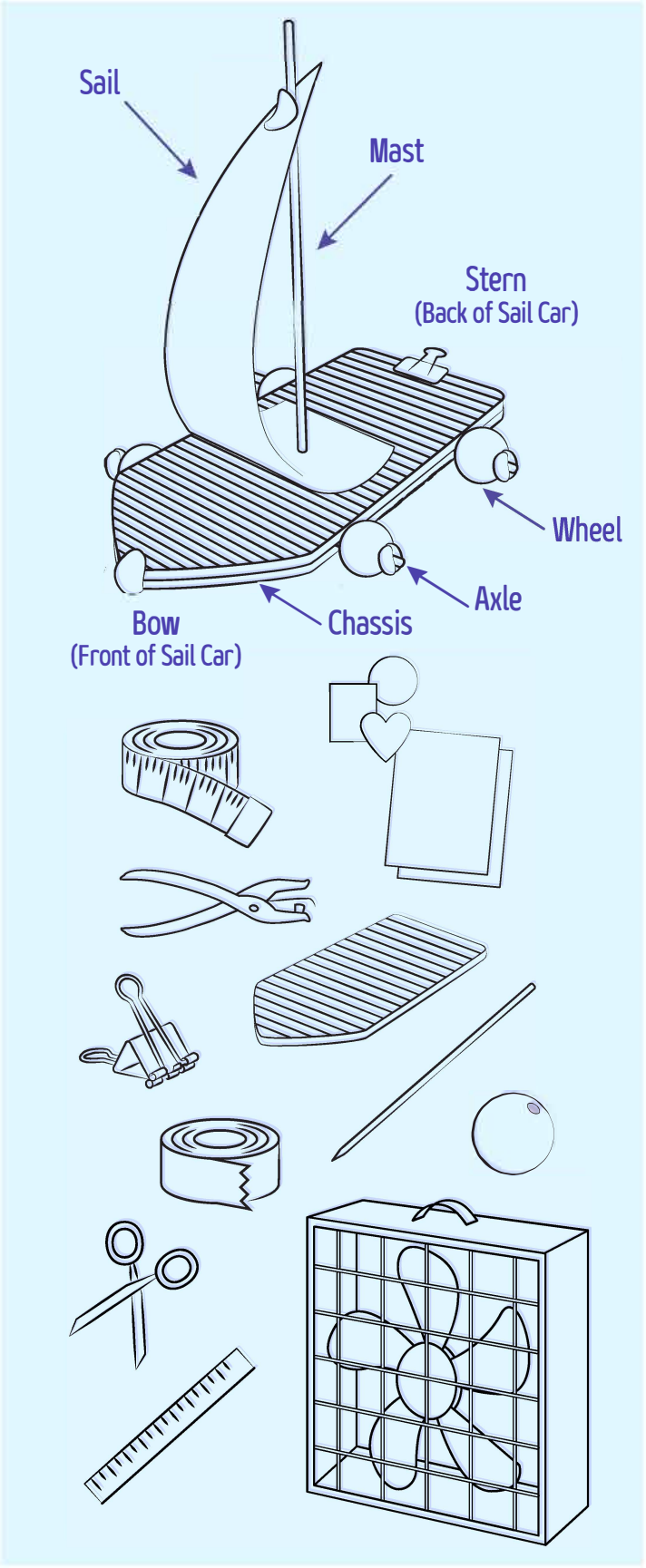
Materials

The illustration to the right is an example of the Sail Car the students will be building.

- Card stock
- Skewers
- Binder clip
- Straws
- Foam stickers
- Craft balls
- Prepared corrugated plastic sheets
  - You can use any size and shape corrugated plastic sheet. Typically these are 8"x4" with a pointed tip but you could make them any size you like. Make sure the flutes are going across the car so you can insert the axels!

Classroom materials to share

- Measuring tape
- Masking tape
- Hole puncher
- Scissors
- 20"x20" standard box fans
- Books or images that show examples of different sail shapes, sizes, and numbers of sails.
- Wire cutters (optional)



REcharge Labs & KidWind have been leaders in K-12 renewable energy education for over 15 years. Their library of materials and programming are now a part of Gale Force Education. Gale Force Education is a non-profit focused on fostering opportunities for students, educators, and the public to explore a future powered by renewable energy.

Learning Goals

This activity demonstrates how wind can be used to propel an object. Students will build sails to catch the wind in order to move the Sail Car as far as possible. Experiment with the number, design, shape, and angle of sails to control the direction, speed, and distance of the Sail Car.

Getting Ready

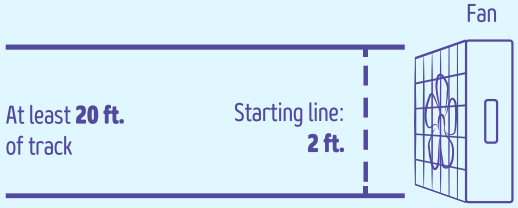
Build and test your own Sail Car before the class begins. This is a valuable preview to the challenges and problems that students will face. Your example will also help you to explain design and vocabulary words.

Organize the materials to distribute to each group. Gather the tools and any additional items you will need to complete the activity.

Have books or images ready that show examples of various sail shapes, sizes, and number of sails.

Use masking tape to create straight race tracks on the floor. The track can be laid on a dense, low-pile carpet or a smooth floor, and the space should be empty and at least 20 feet long. Have as many as three fans lined up next to each other, pointing in the same direction, and at the same wind speed. The track width should be the same as the width of the box fan. Place a starting line about two feet away from the box fans. See illustration below.

Have your measuring tape, extra masking tap, and permanent marker ready to mark the student's distance for each of their tests.



Activity

During the first segment of this activity, students learn vocabulary terms and assemble their Sail Car chassis. During the second stage, students explore different types and arrangements of sails and plan and create their own Sail Cars. They then test multiple trials of their sails on the race track and gather data on their performance.

This activity works best if students work either individually or in pairs. If groups of three are required, be sure the groups have plenty of time to plan and design together before getting their sail materials

Step 1: Beginning questions for students

- Who has seen or been on a boat that uses sails?
- What are the basic parts and features of a sailboat?
- What different kinds of boats can you name that use sails? How are the sails on these boats similar or different?
- How does a sailboat work?

Step 2: What is a Sail Car?

A Sail Car is a cross between a sailboat and a car. A car uses a motor to move forward, but a sail car uses the wind. A sailboat needs water to float, but a Sail Car can move on land because it has wheels.

Step 3: Distribute chassis materials

The first part of the activity is having the students assemble the Sail Car chassis, which is the base of the Sail Car with the axles and wheels. Give each group the materials needed to make one Sail Car chassis:

- 2 bamboo skewers
- 4 wooden balls
- Foam stickers
- 2 corrugated plastic bases
- 1 binder clip
- Scissors or wire cutters

Step 4: Assemble axles and wheels

Starting at the bow of the chassis, count to the 11th corrugated "channel" and push a bamboo skewer through it. Slide one wooden ball onto the piece of skewer sticking out from either side of the chassis **(Fig. A)**. Stick any of the foam stickers on the bamboo skewers to keep the balls on the skewers **(Fig. B)**. Repeat on the other side of the skewer. Then, use the same technique for the back axle, this time inserting the skewer into the 4th channel from the stern.

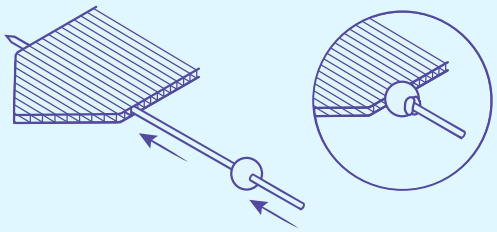


Fig. A

Fig. B

Step 5: Trim the bamboo skewers

There will be extra bamboo skewer lengths sticking out from the wheels. Using scissors or wire cutters, students should cut off the extra lengths, starting ¼" after the foam sticker stoppers **(Fig. C)**. This can be difficult to do with scissors; students might have to make a dent, then snap the bamboo at the dent.

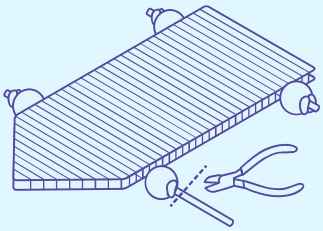
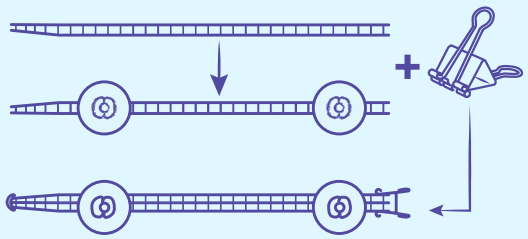


Fig. C

Step 6: Attach bottom

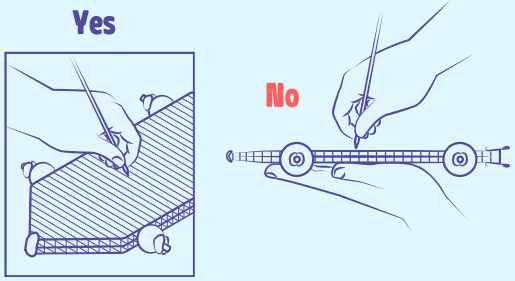
Stack the remaining piece of corrugated plastic directly on top of the assembled chassis **(Fig. D)**. Use the binder clip to attach the two bases together at the stern. This top piece acts as a buffer to keep the sail mast from poking through the chassis and dragging along the floor.

Fig. D



Next students will use the bamboo skewers to make the mast. To make the first mast, use firm pressure to push the pointy end of the skewer through the corrugated plastic base where the mast will be **(Fig. E)**. Warn students to NOT place their hands on the underside of the chasis where the skewer might punch through and poke them.

Fig. E



Step 7: Research sail design

The type and arrangement of sails control how well students' Sail Cars will perform. Give students time to browse books and images of sail types for inspiration for their own designs. Encourage them to draw their design or discuss with team members why they think certain designs will work better than others. Students can create multiple masts of varying heights, sails of all shapes and sizes, two sails on one mast, and billowing sails leaning in different directions. Students can even make sails with holes in them, or sails that look like funnels!

Step 8: Distribute sail materials

Distribute sail materials to students:

- bamboo skewers
- cardstock
- scissors
- foam stickers

Now for the best part: making sails that catch the wind! To make it easier to place sails on the masts, students may use a hole punch to make holes **(Fig. F)**, and use foam stickers to keep sails in place. If the sail hangs over the edge of the base, trim or move it so that it does not rub against the wheels or the ground.

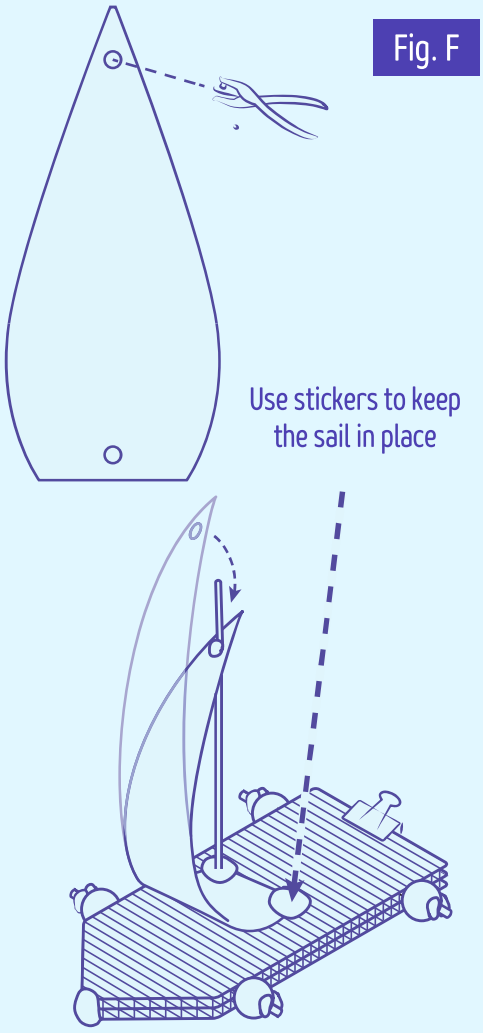


Fig. F

Step 9: Ready, set, go!

The goal of this activity is to make the Sail Car go as far and as straight as possible. Turn fans on. Invite students to place their Sail Cars at the starting line, one car per fan at a time. As soon as the car comes to a complete stop, mark where the front of the car stopped using masking tape and write the student's or team's name on it. Remember, the goal of the race is not about speed, it's about distance!

Step 10: Testing and discussion

The first trial may not be the best trial. Some cars may swerve off track; others may not go very far. To make a Sail Car move in more of a straight line, students should try changing the angle of the sails. They should test out the number of sails to increase the amount of surface area the wind can catch, and experiment by changing different variables.

Do as many tests as possible, then at the end of class ask students to gather again to discuss which designs worked best. How did their designs perform? What aspects of the design do they think had the greatest affect on performance? What would they do differently for next time?

Extension Activity

Making and testing different Sail Car bases can be a great extension activity for students.

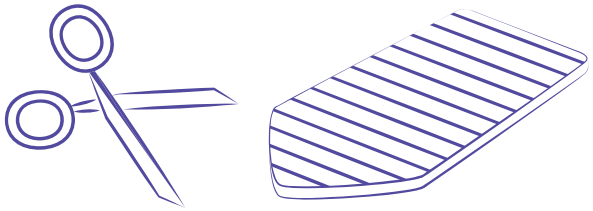
Step 1: Gather materials

You will need to acquire some corrugated plastic. You can purchase corrugated plastic, or "coroplast" at hardware or craft stores ($3–$5 for a 18"x24" sheet), but it's also used for election campaign signs, so it's easy to come by during voting season!

Step 2: Cutting your Sail Car bases

Have students draw out their desired Sail Car base on the coroplast. They can do research on different chassis shapes, as viewed from above. See attached drawings for examples. Or make a template, and give it to students to trace out a pattern.

Coroplast can be difficult to cut with scissors when it is in a large sheet. We suggest precutting the pieces. Using a carpenter's knife, cut them into 4"x8" pieces. Make sure when you cut the coroplast for the 8" length, you are cutting across the corrugation, not in line with it. Coroplast has many "channels," and those channels will be used as axle holders for the wheels.



Vocabulary

Here are some important vocabulary for students to understand as they work through the activities.

Sailboat terms

sail

The sheet that catches the wind.

mast

A tall vertical pole that supports the sails.

hull

The boat base.

bow

Front of the boat.

stern

Back of the boat.

Car terms

chassis

The base frame of a car.

wheel

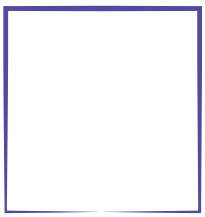
The round part connected to the axle that allows the car to move.

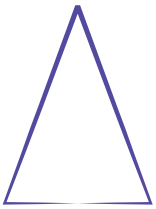
axle

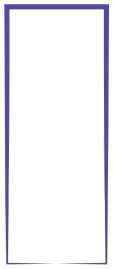
The central shaft for a rotating wheel.

Sail Car Testing Variables

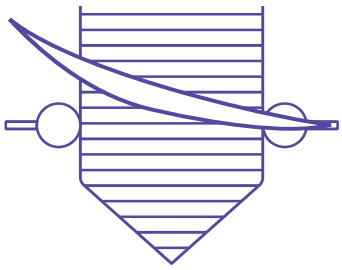
Sail Shapes

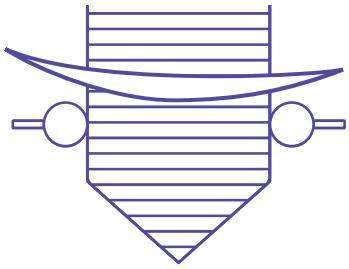




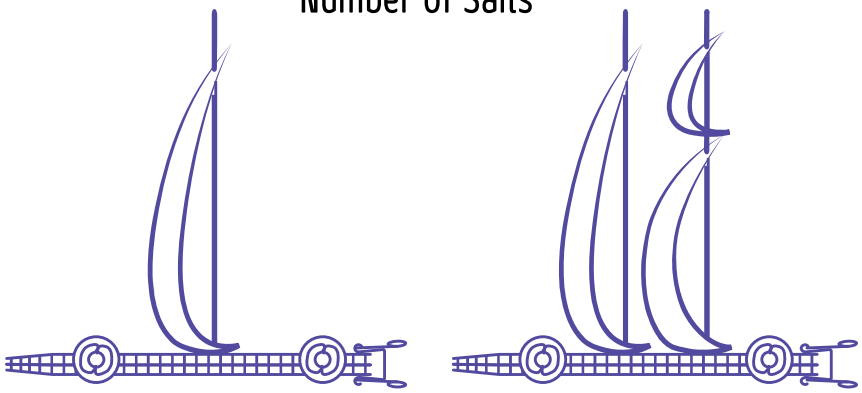


Angle of Sails

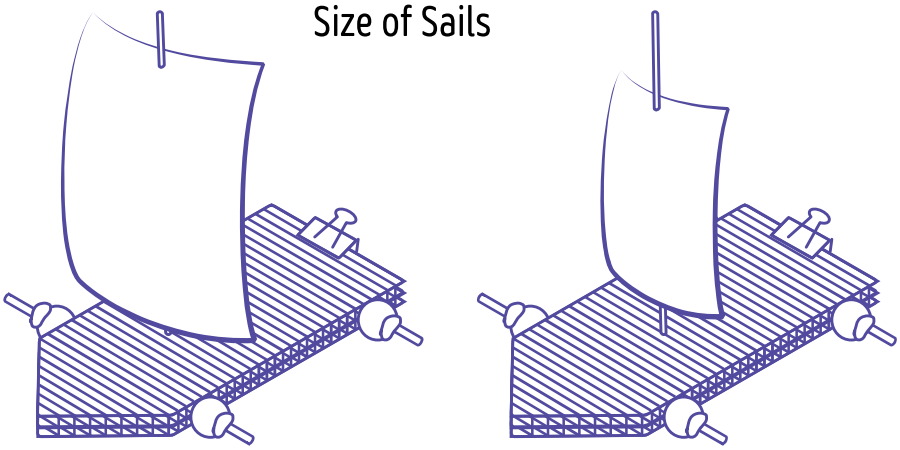




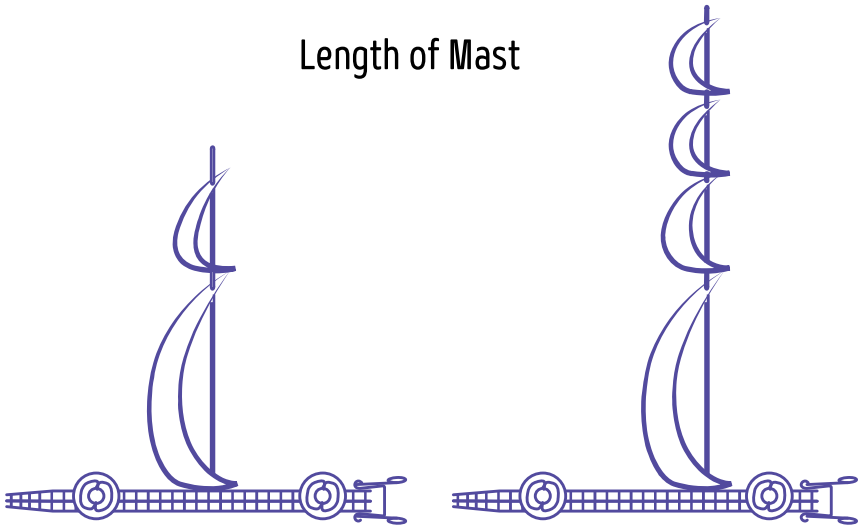
Number of Sails



Size of Sails

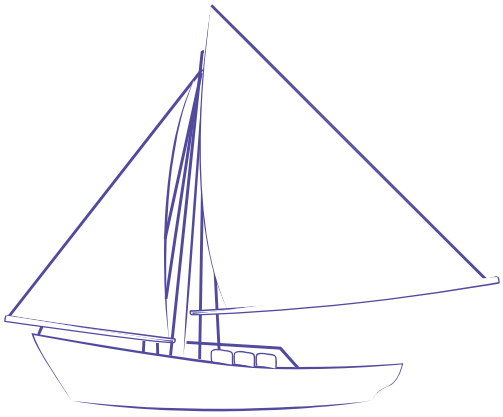


Length of Mast

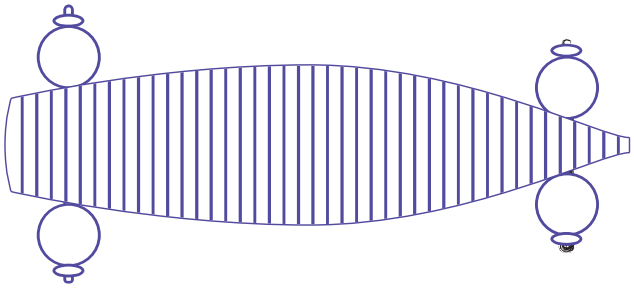


Hull Examples

Pirate Ship Hull

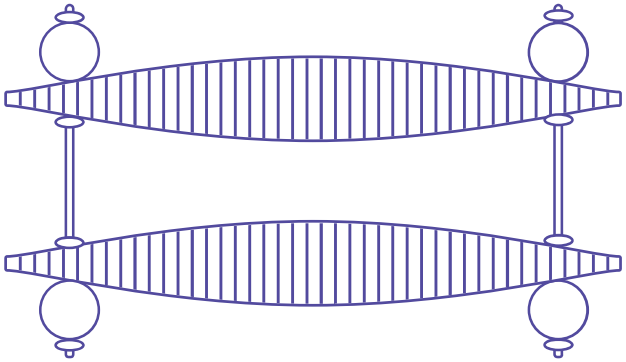


- More hull area allows for more sails

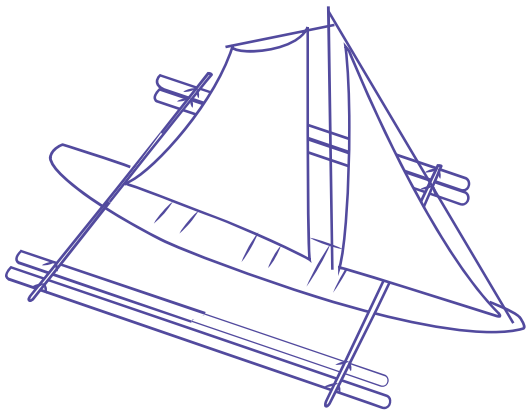


Polynesian Canoe

- Double hull for stability



Paraw (Outrigger)



- Outriggers allow more stability