# GREAT LAKES LEARNING

**LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM**

EPISODE 2403 | SKI SLOPES & SAUNAS

## THE SCIENCE OF SKIING

## OVERVIEW

This lesson will explore the phenomenon of **friction on ski slopes** in the Great Lakes, highlighting why some of the best ski hills are found in the Lake Superior region. Students will delve into the physics principles that enable skiing and snowboarding down a pre-historic volcano in the Keweenaw Peninsula, focusing on concepts like friction, slope ratings, and modeling motion on inclined planes. Through hands-on activities, they will discover the science behind skiing in the Great Lakes region—and what makes it so great.

## LESSON OBJECTIVES

- **Know** how the angle of a slope affects motion
- **Understand** how warmer winters affect ski culture
- **Be able to** test the effect of ski wax on friction to see how it affects the motion of skis on snow

### 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

Many people in the Midwest head to the Rocky Mountains for a skiing adventure, but what if some of the best downhill skiing and snowboarding was found in the Great Lakes region? Well, at Mount Bohemia near Lake Superior, that's exactly the claim. On this exploration into the science of skiing, not only we will discover some of the physics principles that underpin the exhilarating sport of skiing, focusing on concepts such as friction, slope dynamics, speed, and motion, but we will see how skiing in the Keweenaw Peninsula has some of the best slopes to experience. From the trails and hills to the activities and culture, this investigation of skiing in the Great Lakes region will look at all aspects of the science and the sights of the sport and industry itself.

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:

- energy
- properties of water
- measurement
- distance, time, speed and acceleration
- static and dynamic forces

**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: Friction on Ski Slopes**

- MS-PS3-1
- MS-PS3-2
- MS-PS2-2
- MS-ETS1-1
- SEP 1
- SEP 2
- SEP 3
- SEP 4
- SEP 5

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

- Class discussion to elicit and activate prior knowledge about **skiing or snowboarding**
- Teacher notes on **the physics of skiing**
- Watch a segment from *Great Lakes Now* about skiing near Lake Superior
- Class discussions to debrief the video
- Read about **the warmest winter on record in Wisconsin and its effects on ski culture**
- Conduct an experiment to measure the motion of **dry ice**
- **Investigate the relationship between angle and speed** on an inclined plane
- **Test the effects of ski wax** on friction

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.*

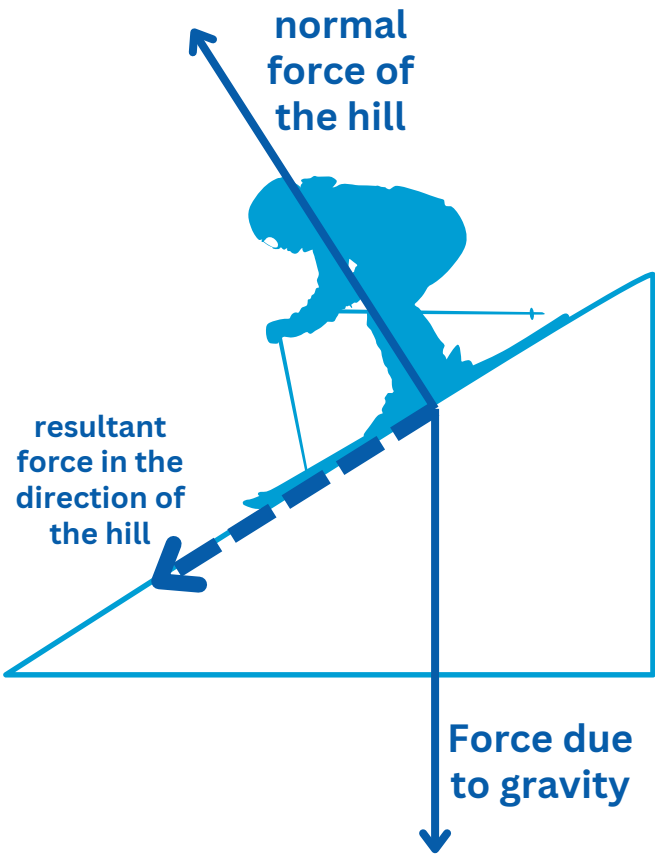
Skiing is more than just a thrilling winter activity—it's a perfect example of the physics principles that govern motion and forces. Understanding these principles not only enhances your ability to navigate slopes effectively but also deepens your appreciation for the science behind the sport. From the moment your skis touch the snow, several key principles come into play.

**Friction**, for instance, determines how easily your skis slide across the snow surface. When the molecules in two different materials interact as surfaces slide alongside one another, the attractions between those molecules cause a pulling force that can work against the motion of the surfaces sliding past each other. This phenomenon is what we experience in friction. It comes in two "flavors" — the static (not moving) kind and dynamic (moving) variety.

Skis are designed with materials that minimize friction, allowing you to smoothly navigate the slopes. And while the smooth skis and slippery snow of the ski hill already have fairly low friction, applying wax to skis and snowboards gives them an additional reduction in friction because the wax is **hydrophobic**, or is water repellant.

The **force due to gravity** of the Earth plays a crucial role too, pulling the skier toward the Earth. But since the slope is angled, the final effect is that they travel downhill as they ski. Understanding the slope rating—ranging from green (gentle) to black diamond (steep)—helps skiers choose paths that match their skill levels.

Additionally, the angle of the slope affects the speed of a snowboarder, because steeper slopes accelerate skiers faster from the incline (normal force) perpendicular to the plane and the force downward due to gravity.




**Balance** and **center of mass** are crucial concepts for skiers to understand and apply, especially in turns, twists, and jumps. Center of mass is the point where the mass of an object is concentrated. Skiers must maintain their center of mass over their skis or snowboards by positioning their weight to maintain stability and control. Shifting their center of mass forward or backward affects the pressure on the skis and can initiate turns or adjust speed.

# 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 **skiing**.
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 **skiing** that they already know about or that came to mind during this exercise.

**B. Bridge to Learning**

After the warm-up, demonstrate the friction between different surfaces by taking a dry erase board and placing blocks/objects of different material (e.g., felt, wood, rubber) on the board next to one another and then tilting the board on an angle to make the blocks slide down the board. Ask students what they notice about the motion of each, and relate that to the low friction needed for skiing that comes from the board/snow.

**C. Close Reading a Video**

Show this PBS LearningMedia video of **Aerial Mavericks ski jumpers** and ask the students to consider how their arms help freestyle aerial skiers twist and turn their bodies. Before students respond, have them do the following with a partner:

- **Review the video** and take notes on key points, visuals, and any questions or observations that arise.
- **Summarize the main content** of the video and identify the primary themes or messages it conveys.
- **Discuss the visual elements**, e.g., angle, lighting, etc., used in the video and how they contribute to its storytelling impact.
- **Explore the concept** of skiing in the video.
- **Engage in a discussion**, sharing insights, reactions, and interpretations of the video as it relates to the question.
- **Answer the question** in a class discussion, allowing partners to talk with other students and share ideas or ask follow-up questions to one another. Facilitate the discussion to arrive at a consensus about how skiers' arms help them to twist and turn their bodies and compare to their prior predictions.

**D. Background Information Notes**

Explain that you will be investigating more about **skiing** in the Great Lakes region before providing 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 skiing on Mount Bohemia in the Lake Superior area of the Great Lakes region. 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 2403 of *Great Lakes Now* called **The Best Skiing in the Midwest?**

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 **skiing**?

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 THE WARMEST WISCONSIN WINTER

The ski industry provides a seasonal source of jobs, business, and recreation for many people in the Great Lakes. But what happens during a warm winter when snowfall is scarce? How do businesses, skiers, and snowboarders contend? As they read, students will learn about the how the ski industry in Hayward, WI faced a critical challenge as the warmest on record threatened their iconic American Birkebeiner ski race and what they did in response to the not-so-wintery weather.

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 **Disappointed Dogs, Sad Skiers, Frustrated Fishermen** by Kari Lydersen from *Great Lakes Now*. 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.

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:

**If you were in charge of organizing this ski race, how would you handle the situation of unseasonably warm weather and the lack of snow?**

You can keep this as a class discussion based on the article itself or, after giving the groups some time to discuss this question, invite them to further research the topics, points of interest, or themes discussed in the article by generating a research question, identifying additional sources, and presenting their findings.

***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, or the teacher might read the article to the entire class.***

# ACTIVITY 3: MAPPING THE MOTION OF DRY ICE

The purpose of this activity is for students to measure the acceleration of a block of dry ice on a flat, smooth surface so that they better understand how lower friction aids skiers.

**Materials:**

- Block of dry ice*
- Flat, smooth surface (such as a lab bench or a large glass/plastic sheet)
- Stopwatch or timer
- Measuring tape, meter stick, or rulers
- Gloves (for handling dry ice safely)
- Tongs or a cloth (for handling dry ice)
- Markers and strips of paper, or stickers
- Chart paper or large dry erase boards

**Notes on dry ice: always handle dry ice with gloves. The pieces of dry ice should be about 2" in diameter. They need to have a flat side. In order to flatten them, let the piece rest on a flat surface and it will vibrate until is flattens itself out and can glide with a push.*

First, inform students that they will investigate and graph the motion of a block of ice to examine its motion over time as it moves in a straight line path. Have students form groups of 4 and make a prediction about the motion of the dry ice block: will it speed up, slow down, or travel at a constant speed once pushed?

Then, have them get their materials and set up their experiment. They can design their own procedure, you can give them a pre-made procedure, or as a class you can discuss what steps are needed to measure the motion of the block of dry ice as it travels across the surface.

***Teaching Tip: If your students are less experienced with graphing, you can review the steps of graphing first.***

**Possible Procedure:**

1. Ensure the surface is flat, smooth, and free from any debris or rough spots.
2. Use tape or markers to mark distances along the surface (e.g., every 0.5 meters).
3. Use gloves and tongs to place the dry ice at the starting point on the surface.
4. Have someone ready with the stopwatch ready to start it when the block releases.
5. Release the block by gently pushing it and letting it go so it can glide slowly across the surface in a straight line path.
6. Use the stopwatch to either: a) measure the time it takes for the dry ice block to travel between each marked distance, or b) announce when a certain time interval has passed (e.g., 1sec, 2sec, or 5sec) so the distance can be marked at each time
7. Be sure to do 3 similar trials to compare your data on subsequent runs of the dry ice.
8. Repeat the experiment multiple times to ensure accuracy and consistency of the measurements. You can consider doing a set of distance based trials (e.g., measure the distance at different time intervals) and then do a separate set of trials that are time based, (e.g., record the times taken to travel from 0 to 0.5 meters, 0.5 to 1 meter, etc.).

Next, give students time to collect data and run their trials with the motion of the dry ice. Have them create a graph of position v. time for their trials on chart paper or large dry erase boards. Depending on ability, they can find the y=mx+b form of the equation of their graphs, with units. Be sure to monitor their data collection, calculations, and graphing to ensure you're providing support where needed based on their level of experience and math abilities.

Last, facilitate a class discussion that allows each group to see the other groups' graphs. Based on the data, have the class talk about their results and experimental procedures to arrive at a consensus about the motion of the dry ice in a straight line path. Make sure they each calculate and report the speed of their block (speed = distance / time). Help them to see that the speed is constant because the forces are balanced once the block is released.

# ACTIVITY 4: MODELING THE STEEPNESS OF SKI SLOPES

The purpose of this activity is for students to observe and measure how the angle and steepness of a ski slope affect a skier's speed by modeling a ski slope and skier with an inclined plane and ball.

**Materials**:

- Inclined plane* (ramp) with an adjustable angle or different inclined planes with varying fixed angles
- Ball (such as a marble or small metal ball)
- Meter stick, tape measurer, or rulers
- Stopwatch or timer
- Protractor (to measure and adjust angles)
- Tape or Velcro strips (to secure the ramp and ball)

*Note: this can be made simply from cardboard and blocks to prop the surface at different angles, or using another design.*

First, inform students that they will be investigating how the angle of an inclined plane affects the speed of a moving object.

Next, have them form groups of four, gather the materials needed for the lab, and begin setup.

Then, have students determine what each person in their group's role will be and review the procedural steps to determine how they will carry out the experiment. They should determine what angles they will choose (at least 5 different trials) and do some practice runs to test out their procedure for measuring the time, distance, and angle of the ball each time. When ready, allow students time to carry out the experiment and record the data for each of their trials, adjusting the angle each time.

Last, have students calculate the speed (e.g., speed = distance/time) and create graphs from their data to show the relationship between the angle v. time.

**Data Collection Procedure:**

1. Set up the inclined plane on a flat surface. Ensure it is stable and securely positioned.
2. Use a protractor to measure and set the initial angle of the inclined plane. Start with a gentle slope (e.g., 5-10 degrees) and have options for steeper angles (e.g., 20 degrees, 30 degrees, etc.).
3. Position the ball at the top of the inclined plane. Ensure it starts from a stationary position in the same spot at each set angle.
4. Release the ball from the top of the inclined plane and simultaneously start the stopwatch.
5. Time how long it takes for the ball to roll down the incline and reach the bottom or a predetermined and marked point.
6. Repeat the experiment for each different angle setting of the inclined plane.
7. Make sure to record the time (t) taken for the ball to travel the same distance down the ramp for each angle.
8. Make sure to record the distance traveled from the starting to ending point of the ball's path of motion down the inclined plane.

**Post-Lab Discussion:**

Have students transfer their graphs to chart paper or large dry erase boards in order to be able to see the results of other groups. Facilitate a whole-group discussion about the results.

Ask students to note what is the same and what is different between each group's results (as shown on their graphs). Focus the conversation to ensure that the group arrives at a consensus about conclusions can be drawn about the relationships between angle and time to travel the fixed distance.

Extend the discussion to make connections between the way the angle affects the motion of the ball, and how the rating (e.g., steepness) of ski hills relates to the skiers' motion.

***Teaching Tip: Set this up and test this experiment out ahead of time, possibly even recording a video of your set up steps to use if you teach more than one class in a day.***

# ACTIVITY 5: TESTING THE EFFECT OF SKI WAX ON FRICTION

The purpose of this activity is for students to investigate how different types of ski wax affect the friction between skis or snowboards and snow.

**Materials**:

- At least 3 different types of ski wax (cold weather wax, all-temperature wax, etc.)
- Heavy plastic blocks with smooth, flat bottoms (to simulate skis)
- Smooth, flat surface (e.g., large dry erase board)
- Stopwatch or timer
- Measuring tape, meter stick, or rulers

First, ask students to turn and talk with a partner and discuss why skiers and snowboarders put wax on their skis and snowboards. Elicit a few responses to arrive at a consensus that while skis and snowboards are designed to glide over snow, applying wax further optimizes their performance, because the wax typically contains hydrophobic (water-repelling) components, thus reducing friction.

Next, inform students that they will be measuring the effect of different types of ski wax on friction. Have students form groups of 3-4 and gather the materials needed to perform the experiment. They should wax up the plastic blocks with each type of wax, leaving one block unwaxed as a control for the experiment.

Then, have students set up an inclined plane using their surface and measure the angle of incline that they chose to use. Each group can select a different angle to investigate as a class how the angle may affect the motion with each wax. Have them do a practice run with the unwaxed block by starting it at a certain spot atop the inclined plane and then determining an ending spot where to measure the time it takes the block to slide down the inclined plane from one spot to the next. When ready, they should perform three trials with each block, beginning with the unwaxed block.

Measuring the time it takes the block to travel down the incline from the start to the finish, and having multiple trials, will allow students to calculate an average time for each block based on its trials. This allows them to account for observed variations in performance due to factors like initial push force, surface smoothness, and any environmental conditions. Encourage them to try and be as consistent as possible with the conditions for each trial on each block.

Last, after students have collected data from each of the blocks across their trials, have them create a graph that visualizes the comparison between the type of wax and the time it takes the block to travel the fixed distance down the ramp at their set angle. Display all the group data side by side so that patterns can easily be seen between experiments done at different angles.

**Post-Lab Discussion:**

Facilitate a whole-group discussion about the results of the experiment. Consider any of the following question prompts to spark discussion:

- What trends did you notice when comparing the average times for each block based on the type of wax used?
- Were there any unexpected results or outliers in the data that may have affected the overall analysis?
- How did variations in factors like initial push force or surface smoothness impact the time it took for the blocks to travel down the incline?
- How did the ski wax affect the friction?
- How do the ingredients in each wax differ? Are there conclusions we can draw about which substances might contribute to the lowest friction and thus best motion for skis?

***Teaching Tip: Wax up a set of blocks and test ahead of time so you can advise students on how much wax to use.***

## 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

**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