GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2302 | ICE CLIMBING

HOW COLD IS MELTING ICE?

Image Credit: Great Lakes Now

OVERVIEW

This lesson will explore the phenomenon of **ice climbing** in the Great Lakes. Students will explore the phase changes associated with water going between the liquid and solid state in order to learn about the formation of ice that is climbable, the melt patterns of ice, and how salinity affects ice melting.

LESSON OBJECTIVES

- **Know** about the winter sport of ice climbing
- **Understand** the how various factors, such as salinity, affect the rate of melting ice
- **Be able to** visualize the melting patterns of ice

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

INTRODUCTION

Ice climbing is an extreme winter sport that is growing in popularity, especially in the Great Lakes Region. In Michigan's Upper Peninsula, cold winters create long climbing seasons, usually from November until May.

According to Bill Thompson, an avid climber and owner of outdoor outfitter Down Wind Sports in Munising, Michigan, the Pictured Rocks National Lakeshore along the shores of Lake Superior offers a unique climbing experience.

This lesson includes multiple activities, including lab 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:

- states of matter
- phase changes
- pressure, force, and density
- force diagrams
- temperature
- energy storage and 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: Ice Climbing

- 2-PS1-4
- 5-PS1-1
- MS-PS1-4
- HS-PS3-4
- SEP-2
- SEP-3
- SEP-6

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

- Class discussion to elicit and activate prior knowledge about **freezing**
- Demonstration of how a materials can support weight
- Teacher notes on ice formation and ice climbing
- Watch a segment from *Great Lakes Now*
- Class discussion to debrief the video
- Read about **warmer winters** in Michigan
- Conduct an experiment to determine how various factors affect the rate of ice melting
- Visualize the melt patterns in melting ice

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. You can select the activities that are best suited for your learners and teaching goals, and then sequence them in a way that makes sense within your learning progression and the scaffolds of the lesson.

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

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

Ice climbing is a sport where people climb up frozen waterfalls or other formations of ice using specialized equipment, including **crampons** (metal spikes that attach to boots), ice axes, and ropes. One important aspect of ice climbing is understanding how ice forms and how it behaves. Water becomes solid when it reaches its **freezing point**—the temperature at which the **phase change** from liquid to solid happens. There are different types of ice, such as hard, brittle ice and softer, more malleable ice.

In order for climbable ice to form, water first has to freeze. As the temperature decreases, the energy that the molecules of water have to move decreases, meaning the motion of the water molecules in liquid water slows down. Eventually, it slows to the point that the molecules cannot move enough to escape the **attractive forces** between them. The result is a **crystal lattice** structure where the water molecules are held in place.

When you climb up an ice formation, you need to be aware of the different types of ice and how each could respond to your **weight** and the **pressure** you put on the ice. For example, if you strike hard ice with your ice axe, it may shatter or crack, which could be dangerous. So, climbers need to know how to choose the right tools and techniques for the type of ice they are climbing on.

Ice climbing involves a number of physical principles, including friction, phase changes, and other forces. A number of forces are involved in ice climbing, including the force of the climber's weight and the force of the ice on the climber. The climber's weight applies a downward force on the ice, via the climbing tools, while the ice provides an equal and opposite upward force to support the climber's weight upward.

The ice tools used in ice climbing provide a good grip on the ice, allowing the climber to generate friction against the ice surface. This helps to keep the climber in place and prevent slipping or falling.

The physics of ice climbing can also be affected by other factors, such as the temperature and quality of the ice. For example, if the ice is too brittle or fragile, it may break under the weight and force of the climber, while if the ice is too soft or slushy, the climber may struggle to get a good grip and generate enough friction to maintain their position. Ice formation is determined by the temperature, yes, but also the conditions under which the water freezes, and the content of the water itself.

Salinity refers to the concentration of dissolved salts in water. When salt is added to water, it changes the properties of the water, including its freezing and melting point. That means that freshwater and seawater will form ice at different temperatures and the water itself will remain frozen—or begin to melt—at different temperatures depending on its salinity. This is the same principle that we take advantage of when we salt the roads before a winter storm takes place to keep ice from forming on the roads.

Ultimately, it's not just knowledge of the science that ice climbers need to be able to read the ice and the terrain to find the safest and most efficient route to the top of their climb, it also requires a lot of focus, skill, and experience to climb ice. It's a challenging and exciting sport that requires a lot of knowledge and skill to find the best route to the summit, but it's also a great way to explore the physical properties of water in action!

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities. It helps students to begin thinking about the topic at the center of the lesson.

1. Ask students to list out on a piece of paper five things that come to mind when thinking of **freezing**.
2. Have students pair up with a partner to share their five ideas with each other. If any ideas appear on both lists, have students circle those.
3. Then, engage students in a whole-group discussion to ask them to share any ideas that were circled.
4. Generate a list of the circled ideas.
5. Ask for volunteers to share any ideas that were not circled that they think are really important to include in this topic.
6. Generate a separate list of those ideas.
7. At the end of making the two lists, have students copy down one single list of all the circled ideas and important ideas in their notebooks or on their paper.
8. Ask students individually to rank the ideas in the list from most to least relevant.
9. Ask for some students to share which term should be most relevant and why they think that is. Engage the whole group in discussion to arrive at consensus about the most relevant idea related to **freezing** that they already know about or that came to mind during this exercise.

Image Credit: 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 by demonstrating how a surface can support weight:

1. Get a large flat, thick sheet of styrofoam and secure it standing up like a wall on the tabletop or the floor.
2. Proceed to wedge wooden kebob skewers into the styrofoam until the point of the skewer reaches the other side but doesn't poke through all the way.
3. Ask students to predict how much weight they think the skewers can support before the styrofoam breaks.
4. Proceed to hang a variety of different masses on the skewer. You should try to keep them all at the same distance by hanging the masses from one another rather than hooking them all onto the skewer next to each other.
5. Ask students to draw a force diagram that depicts what is going on with the forces pushing or pulling in this situation
6. Continue to add mass until either the styrofoam breaks or you decide enough mass has been hung.
7. Ask students to compare the amount they predicted to the actual amount.
8. Explain to them that in a similar way to how the styrofoam can support weight, frozen water can do the same.
9. This is going to be the basis of our lesson on ice climbing today.

C. Close Reading a Photo

Show a photo of a **portaledge** (a tent that rock climbers sleep in hanging off the side of a mountain) and ask students to come up with explanations for how it works.

D. Background Information Notes

Explain that we are going to build on these ideas and learn more about the phase change of **freezing** for water in this lesson. Then proceed to give the notes from the **Teacher Background Information**.

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 *Great Lakes Now* segment discussing the winter recreational sport of ice climbing in Munising, Michigan. During the video they need to jot down four things they took away from 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 the segment from episode 2302 of *Great Lakes Now* called **Ice Climbing**.

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 *Great Lakes Now* video and what they remember from the warm-up activities.

How is what we saw in the video related to what we discussed earlier during the lesson launch activities?

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 goal is to help students make connections between the video segment and what they discussed during the launch activities earlier in the lesson about what they knew about **freezing.**

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 WARMER WINTERS

While many people dislike winter weather—and for good reason—there are plenty of fun activities to do when it's cold and snowy in the Great Lakes. Lots of businesses depend on consistent snowfall and colder temperatures to operate in tourism-based winter economies. Now, warmer winters are threatening not just fun activities like ice climbing, but also the livelihoods of these businesses that depend on those activities. What are the costs of warmer winters?

In this activity, students will use a **Think Pair Square Protocol** for discussing what they will read about this very topic.

First, have students partner up and distribute the article **Warm winter changes — but can't stop — outdoor fun** by Danielle James of the *Capital News Service*. Allow time for students to individually read the article, and have them jot down three things they took away from the article using the **Rose Thorn Bud Protocol**—in their notebook or using the handout.

Then, give students time after reading to discuss the article that they read with their partner. Have students share their rose, thorn, and bud with each other, including 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.

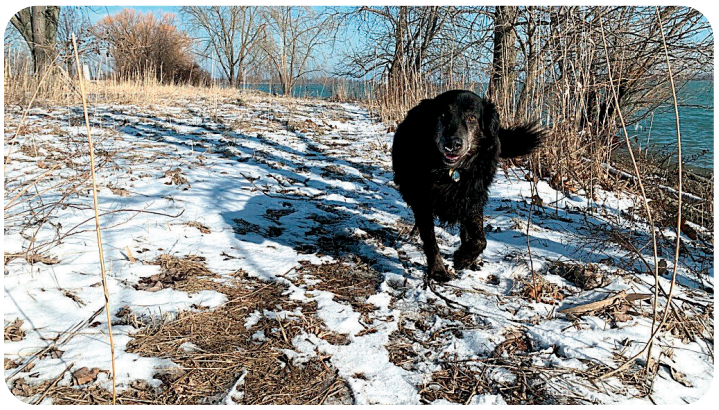

Image Credit: Sandra Svoboda

Last, have each group craft a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that key point with the whole group. As student groups share their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks. Once the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

In what ways do warmer winters pose a threat to activities such as ice climbing?

After giving the groups some time to discuss this question, invite conversation from the whole group to see what consensus can be reached. Be sure to encourage students to support their claims with evidence and reasoning as they discuss in the whole group.

Teaching Tip:
If the reading level of the article is going to be tough for some students to read individually, have partners or small groups read the article together aloud while each follows along.

ACTIVITY 3: VISUALIZING MELTING ICE

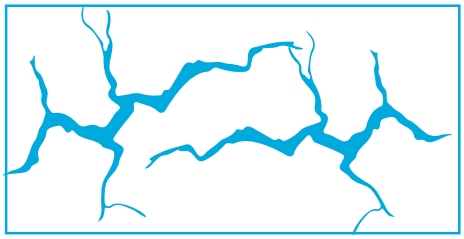

Image Credit: Gary Abud, Jr.

In this activity, students will create an ice sheet, then strategically melt it using salt and visualize the melting pattern using food coloring. You'll be able to see channels, holes, and tunnels in the ice, plus it's really cool to look at.

Materials:

- Water
- Salt (rock salt or coarse Kosher salt)
- Liquid food coloring in individual bottles
- 2oz paper cups
- Disposable aluminum baking trays (size depends on freezer space)
- Paper and colored pencils
- Paper towel

Begin the day ahead by filling the aluminum trays with water to at least one inch thick and allow them to freeze overnight.

Start by explaining that students are going to visualize the melting patterns of frozen water as it undergoes a phase change to become liquid water. Have them draw a prediction of how they think that ice melts and what the pattern looks like for how it will melt. Allow them time to share their drawings with a partner and ask for a few students to verbally share descriptions of their predictions about the melting patterns.

Have students pair or group up, depending on how many ice sheets are available, and obtain the remaining necessary materials for the experiment: a small paper cup with some rock salt in it and some food coloring bottles.

Teaching Tip: This will most likely work best over a two-day period where you first make the ice sheets and then work with them to melt them on day two.

First, have the students place individual grains of rock salt at different positions on the ice sheet. They can put as many or as few as they'd like, and can do a uniform pattern or randomly distribute them. They could even make little mounds of ice by putting several grains all in one spot. Regardless of how the salt is distributed, leave at least 5cm of space between each grain of rock salt to allow space for melting to take place.

Next, have students draw a diagram of their ice sheet and all the rock salt in the proper locations where it was placed. These drawings do not need to be to scale.

Then, have students drop one drop of food coloring—they can use all one color or a combination of colors—on each grain of rock salt. Be sure to squeeze the drops of food coloring from a low height close to the rock salt and to squeeze slowly, so as to reduce the chance of there being splatter.

Last, have students observe what the see (and maybe even hear) as the ice begins to melt. They should see that the melting ice, which forms liquid water, will mix with the food coloring and start to run in different directions taking the food coloring with it and showing a pattern of the melting ice.

Have students draw a diagram of the melting ice tray at a few different times (e.g., 1min, 5min, 10min, 20min, etc. as your time together allows) to create a sort of time-lapse diagram of the ice melting and the pattern. Have students compare diagrams with other groups to discuss how their diagrams were the same/different at various elapsed times of melting.

Engage the whole group in a discussion about what happened, how their diagrams compared to their predictions, and what they think was going on at the smallest possible level in this situation. You can extend thinking by asking them to draw a particle diagram to represent the melting, or to explain verbally why the food coloring didn't mix with the water until it was melted.

ACTIVITY 4: WHAT AFFECTS THE MELTING RATE OF ICE?

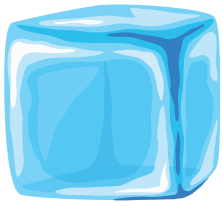

Image Credit: Gary Abud, Jr.

The freezing point of water—pure water that is—at standard temperature and pressure conditions is 0˚C. But what happens if the water isn't pure? What if it has salt or some other impurity dissolved in it? Will it still melt or freeze at 0˚C? As we saw in the ice melting patterns activity, the salt caused some spots on the ice sheet to melt before others that had no salt. There must be something about salt that changes the temperature at which water freezes/melts; otherwise, the ice sheet spots with no salt would have melted at the same temperature. This process of affecting the liquid-solid phase change temperature of a substance is called **freezing point depression**. But are there other effects that salt or different conditions can have on melting ice? In this experiment, students will investigate the factors that affect the rate of ice melting.

Materials:

- Cool and warm water
- Ice (4-6 uniform size/shape cubes per group)
- Salt
- Liquid food coloring*
- Thermometers (digital are ideal for precision)
- Timer
- Stirring rod or wooden skewer
- Clear plastic 16oz cups or or 500mL beakers
- Colander or strainer

Procedure:

1. Student groups will each test different factors and report out results to the whole group
2. You can have students design their own experimental procedure or give them one
3. Each group should have two different containers in which to place 1 ice cube
4. Fill each container with the same amount of water but under different conditions according to what your group is testing:

- cold v. warm water
- saltwater v. freshwater
- still water v. flowing water

First, tell students they are going to compare how quickly ice melts under different conditions to determine which factors have the biggest effect on melting rate. Ask students to predict which factor they think will have the biggest effect and, individually, what will happen to the ice and resulting water temperature under each set of conditions. Predictions can be relative (e.g., "Ice will melt faster in condition A") or specific (e.g., "Ice will melt in X seconds in condition A").

Next, allow students time to plan their experimental procedure and what they will do in their test. For example, a group measuring how fast ice will melt under moving water conditions might run their ice cube under room temperature water inside a strainer with the faucet on full blast and measure the time it takes to melt as compared to how long it takes a cube sitting in room temperature water that is completely still to melt. Be sure to prompt them to maintain controlled conditions with their experiment and take measurements before, during and after the changes.

Then, allow them time to conduct their experiments and collect data. Have groups summarize their findings in a data table and with a diagram that explains what they observed happened in their experiment.

Last, have groups present their results to the everyone so that all the groups can hear about how all the different experimental conditions affected the melting rate of ice. Engage the whole group in a discussion of which factors had the most or least effect on the melting rate. Ask students to explain what they think was happening at the particle level as a basis for their reasoning of why different factors affected the melting rate as they did. Be sure to give the group who tested saltwater time to explain the how the temperature of their water changed as the ice melted in each of their containers.

**Note: liquid food coloring can be added to the liquid water in the containers to help make it easier to distinguish the ice cub from the water and see the size difference to observe melting.*

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.

A. Free Recall

Group students in pairs or triads (e.g., in groups of 2-3 partners) and distribute the **Free Recall Protocol handout**, Alternatively, you can have students do this in their notebooks. Set a 3-min timer and have students generate a list of everything they can remember learning about in this lesson related to the central topic of the lesson. This doesn't have to be in depth, just whatever each group can call to mind. Have them draw lines between any terms that relate to one another. After the timer finishes, give groups a chance to volunteer to share aloud 2-3 things from their free recall lists and any of the connections that they made with those. Jot down any ideas that come up multiple times during the shareout for the whole group to see.

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

Image Credit: Great Lakes Now

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: _____

Free Recall Protocol

With 1-2 partners, generate a list of everything you can remember learning about in this lesson related to the central topic of the lesson. Draw lines between any terms that relate to one another.

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

NAME: _____

Rose, Thorn, Bud Protocol

ROSE

Something that "blossomed" for you in your learning

THORN

Something that challenged your thinking or was difficult to understand

BUD

Something that's new and growing in your mind — a "budding" idea