WATERCRAFT

CHALLENGE 1
LEADER NOTES

The Challenge
Build a boat that can hold 25 pennies for at least ten seconds before sinking.

In this challenge, kids follow the design process to build a boat that can stay afloat and upright while weighed down with a heavy load of pennies. (If metal washers are easier to get, use 15 metal washers [one inch in diameter] instead of 25 pennies.)

1 **Introduce the challenge** (5 minutes)
Begin by telling kids the challenge. Then get them thinking about why things float. Ask:

- If you take two empty, *capped* soda bottles—one big and one small—and push them underwater, which one will be harder to keep down? (*The big one*) Why? (*Both bottles displace [i.e., push aside] some water. The displaced water pushes back on the bottles. The upward push of the water on an object gets bigger as more water is displaced. The big bottle displaces more water than the small one does. So there's more force pushing it up, and it floats better.*)
- Tell kids that buoyancy is the term for describing the force pushing back up on the bottle. The more **buoyancy** something has, the higher it floats in the water.
- How can you make a boat that's very buoyant? (*Make sure it displaces a lot of water.*)

2 **Brainstorm and design** (10 minutes)
Show kids the materials and ask, "What kinds of boats can you make using these materials? How can you design them to carry a heavy load?" After discussing their ideas, have them sketch their designs on a piece of paper or in their design notebooks.

3 **Build, test, evaluate, and redesign** (35 minutes)
Distribute the challenge sheet and have kids begin building. If any of the following issues come up, ask kids questions to get them thinking about how they might solve their problems.

- The boat doesn't float well. *Increase its buoyancy by making its interior space bigger (i.e., making a very wide boat with high sides). Or trap a lot of air in the straws, cups, or frame used to build the boat.*
- The boat leaks. *See if the straws are filling with water. If so, use tape to seal them. Also, check the plastic wrap. Press it tightly or use tape to form a watertight barrier.*
- The boat tips and takes on water. *Make sure the weight is well distributed—spread it evenly across the bottom. Also, a boat can tip when the load is up high. Place the pennies in the lowest part of the boat. Or build a boat with a V-shaped (i.e., triangular) hull, which is generally a more stable design than a flat-bottomed boat.*
- The boat can't support 25 pennies. *Increase its buoyancy by increasing its size and depth.*

DESIGN SQUAD

SHOW KIDS THE RELATED TV EPISODE

Photo: Helen Tsai

In Watercraft, kids figure out how to carry a heavy load in a boat. Show them the PVC Kayak episode in which *Design Squad* teams compete to build kayaks that the team members can maneuver around a slalom course. Get it online at pbs.org/designsquad.

Photo: Lauren Feinberg

Encourage kids to come up with several ways of solving a problem before they move ahead with one idea.

- Someone's design just isn't working. *Suggest making a different kind of boat. With these materials, kids can make platform boats and open boats. Make a platform boat by taping straws together to form a floating platform. Make an open boat by covering a frame of straws with plastic wrap. The open boat design generally supports a heavier load.*

4 Discuss what happened (10 minutes)

Have kids talk about their designs and how they solved any problems that came up. Emphasize the key themes in this challenge—buoyancy and supporting a load—by asking questions such as:

- What are some things that all the boats have in common? (*They float by displacing water, are waterproof, stay upright when floating, and carry a load.*)
- Which held more pennies, a platform raft or a boat built over a frame? (*Generally, a boat built over a frame will hold more pennies than a similar-sized platform of straws will. Its hull displaces more water before starting to sink; it is therefore more buoyant.*)
- How did knowing about buoyancy influence the design of your boat? (*In general, the more water that a boat can displace, the more weight it can support.*)

Photo: Lauren Feinberg

Have kids test the buoyancy of their boats by carefully loading them with pennies or washers.

FOR EVENTS

- Draw kids into your area by asking, "Can you build an unsinkable boat?"
- Kids may be tempted to make huge rafts out of straws or to use large quantities of plastic wrap to waterproof their boats. Limit materials to those listed on the activity sheet unless someone gives good reasons for needing more.
- Provide one container of water per five kids.
- Keep the supply of pennies in the testing area. Kids only need them when they're testing.
- Have towels on hand to mop up spills.

To determine how many materials you'll need for different-sized events, for information on obtaining large quantities of materials, and for other general event tips, see page 7.

Photo: Lauren Feinberg

A boat that can displace a lot of water can support a lot of weight.

WATERCRAFT

DESIGN SQUAD™ PBS®

as built on TV™

pbs.org/designsquad

YOUR CHALLENGE

Design and build a boat out of straws and plastic wrap that can hold 25 pennies for at least ten seconds before sinking.

BRAINSTORM & DESIGN

Look at your materials and think about the questions below. Then sketch your ideas on a piece of paper or in your design notebook.

1. How will you make a boat that floats well enough to support a heavy load without sinking?
2. Should your boat be a platform (e.g., a raft or barge) or an open boat (e.g., a rowboat or canoe)?
3. What's the best way to make your boat waterproof?
4. How big do you need to make your boat to hold 25 pennies?

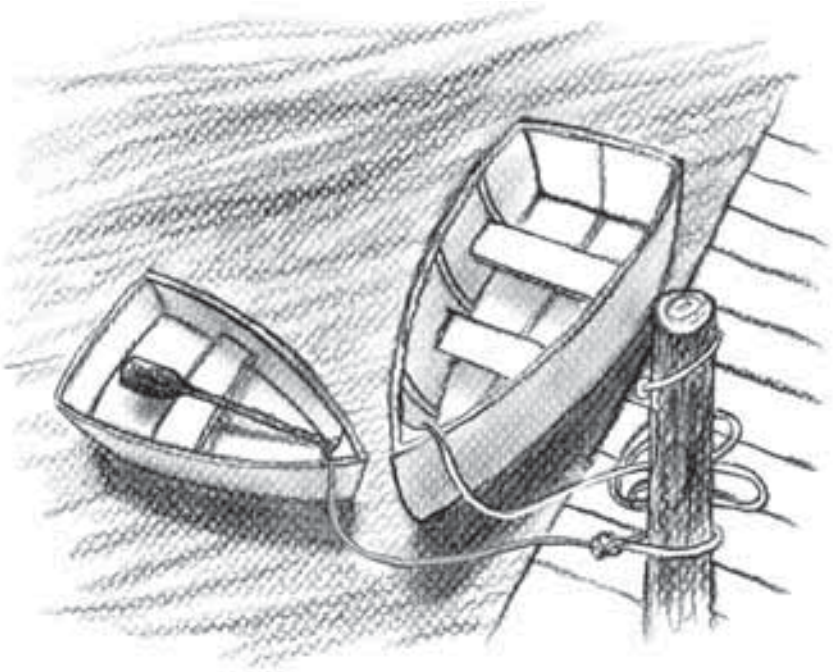
MATERIALS (per person)

- container filled with water (e.g., bucket, sink, plastic tub)
- duct tape
- paper cups (8-ounce or larger)
- 10-inch strip of plastic wrap
- 10 straws
- towels (paper or cloth)
- 25 pennies (or 15 standard, flat steel washers, at least 1 inch in diameter)

BUILD, TEST, EVALUATE & REDESIGN

Use the materials to build your boat. Then test it by floating it in a container of water and adding pennies, one at a time. When you test, your design may not work as planned. When engineers solve a problem, they try different ideas, learn from mistakes, and try again. The steps they use to arrive at a solution is called the ***design process.*** Study the problems and then redesign. For example, if the boat:

- sinks easily—*Increase its ability to float. When you set your boat in water, notice how it sinks down a bit, pushing aside some water. The water pushes right back, pressing on the boat's bottom and sides. The force from these pushes is called* ***buoyancy****. To change your boat's buoyancy, experiment with the boat's width and the height of its sides.*
- leaks a lot—*See if the straws are filling with water or if the plastic wrap is separating.*
- tips easily—*Check how near the weights are to each other. A boat can get tippy when one part is heavier than another.*



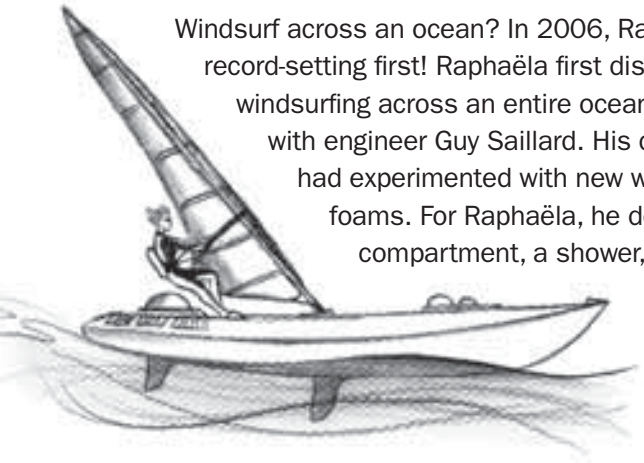
TAKE IT TO THE NEXT LEVEL

- Ready for some heavy lifting? Change your boat so it holds 50 pennies for at least ten seconds before sinking.
- Less is more! Build another boat that can hold 25 pennies, but use only half the amount of materials that you used for your first boat.

MAKE IT ONLINE

Underwater boat?
Build a self-propelled submarine out of 2 soda bottles, a rubber band, and 2 paper clips. See how on Make Magazine's project page at makezine.com/designsquad.

ENGINEERING IN ACTION



Windsurf across an ocean? In 2006, Raphaëla le Gouvello windsurfed 3,541 miles across the Indian Ocean—a record-setting first! Raphaëla first discovered windsurfing while on a family vacation. Soon, the idea of windsurfing across an entire ocean caught her imagination. To turn her dream into reality, she teamed up with engineer Guy Saillard. His challenge was to make her a sailboard she could live on. For years, Guy had experimented with new ways to use durable hi-tech materials such as epoxy resin, carbon fiber, and foams. For Raphaëla, he designed a strong, lightweight, 25-foot-long sailboard. It has a sleeping compartment, a shower, and its own satellite communication system—all the comforts of home. Or not! The cabin was only 8 feet long, 20 inches wide, and 31 inches high (slightly bigger than a coffin). If an engineer could build you the boat of your dreams, would you want to take a trip like Raphaëla's? Here's a snapshot:

- **Length of trip:** Two months.
- **Time sailed each day:** Seven hours.
- **Time spent sleeping:** Seven hours.
- **Weight of her first-aid kit:** 26 pounds.
- **Other things she did each day:** Send e-mail, check her course, get weather reports, talk to her support team by radio, relax, and make and eat meals.
- **Amount of water she used per shower:** A half gallon. The average shower in the US uses 18 gallons! Her boat only holds five gallons, but it has a solar-powered device that makes fresh water by taking the salt out of seawater.

DESIGN SQUAD PBS

Watch the DESIGN SQUAD PVC Kayak episode on PBS or online at pbs.org/designsquad.

cpb intel Education NCEES National Council of Examiners for Engineering and Surveying NOYCE FOUNDATION NORTHROP GRUMMAN Foundation IEEE

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