

Activity 3:

Water Wedges

Overview

Participants consider how a simple machine, a wedge, can be used to push materials apart — and apply the concept to creating a model boat. In small groups, they construct and test two types of boats — such as a raft and another with a bow to serve as a wedge — to see which would move faster through the water during a race at a community park.

Activity Time:

30 to 45 minutes

Intended Audience:

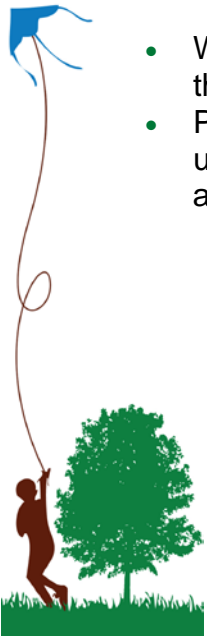
Families or other mixed-age groups, including children ages 4–7
with assistance from an older child, teen, or adult

School-aged children ages 8–9

Tweens up to about age 14

What's the Point?

- Wedges are a type of simple machine that can be used to push things apart — the bow of a boat is one fun example that is found at a park!
- Participating children, tweens, and adults, like engineers, can create and improve upon a model boat through the creative process of thinking, building, testing . . . and doing it again!



Materials

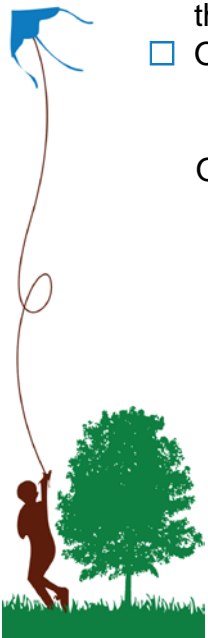
For the Facilitator

- Implementation Guide* (available at www.starnetlibraries.org), which includes:
 - Playful Building's* key features
 - Annotated facilitation outline
 - Facilitator background information
 - Shopping list
 - Extended supporting media suggestions
 - Correlations to National Science Education Standards
 - Contact information
 - STAR_Net project overview
 - Credits and acknowledgments
- Brief Facilitation Outline* page
- Supplies for preparing empty, reused containers:
 - 1 pair of rubber gloves (and any other desired safety gear)
 - 1 (1-gallon) bucket or bowl filled with very warm water
 - 1 tablespoon bleach
 - Scissors
- 1 jar of blue or green glitter
- Optional: 1 (~6"-wide) stainless steel strainer with a fine mesh
- Playful Building* PowerPoint presentation (or the instruction slides printed for the groups to use) (available at www.starnetlibraries.org)

Facility Needs

- Access to water
- 3 or more tables
- Optional: 15–20 chairs arranged at the table(s) for groups or families to sit together while they fold paper
- Optional: computer, speakers, projector, projection screen, and access to the Internet
- Optional: a writing surface where the groups may sketch and write, such as:

<input type="checkbox"/> 1 white board	AND	<input type="checkbox"/> 4–8 dry-erase or other appropriate low- or no-odor markers
OR		
<input type="checkbox"/> 2–4 (~36" x 48") pieces of butcher paper, posted on the wall or used to cover the tables		OR
		<input type="checkbox"/> 4–8 crayons
OR		
<input type="checkbox"/> 5 or more sheets of poster paper		



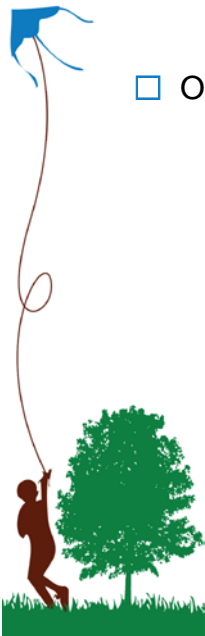
For Each Small Group of 3-4 Participants

- A choice of materials for making a boat with a bow:
 - 1 (pint- or quart-sized) clean, empty cardboard milk or juice carton (with a “pointed” top)
 - 2–4 (8½" × 11") sheets of glossy paper (recycled flyers or small posters work well) (*recommended for use with ages 9 and up*)
- AND 1 box cutter for an adult helper to use

Facilitator’s Note: Glossy paper will last longer in water than regular paper, but it will still need to be replaced after each use.

- A selection of materials for making a boat without a bow, such as
 - 1 aluminum pie pan
 - 1 (1' × 1') sheet of aluminum foil
 - 1 (1' × 1') sheet of bubble wrap
 - 2 Ziploc® sandwich bags
 - A variety of clean, empty reused containers:
 - 1 (8-oz.) water bottle
 - 1 small Styrofoam container (e.g., a clamshell or cup)
 - 12–24 drinking straws, all of one color, cut in half

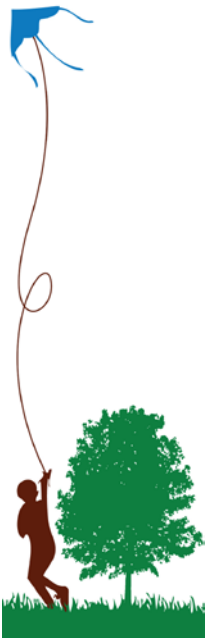
Facilitator’s Note: Children become distracted with creating color patterns or rainbows with their rafts if multiple colors of straws are available. Since the boat without a bow is unlikely to be the most successful design, redirect that creativity to the engineering design process instead. Offer additional time at the end for children to decorate their most successful designs.



- 2–4 (~9" × 12") sheets of plastic wrap (*recommended for use with ages 9 and up*)
- Optional: a selection of materials to build sails and/or balloon “motors”:
 - 1 sheet of construction paper
 - 1 (4" or 6" square) piece of fabric
 - 1 skewer, dowel, or other stick
 - 1 balloon
 - 1 clean, reused plastic grocery bag

For an Audience of 15-20 to Share

- 1 (8½" x 11") *Be Creative...Be an Engineer!* poster (for tweens, teens, and adult helpers)
- 3 (9" x 13" or larger) pans or plastic tubs each filled with water to at least about 2" deep OR 1 wading pool filled with water to at least about 2" deep
- 6 pairs of safety scissors
- 6 rolls of Scotch tape
- 6 rolls of masking tape
- 6 rolls of packing tape
- 6 rolls of duct tape (in fun colors, if possible)
- 6 rolls of string
- 6 staplers (for a teen or adult helper to use)
- 1 roll of paper towels
- Optional: 6 (4- or 6-oz.) containers of Play-Doh (for holding parts in place)



Supporting Media

Consider setting up a digital media player (such as a computer), speakers, and access to the Internet to display videos, images, podcasts, or websites before, during, or after the activity.

A more extensive list is included in the *Implementation Guide*.

Online Resources

Watch the related episodes of **Design Squad**, available in full at pbskids.org/designsquad:

“PVC Kayak,” Episode 202, **Design Squad**. PBS. WGBH Educational Foundation

“Aquatic Robotics,” Episode 208, **Design Squad**. PBS. WGBH Educational Foundation

“How to Make a Paper Boat,” edited by user Brigitta M. and others at www.wikihow.com/Make-a-Paper-Boat

“How to Make a Paper Boat, origami,” uploaded by user guainfantilUS at www.youtube.com/watch?v=hiAWx8odStA

Grand Challenges for Engineering

www.nae.edu/Activities/Projects/grand-challenges-project/Videos_grandchallenges.aspx

“Build your Dream”

“Joy of Living”

Books

Easy Origami

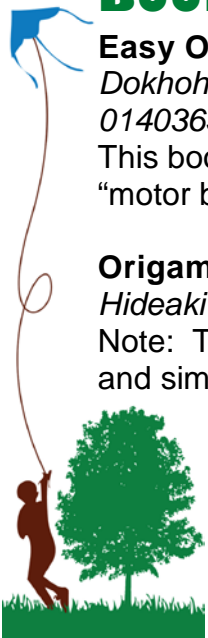
Dokhohtei Nakano (translated by Eric Kenneway), Puffin, 1994, ISBN-13: 978-0140365252

This book provides instructions for two boats with bows, a “floating boat” and “motor boat.”

Origami

Hideaki Sakata, Japan Publications Trading, 1984, ISBN-13: 978-0870405808

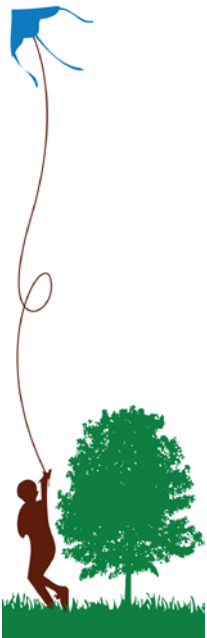
Note: This book is out of print, but is recommended if available. Its colorful photographs and simple directions are excellent for beginners.



“Project 1: Rocket Boat” from **Rocket Science: 50 Flying, Floating, Flipping, Spinning Gadgets Kids Create Themselves**

Jim Wiese, John Wiley & Sons, Inc., 1995, ISBN: 9780471113577

Wiese provides instructions for the children, and when necessary, their adult helpers.
Appropriate for ages 9 and up.



Preparation and Cleanup Tips

Before the day of the activity

- Use the *Implementation Guide* to determine the setup of your engineering program(s), organize and prepare your presentation, and help you collect the materials.
- Prepare publicity materials for these or any other future engineering and technology events.
- Optional: Incorporate the *Playful Building* PowerPoint presentation into your facilitation plan. Modify the presentation to suit your needs.
- Collect and prepare materials that are appropriate for your target audience. Children ages 4 and up (with assistance until about age 9) can create boats using cardboard milk or juice cartons, aluminum pie pans, aluminum foil, bubble wrap, sandwich bags, and various clean, empty reused containers. Origami boat folding is recommended for ages 9 and up, since the folds require care and patience. (Younger children may also participate if an older child or adult does most of the folding.) Plastic wrap is recommended for ages 9 and up, since it can be challenging to work with (but effective for making boats water resistant!).
 - Clean recycled containers using a dilute bleach solution.
 - Optional: Identify instructions for folding origami boats.

Facilitator's Note: Since people learn best when they are able to use multiple senses, provide origami-folding instructions both orally (from a facilitator or online video tutorial) and in print (from books or text and images online). If you use an online video tutorial, view the video in full before the event to ensure that the instructor provides clear instructions at a pace that even novice paper folders can keep up with.

- Make model boats, one with a bow and one without, to get an idea of how they can be constructed. Practice folding origami boats.

Facilitator's Note: This activity is intentionally open-ended to encourage creativity; the following are a few examples of how boats can be constructed from the materials listed here.

Raft

1. Attach inflated sandwich bags to an aluminum pie pan (to add buoyancy).

OR

1. Cut 6 straws in half. Place the 12 straw pieces parallel to each other on a sheet of plastic wrap.
2. Wrap the entire group of straws with plastic wrap to form a flat layer so that water cannot enter the straws.



3. Secure the wrapping with tape.

Boat with a bow

1. Fold one sheet of glossy paper into an origami boat using the instructions provided in an online tutorial or origami book.

OR

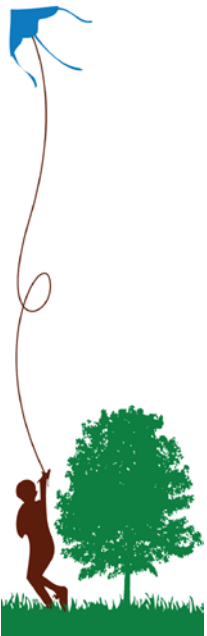
1. Set a milk or juice carton on its side on a flat surface (oriented so that the boat will have a wedge-shaped front).
2. Use the box scissors to cut out a rectangle from one side so the remaining three sides form the hull (an adult helper can do this for the children).

The day of the activity

- Set up the facility.
- Set out the materials. Reserve the materials to build sails and/or balloon “motors” until step eight during the activity:
- Print the *Brief Facilitation Outline* page, which integrates the steps of the activity with the annotated facilitation outline presented in the *Implementation Guide*, to use as presentation notes.
- Provide access to any supporting media and the *Playful Building* PowerPoint presentation (or printed copies of the instructions slides for this activity).
- Set out the *Be Creative* poster (or hang it on a nearby wall).
- Sprinkle glitter on the water’s surface in the pans, tubs, or wading pool to make the water movements easier to see.

Cleanup

- Dispose of the water by pouring it through the stainless steel strainer to capture the glitter (perhaps for reuse).



Activity

1. Ask questions about what the participants know about wedges and the ways they are used to facilitate a conversation about the following points:
 - Wedges are often used to push things apart.
 - Wedges have a big (wide) end and a small (narrow) end. Pushing on the bigger end causes an even bigger push (force) on the smaller end in front, pushing the material apart.

Facilitator's Note:

How does a wedge work? Consider the bow of a boat being propelled through water. The force of the propeller is transferred to the bow, where it is a larger force because the bow is smaller. The bow passes that force on to the water it touches — as two forces pushing away, perpendicular to the sides of the bow. Those forces push the water apart, allowing the boat to move forward more easily.

Credit: Lunar and Planetary Institute



- Wedges help us:
 - Build our homes and other buildings — and maintain them (nails, axes, and saw)
 - Eat (incisor teeth, knives, and the edges of forks used for cutting).
 - Have fun!
 - The wedge-shaped noses of model airplanes cut through the air as they fly.
 - The bows of boats cut through the water as they move.

Optional: Use the supporting media to explore how tweens undertake watercraft design challenges and engineers use cutting-edge watercraft design to explore oceans.



- Challenge the participants, working in groups, to think about and build two types of boats — a boat *without* a bow (such as a raft or other boat with a squared or rounded front edge) and another *with* a bow (with a triangular-shaped front edge) to serve as a wedge — then test them to see which design would move faster through the water during a race. Allow time for questions.

Facilitator's Note: Two types of boats are compared in this activity to help the children visualize how a wedge can be used to cut through materials — in this case, the bow of a boat cuts through water.



A raft pushes water along in front of itself.



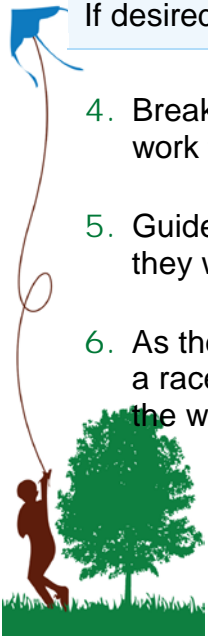
A boat with a bow slices through the water, allowing the boat to move forward more easily.

Glitter floating on the surface of the water allows the children to see how water is pushed aside by the boats as they are moved through the water.

A boat without a bow is fairly simple to design and construct, although young children may need help from an older child or adult. Children ages eight and up (or children as young as six with help) and adults may enjoy the challenge of building an origami boat. Younger children may prefer to use cardboard milk or juice cartons.

If desired, provide model boats for those who are unable or unwilling to build their own.

- Break into groups (with three to four people each) and begin. Encourage each family to work together as a group — parents too!
- Guide the children through the initial engineering design process of think and build as they work.
- As the groups complete their designs, help them test the two types of boats — perhaps as a race! Note how the bows push water aside to help the boat move more easily through the water.

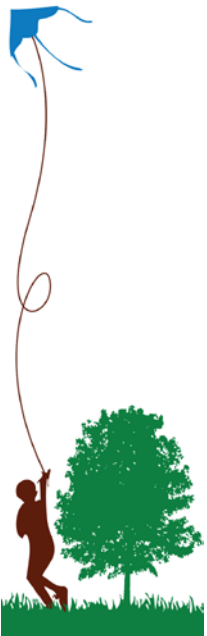


7. Ask the participants to explain which type of model boat, a raft or a boat with a bow, they might build for a race at the community park and why. Listen for explanations that identify the boat with a bow as a better design, since the bow serves as a wedge that cuts through water.
8. Emphasize the engineering design process by having the groups methodically improve one aspect of their boats at a time. Suggest:
 - Adding tape to help keep the boat from becoming waterlogged;
 - Spreading the weight of the materials out (creating a larger surface area) to help the boat float (i.e., be more buoyant); or
 - Using a different material to construct the boat.

Facilitator's Note: As time allows, have the groups change one thing at a time after each test. Adjusting and retesting their ideas is the best way to experience the ongoing work of an engineer! They will be rewarded by seeing improvement.

Reassure the participants that there isn't a "right" answer that they must arrive at on the first try. Furthermore, failure is an essential part of figuring out what works and what doesn't. It is OK to fail — and try again . . . and again . . . and again!

9. Optional: Use additional materials to modify the most successful type (boats with bows) to be sailboats or balloon-powered "motor" boats.
10. Optional: Have each group present their fastest boat design to the entire audience.



Extensions

Build a *Real* Model or Full-Sized Boat

The *Water Wedges* activity introduces some basic experience relating to a simple machine, and a natural outgrowth could be to build and test a model or full-sized boat at an existing park. Consider taking the *Playful Building* module to the next level: Encourage teens and adults to build one or more boats — and perhaps even hold a race!

Additional Activities

Allow additional time, per the instructions provided on these external websites, if incorporating these activities.

“Egg Boat,” **ZOOMsci**, © 1998–2010 WGBH

pbskids.org/zoom/activities/sci/eggboat.html

Children ages 4 and up design and build a boat using aluminum pie pans, plastic bags, and tape. They are challenged to see how many eggs their boats can hold without sinking (young children will need assistance from an older child or adult).

“Soda Bottle Boat,” **ZOOMsci**, © 1998–2010 WGBH

pbskids.org/zoom/activities/sci/sodabottleboat.html

This activity outlines step-by-step instructions for creating a boat (without a bow) from an empty soda bottle that is propelled by a reaction between baking soda and vinegar. Appropriate for use with ages 5 and up (young children will need assistance from an older child or adult).

“Float-a-Boat Challenge,” **Invention at Play**, Smithsonian National Museum of American History

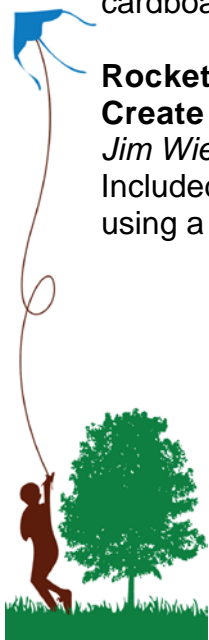
inventionatplay.org/iapfamilyguide.pdf (Family Guide en Español)

Children ages 10 and under, working with an adult, build and test model boats made of cardboard, Bubble Wrap, aluminum foil, and other materials.

Rocket Science: 50 Flying, Floating, Flipping, Spinning Gadgets Kids Create Themselves

Jim Wiese, John Wiley & Sons, Inc., 1995, ISBN: 9780471113577

Included in this book are step-by-step instructions for building a balloon-powered “rocket boat” using a milk carton and balloon. Appropriate for ages 9–12.



“Watercraft: Challenge 1 Leader Notes,” **PBS Design Squad**

pbskids.org/designsquad/pdf/parentseducators/DS_Act_Guide_Lead_Watercraft.pdf

Tweens are challenged to use straws and plastic wrap to build a boat that can stay afloat for 10 seconds — while carrying a load of 25 pennies! Instruction pages for the children are available in English and Spanish. Appropriate for use with ages 9–12.

“Paddle Power: Challenge 4 Leader Notes,” **PBS Design Squad**

pbskids.org/designsquad/pdf/parentseducators/DS_Act_Guide_Lead_PaddlePower.pdf

Tweens are challenged to build a boat (likely without a bow) that uses a rubber band as its power source.

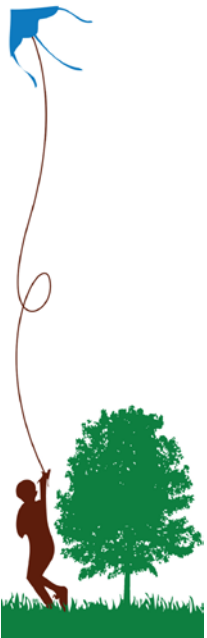
References

This activity was inspired by the following educational materials:

“An Introduction to Simple Machines,” **Pre/Post Activities**, Copyright ©2008 Children’s Museum of Houston.

Engineering: Simple Machines, Integrated Teaching and Learning Program, College of Engineering, University of Colorado at Boulder, ©2005 by Regents of the University of Colorado, www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_simple/cub_simple_lesson01.xml.

“Aztec Artifacts,” **Online Science Activities**, Museum of Science and Industry, Chicago. www.msichicago.org/online-science/activities/activity-detail/activities/simple-machines-build-a-lever/browseactivities/0/



Brief Facilitation Outline

Introduction

- Introduce yourself and the library.
- Frame the activity with the main message: Engineers work to solve the basic challenges of life — including having fun!
- Conversation:
 - Ask open-ended questions about things we need for *enjoyment* in life.
 - Discuss the role of building on others' ideas in engineering.
 - Ask questions about wedges — what they are, how they make it easier to push things apart, and some real-life examples.

Activity

- Use supporting media to explore how tweens and/or professional engineers create and use watercraft (optional).
- Challenge (in groups of 3–4; parents too!): Think about and build two types of boats (one with a bow and one without), and then test them to see which design moves faster.
- Encourage persistence: Successful engineering involves a process of thinking, building, testing . . . and doing it again!
- Emphasize the engineering design process; encourage groups to methodically improve one aspect of their boats at a time. Suggest:
 - Adding tape to help keep the boat from becoming waterlogged,
 - Spreading the weight of the materials out to help the boat float, or
 - Using a different material to construct the boat.
- Use additional materials to modify the most successful type (boats with bows) to be sailboats or balloon-powered “motor” boats (optional).
- Present the fastest boat designs (optional).

Conclusion

- Summarize the groups' explorations of how engineers solve life's challenges.
- Congratulate the groups on their accomplishments.
- Advertise any future engineering and technology events.



Activity Materials to Print



Be Creative...Be an Engineer!

Think, build, test, do it again: That's the process engineers use when they tackle a problem. Engineers don't have official rules telling them to follow this set of steps. But, over time they've learned that they get the best results this way:

They think and brainstorm about a problem and factors they have to consider to solve it. They come up with an idea and build a prototype. They test the prototype. And, then they repeat the process to improve their results.

Engineers often move back and forth within the loop, repeating two steps over and over again before moving forward. It's a key to engineering success.

