GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2203 | SAILING ON ICE

SAILING CLOSE TO THE WINTER WIND

Image Credit: Great Lakes Now

OVERVIEW

This lesson will explore the phenomenon of **wind** in the winter through the pastime of ice boating to learn about the science behind how winds are produced, sailboats move, and how wind can be a renewable source of energy. Learners will engage in design projects to build a wind-powered sail cart, anemometer, and windmill.

LESSON OBJECTIVES

- **Know** about the pastime of ice boating and how the boats utilize the wind to move
- **Understand** how to measure wind speed and how an anemometer works
- **Be able to** engineer a wind-powered sail cart to compete in a race against peers

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
- Project supplies (see individual activities for a full list)
- Copies of the Student Handouts

INTRODUCTION

In this lesson, students will be introduced to the phenomenon of **wind** and how the horizontal movement of air can generate energy, move ice boats on the Great Lakes, or spin an anemometer so that it can measure the wind speed.

They will learn about how winds are produced and can move objects like boats through molecular collisions. They will also learn about how the winds differ in colder-weather months from warmer seasons. They will apply their learning through designing projects that use wind to power them.

This lesson includes multiple activities, including engineering and design projects, 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:

- Speed, time, and distance
- Measurement
- Temperature and states of matter
- Energy and energy transfer

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

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

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

NGSS CONNECTIONS

Phenomenon: Wind

- 4-ESS3-1
- 4-PS3-1.
- SEP-1
- SEP-2
- MS-ESS2-5
- HS-PS3-3
- SEP-5

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 wind
- Close reading a **video** on the jet stream
- Watch a *Great Lakes Now* segment on **ice boating** around the Great Lakes
- Class discussion to debrief video
- Read about **what it's like to sail across Lake Superior**
- Build a functional anemometer to measure wind speed
- Engineer a wind-powered sail cart to race against peers
- Design a windmill to do a work task

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

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.*

What we call **wind** is simply the horizontal movement of a mass of air. Typically, air that is in a more compact area (at a **higher pressure**) spreads out into an area that has more space (at a **lower pressure**). This motion is what we observe as wind. It's based on the temperature and density of the particles in the air.

As some air is heated by sunlight, for example, the molecules in the air move faster and start to spread out. Then, the hot air rises and displaces the cooler more compact air, causing it to sink underneath the hot air. This rising-and-sinking pattern of motion is called a **convection current** and is one way that winds are produced. Landforms and bodies of water can also affect air temperature and generate winds.

As the moving molecules in the air collide with surfaces, the **collisions** can cause the motion of other objects, such as what occurs with the sail of a boat or windmill. Using measurements of time and distance one can calculate the speed of a moving object, e.g., how many meters a boat moves per second would be its speed.

However, since we cannot see the wind itself, but we can see the things that the wind moves, we have to measure wind speed indirectly by gauging the speed of an object that the wind has moved. Wind speed is measured with a tool called an **anemometer.** This weather instrument spins as the wind pushes it. The faster the wind is blowing, the quicker it spins,

Calculating the circumference of the anemometer (its diameter multiplied by 3.14, π) allows one to know the distance it moves every time it spins around once. By timing the number of spins, say in a ten-second interval, and then finding the unit rate of spins per second, you can use the anemometer to indirectly determine **wind speed**.

Just as an anemometer rotates as the wind pushes it, a special type of windmill, called a **wind turbine**, spins as the wind blows nearby. The curved blades of the turbine, which look like a giant airplane propeller, are attached to a large central rod that has a **generator** connected to it. Just like gasoline-fueled generators that power homes when storms knock out electricity, wind turbine generators generate electricity as they spin. The resulting electricity is transferred through wires to provide power. Show **this video from Michigan Learning Channel** and **this video from NOVA** to see how wind turbines work.

Since the molecules in the air are constantly moving all over the world, wind is a **renewable resource**—a means of generating electricity that doesn't deplete. And since generating energy from wind doesn't produce carbon emissions, it is thus a "clean" source of energy.

Just as a wind turbine or windmill can be rotated by the moving air, a sailboat can be moved horizontally across the water by wind. Several forces are involved in the motion of a sailboat: the **weight** of the boat downward due to gravity, **buoyancy** upward from the water, **thrust** from the wind in the direction it blows, and **drag** against the direction of motion from resistance by the water or air friction. The combination of these forces, along with the angle of the sail, affect the motion of the boat. **This video from PBS LearningMedia and DragonflyTV** show how wind direction and boat angle both affect sailboat speed.

In contrast to traditional sailboats, ice boats glide along the surface of the ice rather than being partially submerged under liquid water. The lower **friction** provides less drag, and thus ice boats can travel much more quickly. What is more is that in the winter, higher altitude wind bands, called the **jet stream**, shift further south, making wintertime windier than the summer months. Stronger winds mean better ice boating.

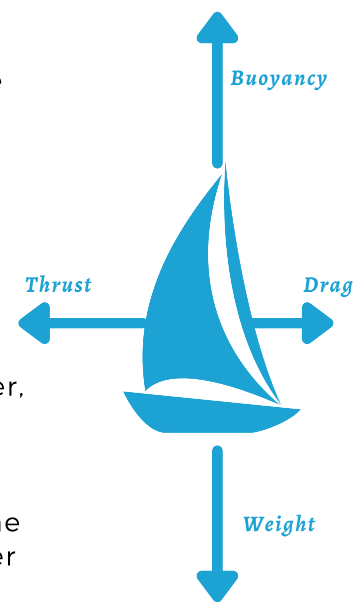


Image Credit: Gary Abud, Jr.

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities. **Note: you will need to obtain a paper sky lantern for this warm up.*

1. Before beginning the the warm up, have an unlit paper sky lantern out for students to see. This lantern behaves like a miniature hot air balloon.
2. Ask students to observe the lantern before its candle is lit—list out what they notice.
3. Now, ask them to turn and talk with a partner to compare the temperature of the air in the room to the temperature of the air inside of the unlit paper lantern.
4. Show students that the paper lantern falls when you release it from your hand.
5. Light the candle on the paper lantern and ask students to observe what happens.
6. Let them share things they notice as the lantern floats, rises, and moves.
7. Have them turn and talk with a partner about how the temperature of the air in the room compares now to the air temperature of lit paper lantern.
8. Guide them to make connections between the hotter air containing faster moving particles and spreading out to inflate the lantern, all before the lantern floated.
9. Explain that, because the hotter air spread out, it became less dense and thus floats to the top of the colder room temperature air like oil floats on top of water.
10. Next demonstrate in a large glass or beaker what happens when you pour oil into water.
11. Give students time to observe the motion of the oil once it is poured into the water.
12. Guide them to notice all the directions that the oil takes as it eventually rises above the water.
13. Conclude by explaining that in the same way as the oil could be visibly observed moving around the air moves around similarly based on temperature differences, causing what we call wind.

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 what happens when you open a hot oven.
2. Have them draw a particle diagram of ***before, during, and after*** to illustrate what is going on at the smallest imaginable level when the oven opens.
3. Invite a few groups to share their particle diagrams and thinking with everyone.
4. Help the class come to a consensus that the hotter air from the oven is rising up into the cooler room temperature air.
5. Draw a summary particle diagram on the board for the class and inform them that this will be a model for them to examine today's lesson on wind.

C. Background Information Notes

Explain that we are going to build on these ideas and expand on the *hot oven* idea by learning a little more about how wind is produced. Then give the notes from the **Teacher Background Information**.

D. Close Reading a Video

Start by introducing that the **jet stream** is a band of wind high in the atmosphere that moves through large regions of the world, These high speed winds result from great pressure differences in the upper regions of the atmosphere and flow from west to east because of earth's rotation. Inform students that they are about to analyze an **animation of the jet stream over North America** from PBS LearningMedia.

Their task is to pay close attention to what's going on in the video and discuss it with a partner before writing out 4 sticky notes of observations about what they notice and wonder. Then, collect and display the stickies for all to see and discuss as a class. Last, ask students to make connections between the jet stream and the earlier discussion about the hot oven and sky lantern.

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 segment from *Great Lakes Now* that discusses ice boating around the Great Lakes. During the video they need to jot down four things they took away from watching the video 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 first segment from episode 2203 of *Great Lakes Now* called, **Ice Boating**.

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 sky lantern, oven and jet stream, asking them:

How is what we saw in the video the related to what we discussed earlier in this lesson?

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 ways that winds are produced in winter months and how wind helps ice boats to move.

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 SAILING ACROSS 3 GREAT LAKES

This activity aims to provide students an understanding of what it's like to depend on the wind for travel as they learn what it's like to sail across three of the Great Lakes aboard a sailboat in a single summer.

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

First, have students partner up and distribute the article entitled: **[Superior Crossing: Sailing Across the Biggest, Deepest and Coldest Great Lake]** by Sandra Svoboda from *Great Lakes Now*.

Allow time for students to individually read the article, and have them jot down three things they learned in the article.

Then, give students time after reading to discuss the article that they read with their partner. Have students share which three points they noted from the article and how those points connect to each other. The pair should come up with a statement to summarize all of their article takeaways.

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.

Encourage them to come to a consensus about which point they found most important or interesting in the article.

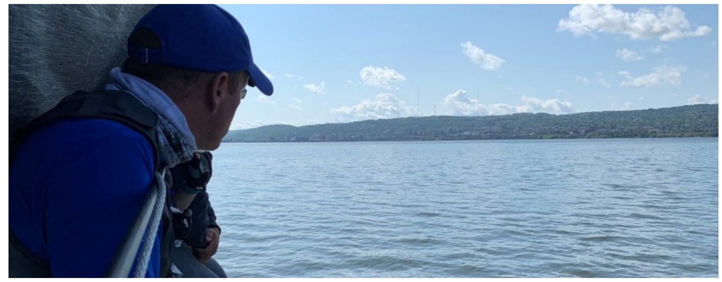


Image Credit: Great Lakes Now

Last, have each group come up with a summary statement of 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.

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

How did wind play a positive and a negative role in sailing across three of the Great Lakes in a single summer?

After giving the groups some time to discuss this question, invite conversation from the entire class to compare the roles of wind in sailing.

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

ACTIVITY 3: ENGINEER A SAIL CART

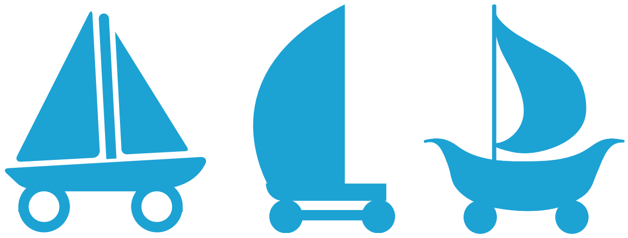


Image Credit: Gary Abud, Jr.

The purpose of this experiment is for students to build a wind-powered cart that utilizes a sail so that it can be moved by the air.

Context:
This is an engineering challenge that can be done outside of class individually by students or with one partner. Alternatively, you can provide time during class—and supply the necessary materials or have students bring in their own—to design and build the carts. A variety of household materials can be used or students can research and select the materials they use.

Guidelines: All sail carts* must have at least:

1. a body
2. at least 1 sail
3. 2 axles
4. 4 round wheels

Suggested Materials: Possible materials to consider might include, but aren't limited to:

- DVDs, bottle caps, jar lids, cardboard circles
  - *for wheels*
- Wooden dowels, straws, chopsticks, pencils, masking tape, or rubber bands
  - *for axles*
- Cardboard, construction paper, paper towel or toilet paper tubes
  - *for the body of the sail cart*
- Aluminum foil, paper plate, notebook paper, paper towel, felt, or facial tissue
  - *for the sail*

**Sail carts may have additional features as students determine that the design calls for. They may be decorated in any fashion.*

Testing and Racing Notes:
You will need to provide a source of wind, e.g., a box fan, that students can use to test their sail carts. Allow them time to test their sail carts individually and make improvements to their design before holding the sail cart race.

Project Steps:
First, communicate the project, with its guidelines** and your given timeline, to students. Emphasize that the objective is not as much to create the best looking sail cart but one that is fully functional.

Then, allow students time to research materials in, or outside of, class and design the sail carts.

Next, have students test their designs and make adjustments or improvements.

Last, hold a sail cart race*** where heats of 2-3 sail carts at a time line up next to one another in front of the wind source (e.g., box fan) and you see which sail cart travels the farthest before stopping after the fan is turned on. Students should measure and record the distance their sail cart travels.

***Note: teachers can evaluate these sail cart projects and their functionality according to a criteria that best suits the format of their learning setting.*

****You can allow students to race in a single heat or compete in tournament style according to a bracket where the winner moves on to race other winners in subsequent rounds until one champion is determined.*

Image Credit: Great Lakes Now

ACTIVITY 4: BUILD AN ANEMOMETER

The purpose of this activity is for students to build a working anemometer* and use it to measure the speed of the wind (either naturally-occurring wind outdoors or wind produced indoors using a fan).

The type of anemometer students will be making in this activity is a version of the hemispherical "cup" anemometer that was invented in 1846 by John Thomas Romney Robinson. You will want to show **a photo of a traditional cup anemometer like this**.

Materials Needed:

- stopwatch or timer measured in seconds
- plastic straws
- masking or gift-wrapping tape
- flat thumb tacks or T-pins
- pencils
- small paper cups (2oz or 3oz)
- scissors
- a box fan

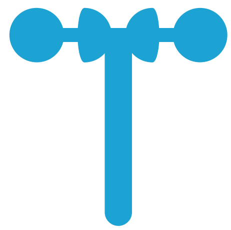
First, inform students that they will be working with a partner to build a cup anemometer to measure wind speed. Show students a photo of a cup anemometer.

Then, provide students the supplies they'll need to build their anemometers. They do not all have to be built to look exactly alike.

Next, give students time to plan out how they are going to build** their anemometers using the given materials. Encourage them to make a sketch of their design before they begin building their anemometers.

**Build an anemometer of your own to work through the steps before doing this activity.*

***If students are struggling to see how the materials would combine to make an anemometer, ask them to draw a cup anemometer like they one that was shown to them and list out which materials could correspond to each part of the device.*



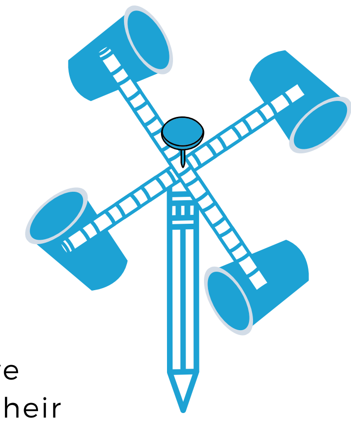


Image Credit: Gary Abud, Jr.

Last, after groups have completed building their anemometers, allow them time to test their designs and make improvements (and, if needed, retest and further make adjustments to the design.) Once anemometers are completed and working, it's time to use them to measure wind speed! That will require a bit of calibration first, though. Here's how:

1. Measure the diameter of their anemometer from the outside edge of one cup all the way across to the outside edge of the opposing cup.
2. Use the diameter to calculate the circumference of the anemometer according to the formula $C = \pi d$. This will give you the distance a cup travels around the anemometer once.
3. Now use a fan to get the anemometer spinning at a steady rate.
4. Have students watch their spinning anemometer (maybe even marking one of the cups with a colored marker so it is easier to follow while spinning.)
5. Start the timer and measure the time it takes for the anemometer to spin around ten full times.
6. Divide the time for ten spins by ten to get the time for one spin.
7. Knowing the distance for one spin divided by the time to complete one spin will give you the speed.

The anemometer can now be used in the same way to measure various wind speeds. The units students used to measure distance and time can be converted to determine wind speed in miles per hour.

ACTIVITY 5: DESIGN A WORKING WINDMILL

Image Credit: Gary Abud, Jr.

The purpose of this activity is for students to design a working windmill that can lift a weighted object.

This type of windmill can be likened to a wind turbine in its design more so than a traditional windmill. However, instead of an electricity generator, it will have a spool of string attached to a weight that coils up as the windmill turns to lift the weight. *Note: you should build a prototype yourself before doing this project to test out the procedure.*

Materials Needed:

- wooden dowels, shish kebob skewers, or chopsticks
- straws (paper or milkshake straws are strongest and better than plastic for this)
- tape
- scissors
- cardboard
- pencils
- toothpicks
- styrofoam cups (8oz or 16oz)
- string
- 1 quart milk cartons
- beans, candies, or other weighted objects
- box fan

First, inform students that they will be working with a group to construct a windmill that can lift weight. Provide them time to research the available materials, plan, and sketch out their windmill designs.*

Then, make materials available to groups and give them work time to build, test, and refine their windmill designs.

Next, provide students an opportunity to test their windmills using the fan. Encourage them to adjust the angle of the blades on their windmill and retest until they achieve an optimal spin angle.

Last, once windmills are complete, and students' designs have been thoroughly tested, it is time to test** their ability to lift weight. Students can fill their "payload" cups with the weighted objects and test out their windmill's ability to lift the weight all the way to the top without breaking or failing.

Students should use a balance/scale to record the mass/weight of the payload that their windmill was able to lift.

For an added challenge, groups can try a heavier load and see if their windmill can lift it when the fan is blowing on it. You can allow groups to retest their windmills until they max out their weight or fail.

**Designs do not have to all look the same way, nor be made of the same materials, but should all be required to satisfy some minimum criteria in terms of size and amount of weight to lift.*

***Teachers can evaluate these sail cart projects and their functionality according to a criteria that best suits the format of their learning setting.*

Image Credit: Gary Abud, Jr.

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.**

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