GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 1029 | WOODEN BOATS

GREAT LAKES NOW FLOATS MY BOAT

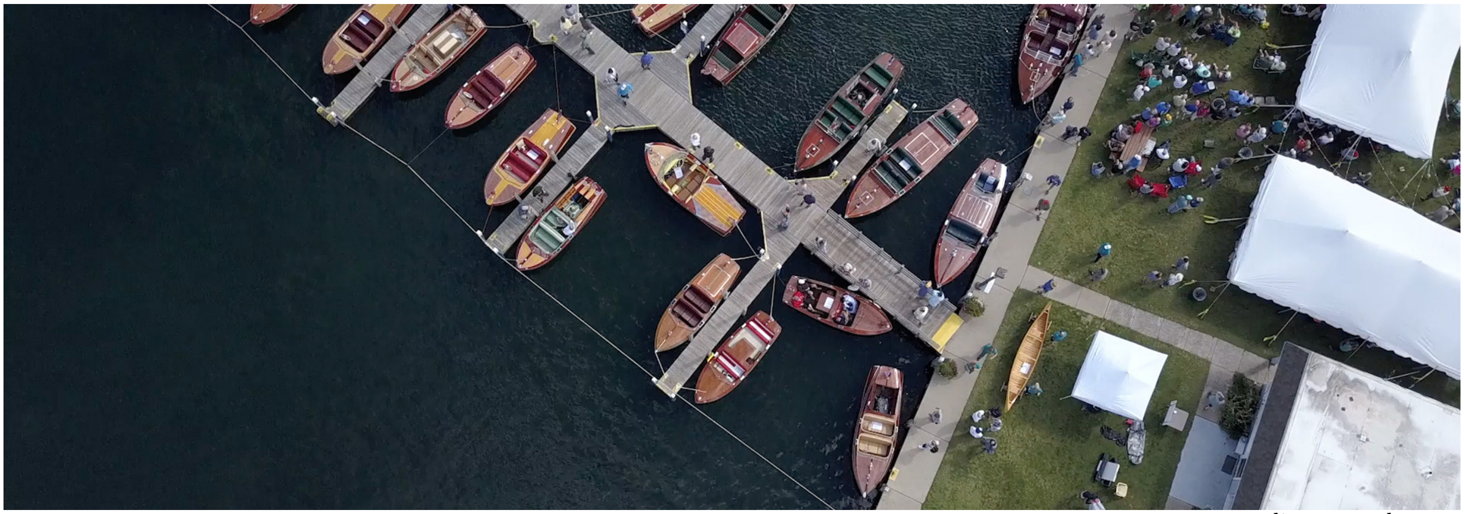


Image Credit: Great Lakes Now

OVERVIEW

This lesson will introduce students to the phenomena of **buoyancy** and **water displacement** by helping them understand why a boat floats, learn about how boats have been made out of various materials—including wood—over the years, and engineer a boat according to certain constraints to hold a certain amount of weight.

LESSON OBJECTIVES

- **Know** how the upward buoyant force that keeps a boat afloat is related to the amount of water displaced
- **Understand** the how the design of a boat helps it to stay afloat and hold weight
- **Be able to** design and build a model boat out of aluminum foil and tape to float in water and hold a specific amount of weight without sinking

WHAT YOU'LL NEED

- Computer or mobile device with Internet access to view video and online resources
- Notebooks and pencils
- Chart paper
- Sticky notes
- Markers
- Aluminum Foil
- Scissors & Tape
- A large bin of water
- Small objects
- Copies of the Student Handouts

INTRODUCTION

In this lesson, students will be introduced to the phenomenon of buoyancy, commonly associated with Archimedes' principle, through the science of boat building as featured in the **Great Lakes Boat Building School**, to understand how boat design utilizes Archimedes' Principle.

They will learn what buoyancy is, understand how boats are built to hold weight on the water, and engage in a design challenge to build a cargo boat.

This lesson includes multiple activities that can span the course of several sessions or be adapted to fit the needs of your group's meeting format.

Some prior knowledge* with which students should be familiar includes:

- Forces and motion
- Measurement
- Mass, volume, and density

Follow this QR Code or hyperlink to the Episode Landing Page!

Check out our online collection of lessons for more activities related to these topics.

*****The sequence of these activities is flexible, and can be rearranged to fit your teaching needs.***

NGSS CONNECTIONS

Phenomenon: Buoyancy

- MS-ETS1-1
- MS-ETS1-2
- PS2.A
- MS-ETS1-3
- MS-ETS1-4

During the course of the lesson, students will progress through the following sequence** of activities:

- Class discussion to elicit or activate prior knowledge
- Teacher notes on Archimedes' Principle and buoyancy
- Close reading a **photo**
- Watch a *Great Lakes Now* segment on wooden boat building
- Class discussion to debrief video
- Create a mini boat out of aluminum foil to hold cargo
- Read about the S.S. Badger Ferry

The lesson progresses through three major sections: **launch, activities, and closure.** After the launch of the lesson sequence, you are ready to begin the lesson activities. Once finished with the activities, students will synthesize their learning in the closure section.

If you use this lesson or any of its activities with your learners, we'd love to hear about it!

Contact us with any feedback or questions at: ***GreatLakesNow@DPTV.org***

TEACHER BACKGROUND INFORMATION

by Great Lakes Now Contributor, Gary G. Abud, Jr.

**This information can be presented by the teacher as notes to students at the teacher's discretion.*

"Any object, wholly or partially immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object."
— *Archimedes of Syracuse, Sicily*

During the 3rd century BC, Greek mathematician Archimedes of Sicily became famous for devising a method to determine the volume of irregular-shaped objects by water displacement—proposing that the volume of water displaced was equal to the volume of the object submerged. Later this became known as Archimedes' Principle.

He later applied this principle to explain how objects were able to float in water and other fluids. Known as the Law of Buoyancy, Archimedes is credited with the idea that the upward buoyant force of a fluid on an object is directly related to the weight of the fluid displaced by that object.

In other words, if an object placed in water displaced 10lbs of water when it was submerged, the water would exert roughly 10lbs of upward force (e.g., the buoyant force) on the object. That means that if the object itself had a weight of 10lbs or less, the water would support its weight and it would float—or be buoyed up—and if the object were heavier than 10lbs, it would sink.

This principle of water displacement as it relates to buoyancy is critical to the design of boats. In order for a boat to float, it must displace a volume of water with a greater weight than the weight of the boat (e.g., force due to gravity) itself; otherwise, it will sink.

If a boat is to hold cargo while it travels on the water, as freighters are designed to do, it must displace an even greater volume of water to provide additional buoyant force that will support the weight of the boat plus its cargo.

This can be illustrated using force diagrams, with arrows representing the forces acting on an object, like a boat.

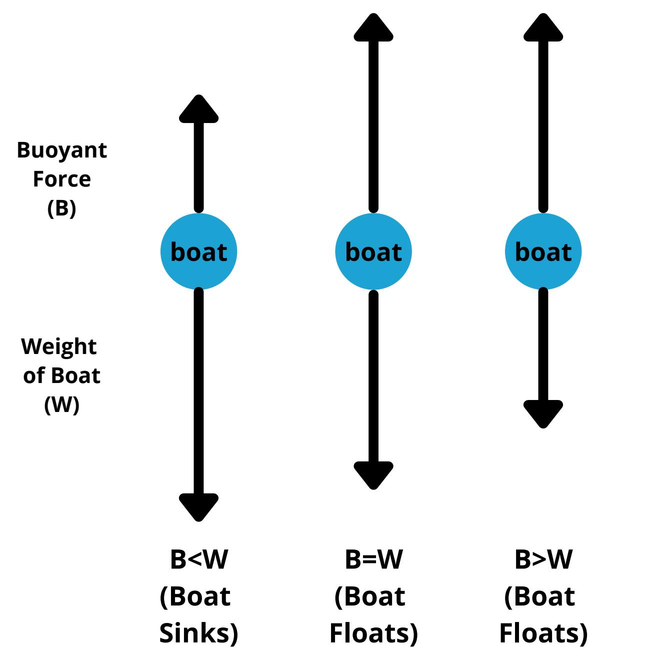


Image Credit: Gary G. Abud, Jr.

Calculating the total volume of a boat from its dimensions will give the maximum amount of water volume it could displace before sinking. Half that volume would allow the boat to be halfway submerged while floating.

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities.

1. Begin by asking students to call to mind a time when they saw a boat floating on the water, or were in a boat on the water themselves.
2. Have students describe what they noticed about how the boat moved in the water.
3. If it doesn't come up, prompt students to consider the forces acting on the boat by asking them what allowed the boat to stay afloat.
4. To introduce the concept of water displacement, ask students to consider what happens in a swimming pool when a lot of people are in it versus when it is empty.
5. Call their attention to the rising water level in a pool when people are in it and help them to consider what happens when a boat goes into the water.
6. Draw a progression diagram (e.g., before, during, later) of more and more people in a swimming pool, and make sure to show the water level at each progression.
7. Have students draw what they think would happen to a boat if more and more people got on the boat, showing a progression diagram (e.g., before, during, later) of people on a boat and how the boat will behave.
8. Ask for some volunteers to describe their drawings and have students compare the pool and boat scenario.

Photo Credit: Paul LaMarre III, Courtesy of Great Lakes Now

B. Bridge to Learning

After the warm-up activity has concluded, help students prepare for the learning that is about to come.

1. Ask them to discuss with a partner the following situation:
   a. you put 5lbs of bananas on a hanging scale at the grocery store—what does the scale read?
   b. while the bananas are on the scale, you push up the bottom of the scale with your hand a little—what does the scale read now
   c. you take your hand completely off the scale—what does the scale read now?
2. Ask them to draw a progression diagram in their notebooks to make their thinking visible to each other.
3. Have a few student pairs share out.
4. Draw a summary diagram on for all to see that captures the group consensus of what's happening.

C. Close Reading a Photo

Provide students a copy of any/all of these **Freighter Photos** from *Great Lakes Now* and have them write out 4 sticky notes to answer the following questions with their partner:

1. What do you notice in this image?
2. What do you wonder?
3. How does such a large object stay afloat on the water?
4. How is the boat on the water like the fruit on the scale?

Then, collect and display the stickies for all to see and discuss as a class.

D. Background Information Notes

Explain these photos are of freighters around the Great Lakes and provide students notes about **buoyancy and Archimedes' Principle** from the Teacher Background Information connecting it to the photos.

ACTIVITY 1: WATCH A GREAT LAKES NOW SEGMENT

This activity is a video discussion of a *Great Lakes Now* episode segment.

First, inform students that they will be watching a video from *Great Lakes Now* that discusses the design and building of wooden boats. During the video they need to jot down four things they took away from watching using the **4 Notes Summary Protocol**.

Then, if students are not already familiar, introduce them to the 4 Notes Summary Protocol, which they will use after they finish watching the video, where they write down one of each of the following notes:

- **Oooh!** (something that was interesting)
- **Aaah!** (something that was an ah-ha moment)
- **Hmmm...** (something that left them wanting to know more)
- **Huh?** (a question they have afterward)

Next, have students watch this segment from episode 1029 of *Great Lakes Now* called, **Wooden Boat Building**.

Last, have students complete their individual 4 Notes Summary and then discuss those in groups of 3-4 students.

***Teaching Tip*: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.**

Post-Video Discussion

After the groups have had time to go over their 4 Notes Summaries, invite a handful of students to share out some of their notes, eliciting at least 1-2 of each of the 4 Notes and listing those somewhere for the whole group to see.

Ask students to turn back and talk with their groups to make connections between the video and what they did in the warm up activity, with the discussion of the swimming pool, fruit scale, and photos of freighters, asking them: how is what we saw in the video the same as what we learned earlier in this lesson? How is it different?

After giving the groups some time to talk, bring the whole group back together for a shareout and discussion of ideas.

In this culminating discussion, the goals are to help students make connections between the design and building of wooden boats with the concepts of buoyancy and Archimedes' Principle.

Once the discussion finishes, have each student write a "**Sum It Up**" statement in their notebooks. This is a single sentence that captures the big idea of what was just learned.

Have 2-3 students share out their **Sum It Up** statements before concluding this activity.

ACTIVITY 2: READ ABOUT A CAR FERRY

This activity aims to provide students a better understanding of just how much weight boats can hold when they're able to displace enough water because of the size of their design.

They will read about the S.S. Badger, a car ferry on Lake Michigan that has been in operation for decades moving large cargo between Wisconsin and Michigan across the lake.

In this activity, students will use a **Think Pair Square Protocol** for discussing the article that they will read individually.

First, distribute the article entitled "**SS Badger: The last of Lake Michigan's car ferries**" by Melissa Walsh from *Great Lakes Now*, giving students time individually to read the article, and ask them to jot down 3 things they learned in the article.

Then, have students pair up with a partner to discuss the article and which 3 points they noted from it.

Next, have two student pairs join up, standing near each other to form the four corners of a square, to discuss the article and what they talked about in their pairs.

Last, have each group come up with a summary statement about the most important point from their discussion and ask for a volunteer in each group to share that most important point with the whole group.

As student groups share out their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks.

Inform them that they will be using some of the information from this article and discussion in a later activity to design their own boat to hold cargo.

After the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

How did the structure and function of car ferries change over time?

After giving the groups some time to discuss this question, open up the conversation to the entire class to discuss the merits of different possible solutions for the problem of algal blooms and harmful algal blooms.

Further Reading on the Subject:
An additional article further discussing the Design Thinking Process is included in this lesson as an optional extension activity to for students to read and discuss with one another, again, using the ***Think Pair Square Protocol****.*

***Teaching Tip*: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.**

ACTIVITY 3: ENGINEER A CARGO BOAT

Image Credit: Gary Abud, Jr.

The purpose of this activity is for students to create a boat out of aluminum foil and tape that will hold the most cargo without sinking.

First, inform students that they will be working with their groups to create a boat out of one square foot of aluminum foil and one linear foot of office tape to hold a minimum amount* of cargo (e.g., 500g).

Show them the "cargo" that their boat will need to hold (e.g., pennies, small candies such as M&Ms, dry rice or beans, etc.) and provide them 500g of cargo.

Then, provide students with the supplies to construct their cargo boats (e.g., tape, foil, scissors) with their groups and monitor group activity as students work.

***Teaching Tip**: Encourage students to plan their design according to the principles learned earlier in this lesson before beginning their builds.*

Next, fill a water tank (using a plastic bin, disposable bakeware pan, etc.) for groups to test their boats in. Have students launch their boats on the water and begin adding cargo to them. Students should continue adding cargo until they either reach the minimum amount (e.g., 500g) required for the challenge or their boat sinks. If their boat holds the minimum amount without sinking, they can continue adding more cargo until the boat sinks to see which boat holds the most cargo. Make sure groups measure the maximum amount of cargo that their boat was able to hold before sinking.

Last, engage students in a whole-group discussion about the various designs of boats, how each one fared, and what features of the boat design made for more or less successful cargo holding.

Create a list of the features that the group agrees contributed to a more successful boat design and the ability to hold more cargo. Invite students to make connections between what they learned in this engineering design challenge and how wooden boats and freighters have to be built.

**Inform students that for an added element of challenge, if they pass the minimum cargo test, they may test their boats to failure, measuring the maximum cargo they can hold before sinking to see which boat designs fares best.*

LESSON CLOSURE

After the conclusion of all the activities, help students to make connections* between everything they did in the lesson and what they learned overall by:

A. Compare and Connect

Initiate a discussion with students where you ask them to identify ways in which each activity corresponded to the other activities. This could be in terms of what was done, what was learned, or specific moments of the activities that corresponded with others. Guide students to refer to each other's thinking by asking them to make connections between specific features of the activities and how they all connect to the big ideas of the lesson. Make sure to invite students to connect other students' responses to their own ideas in the discussion.

B. Lesson Synthesis

Give students individual thinking and writing time in their notebooks to synthesize their learning, by jotting down their own reflections using the **Word, Phrase, Sentence Protocol.**

In the Word-Phrase-Sentence Protocol, students write:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

C. Cool Down

After the individual synthesis is complete, students should share their synthesis with a partner.

After sharing their syntheses, have students complete a **3, 2, 1 Review** for the lesson with their partner, recording in their notebooks or, optionally, on exit ticket slips to submit, each of the following:

- **3 things** that they liked or learned
- **2 ideas** that make more sense now
- **1 question** that they were left with

Invite several students to share aloud what they wrote in either the synthesis or 3, 2, 1 Review.

Lastly, ask one student volunteer to summarize what has been heard from the students as a final summary of student learning.

**Optionally here, the teacher can revisit the learning objectives and make connections more explicit for students.*

***Teaching Tip*: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.**

FURTHER READING: DESIGN THINKING

by Great Lakes Now Contributor, Gary G. Abud, Jr.

Whether you're designing wooden boats or engineering freighters to ship cargo on the Great Lakes, a set of thinking and action steps known as **Design Thinking** can power up your ability to solve problems. Though there is no one single definition of all the steps involved, or the sequence in which they are carried out, one thing designers and engineers alike agree on is that Design Thinking is a process.

There are four main aspects of the process:

1. **understanding a situation and a user's needs**
2. **defining the problem and possible solutions**
3. **prototyping and testing**
4. **reflecting on feedback to refine solutions**

The Henry Ford Learning Institute defines the Design Thinking process as "a collection of mindsets that enable/allow us to explore problems creatively, then reframe and act on them." (hfli.org/approach)

It all starts with observing a particular situation and noticing a problem that needs to be addressed. You can observe human activity, the function of objects, or even entire systems. Understanding the gap between what currently is happening and what's possible is what starts the Design Thinking process.

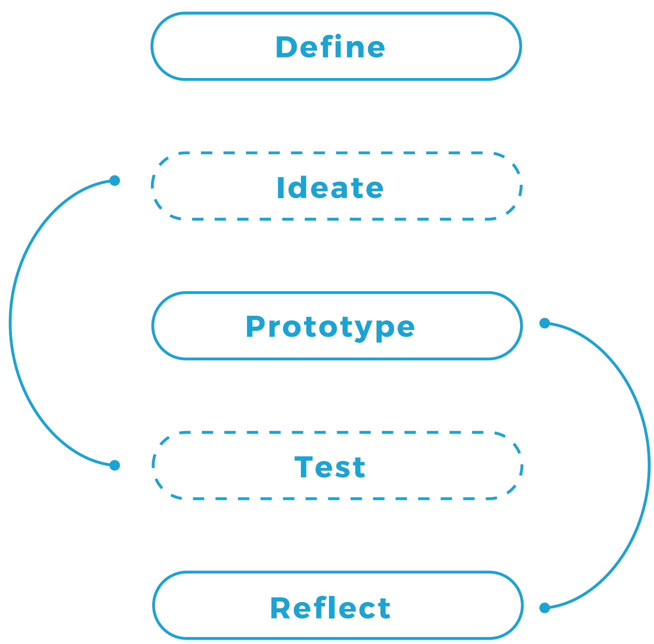
Take for example observing your grandma have difficulty using cooking utensils because of arthritis. You might wonder: "how might I design utensils that can be used by my grandma with arthritis who loves to cook?" Crafting a user-insight statement like this can help define the problem and inform solutions.

Next, it's time to ideate, or generate possible solutions. In this brainstorming step, all ideas for solutions are considered equally possible. Narrowing down the list from what's possible to what's doable comes later, and that's based on any constraints, like cost, to the given situation or to potential solutions.

Image Credit: James Proffitt, Courtesy of Great Lakes Now

Once you've whittled down the list to a winning idea, it's time to create a prototype and put it to the test. After trying out the solution, you're bound to get feedback on how well it works. That will allow you to reflect on your design and refine it to improve your solution. As the process cycles back on itself, new prototypes, more testing, and further feedback and refinement come about until you've got a ready-to-use solution to the problem.

While some problems are more obvious than others, Design Thinking can help make the process of reaching a solution easier to manage and achieve. That's why some of the most notable designers in the world—like the OXO company, creators of Good Grips kitchen utensils—use this very process. Ultimately, designing solutions with people in mind makes for the best motivation to solve problems and create innovative solutions.



Design Thinking Process, Image Credit: Gary G. Abud, Jr.

NAME: ______________________

A Word, Phrase, Sentence Protocol

What is a **word** that you thought was most important from this lesson?

What is a **phrase** that you would like to remember from this lesson?

What is a **sentence** that sums up what you learned in this lesson?

3, 2, 1 Review Protocol

What are **3 things that you liked or learned** from this lesson's activities?

-
-
-

What are **2 ideas that make more sense** now to you?

-
-

What is **1 question that you were left with** after this lesson?

-

NAME: ______________________

4 Notes Summary Protocol

OOOH!

Something that was interesting to you

AAAH!

Something that became clearer; an "ah-ha" moment

HMMM...

Something that left you wanting to learn more

HUH?

Something you questioned or wondered

Sum It Up Statement:

Summarize your group discussion about your 4 Notes Summaries below:

NAME: ______________________

Think Pair Square Protocol

THINK

Write down your own individual ideas

PAIR

Summarize what you and your partner discussed

SQUARE

Summarize what your group discussed