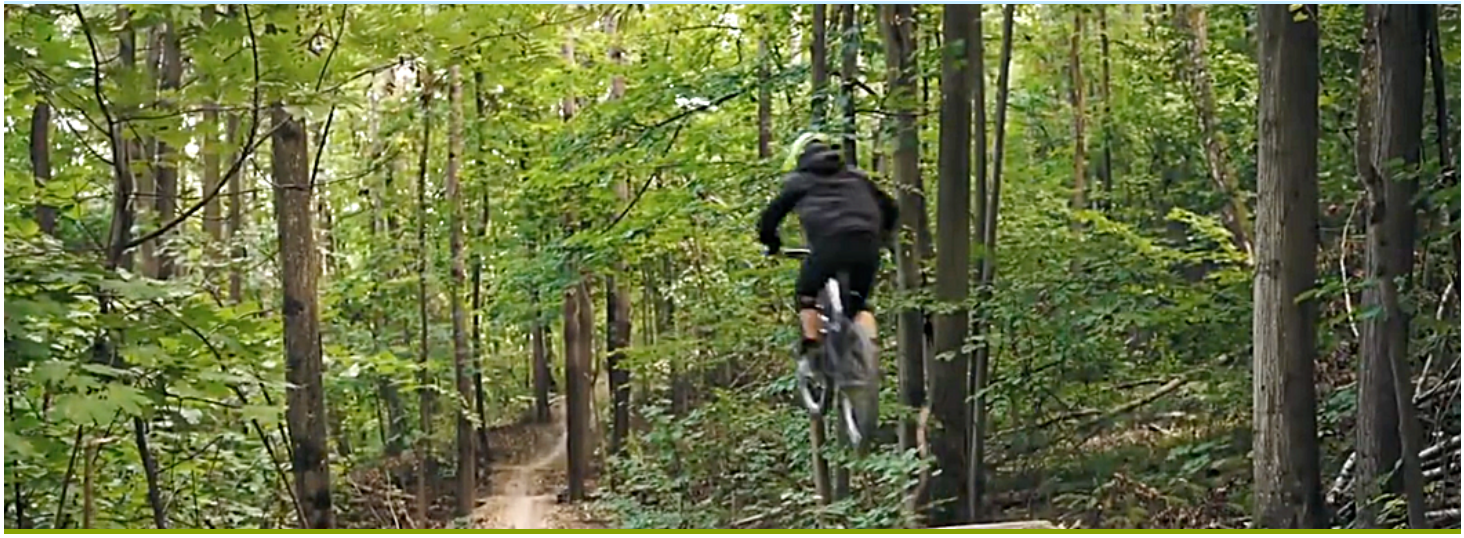
GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2309 | TRAILS AND WETLANDS

GREAT LAKES GRADIENTS



OVERVIEW

This lesson will explore the phenomenon of natural **gradient**, as students learn about how the natural flow of the Great Lakes landscape can provide a smooth path for mountain bike riding. They will explore the physics of accelerated motion, explore the math of slope, and investigate existing and planned trails in the Great Lakes before building a slow, smooth-rolling trail to move marbles, modeling the design of mountain biking trails.

LESSON OBJECTIVES

- **Know** how the gradient of a hill is calculated
- **Understand** how gradient relates to acceleration
- **Be able to** engineer a circuitous path to allow a marble to roll downhill from one location to another at the slowest speed possible

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

The Great Lakes landscape is home to some intricate hilly terrain, which was carved out by glaciers in millennia past, and landscape makes it possible for us not only to have the watershed that we do, but it also provides a large diversity of landforms that are perfect for mountain bike trails. As stewards of the natural landscapes that we call "HOMES" in the Great Lakes, we'll learn about how the land is being shaped into popular paths for bikers to traverse the slopes of the Great Lakes hills when there isn't snow.

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:

- calculating slope
- slope-intercept form of an equation
- graphing
- position, time, speed, velocity, acceleration
- Internet research
- persuasive speech and writing

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: Gradient

- MS-PS2: 2 & 4
- MS-PS3: 1 & 2
- MS-ETS1: 1-3
- MS-ESS3: 3 & 4
- SEP 2
- SEP 3
- SEP 4
- SEP 5
- 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 the concept of **gradient**
- Teacher notes on **slopes and gradients**
- Watch a segment from *Great Lakes Now*
- Class discussion to debrief the video
- Read about the Detroit River Trail
- Debate the best bike trails in the Great Lakes region
- Experiment with accelerated motion
- Design a track to move a marble from one place to another at the slowest possible rate

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

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

B. Bridge to Learning

Activate prior knowledge by having students use graph paper to create individual line graphs with varying slopes. Review the concept of slope, calculate the slopes they've graphed, and have students showcase their graphs. Then, conduct a gallery walk to compare and contrast the graphs.

C. Close Reading a Video

Play the **video of mountain biking in Minnesota from PBS LearningMedia** on a centralized display or make the video available to students individually to watch. It parallels the story in the *Great Lakes Now* segment in Activity 1, helping students establish connections between gradient, slope, inclusivity in recreation, and mountain biking trails. To facilitate the close reading, instruct students to:

1. **Watch the video** attentively and take notes on key points, visuals, and any questions or observations that arise.
2. **Summarize the main content** of the video and identify the primary themes or messages it conveys.
3. **Discuss the visual and auditory elements** used in the video and how they contribute to its storytelling impact.
4. **Explore the concept of inclusivity** in outdoor recreation mentioned in the video. Talk about its importance and its impact on community engagement.
5. **Engage in a class discussion**, sharing insights, reactions, and interpretations of the video.
6. **Analyze the video's effectiveness** in conveying its message. Did the video achieve its intended purpose? Were there any elements that could have been improved?

D. Background Information Notes

Explain that we are about to learn more about gradients. Then, give the **Teacher Background Notes** to students.

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.*

Whether driving on the road or riding along a mountain biking trail, the **gradient** refers to the steepness of the terrain, typically measured as a ratio of vertical height (e.g., elevation change) to horizontal distance along a segment of the path. Similar to the mathematical concept of **slope**, which refers to the rise-to-run ratio of the curve on a graph, gradient can communicate physical and mathematical information all at the same time. Gradient is typically expressed as a percentage or as a fraction. A 1ft:10ft gradient would have a value of 1/10, or 0.10. Expressed as a percent, this would be a 10% gradient.

The gradient of a mountain biking trail is a crucial factor that determines the trail's difficulty level and the effort required by riders. Steeper slopes can make trails more challenging and physically demanding, while flatter slopes may provide a smoother and easier ride. Mountain bikers often consider the slope when choosing trails to match their skill and fitness levels, but designers of the trails have to consider how the gradient of the land will impact the safety and ease of riding on the trail for bikers.

Steeper gradients can result in greater speeds down the trail, which can be hard to handle and increase the chance of a crash if a biker hits some debris. When it comes to turns on the trail, it can be difficult to stay in a turn at higher speeds and not slide out. That's why some turns are banked to help keep bikes on the trail through the turn. And just like with drivable roads, turns have banks, but they also have speed limits to ensure that cars stay in them. For mountain bike trail design, combining the gradients of downhill straight segments of the trail with turns, engineers need to consider how fast a bike might enter a turn based on coming out of a downhill slope. If the resulting speed is too great for the turn, it can cause accidents and injuries to bikers.

Biker speed depends on gradient and pedaling effort. The steeper the slope, the faster they can go without pedaling, because as a biker descends a hill, the force due to gravity increases their velocity. **Velocity** measures how the position of an object changes over time; it communicates speed and direction together. A change in velocity over time, or **acceleration**, is also affected by slope steepness. When a biker descends a steep slope, they experience a greater rate of acceleration due to gravity. Conversely, when climbing a steep slope, they may need to pedal harder to overcome the force due to gravity and maintain their speed.

To ensure rider safety, trail designers consider how bikers will accelerate at various points along the trail and take steps to keep both velocity and acceleration at safe levels. That's where gradient plays an essential role. In both trail design, as well as road construction, gradients must be suitable to ensure safe and efficient travel for vehicles. Steep gradients can pose difficulties in climbing hills and cause increased braking force on descents, which can be dangerous when roads are wet or icy.

Other applications where gradient is important include landscaping design, the gradient plays a role in land grading or leveling it as engineers adjust the slope of the land to prevent erosion, control drainage, or design a specific landscape. This is especially important when designing large areas of land such as golf courses or parks.

But perhaps one of the most common uses of gradient and slope by engineers is for effective water management. Proper slopes can help direct rainwater away from buildings or other structures and prevent flooding. They also help cities to direct water to specific areas for treatment or to combat the effects of a watershed on homes or businesses.

All these applications of gradient follow the same principles: the steeper the gradient, the more acceleration is possible and the longer an amount of time an object has to accelerate, the greater velocities it can reach. That's why gradient, whether on trails, roads, or in landscaping, is a fundamental factor that influences safety and efficiency in various engineering and design applications.

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 about how natural gradients in the Great Lakes have been turned into epic mountain biking trails. 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 2309** of *Great Lakes Now* called **Building the Ultimate Mountain Bike Trail**.

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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 **gradients.**

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 DETROIT RIVER TRAIL

In this activity, students will read about how a new greenway trail in southeast Michigan aims to promote outdoor recreation, health benefits, and environmental awareness while creating a regional natural resource destination in southeast Michigan.

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 **New Trail Connects People With Secluded Detroit River Wetlands** by John Hartig 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:

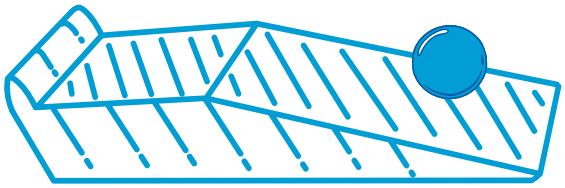
How can individuals and communities get involved in similar initiatives in their own areas to promote conservation and outdoor access?

You can keep this as a class discussion based on the article itself, or this can be extended into a writing assignment, presentation project, or further research on the topic to allow students to engage more deeply with the issue.

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: INVESTIGATING ACCELERATED MOTION

The purpose of this activity is to explore and understand the concept of accelerated linear motion by observing the motion of rolling balls on inclined ramps.



Materials

- Inclined ramps (can be constructed or obtained pre-made)
- Stopwatch
- Meter stick or ruler
- Steel balls (marbles or ball bearings)
- Chart paper or butcher paper
- Markers

First, inform students that they will be investigating the motion of a ball rolling down an inclined plane. Have them form groups of 3-4 and gather their materials.

Next, have students set up the ramps. They should have a low gradient, e.g., a small height to length ratio. They should be 1-2 meters in length. Run paper along one side of the ramp so that marks can be made with the marker as the ball rolls down the ramp. It's crucial that the ramp is long enough and has a low enough gradient for the ball to take at least 3-5 seconds to roll down it.

Then, give students time to perform several trials of their experiments. The procedure should have them releasing the ball at the same time they start the stop watch. Every time 1 second of time passes, the time keeper should say so, calling out something like "now" or counting each whole second as it passes, e.g., "1...2...3..." so that the student in the group who is dabbing the paper with the marker to mark where the ball is each second will know when to make their mark.

Last, have groups make a data table and graph to represent the position v. time of the ball on the ramp during each trial.

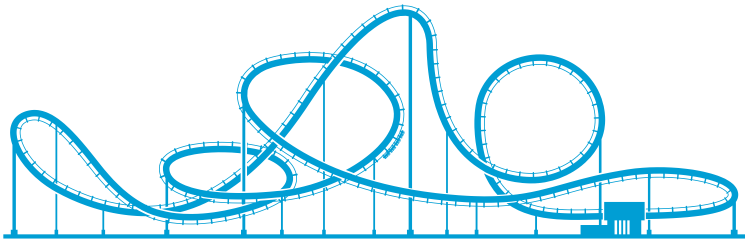
Experimental Trials

1. Have students vary the height of the ramp to increase the gradient to provide three different gradients to measure
2. Students should repeat their measurements 3 times at each gradient to ensure consistency and the proper measurement of position of the ball

Data Analysis and Debrief

1. After marking the paper for each repeated measurement of each gradient trial, students should measure the position from the starting line of their ramp (e.g., the 0 meter line) in centimeters to each dot.
2. To account for variability in their measurements, they can take the average of the measurements they got for each second of time in each trial.
3. They should make a data table that has time in seconds (s) and position in centimeters (cm) for each trial based on the average position measurements.
4. Create a graph that shows the position and time of the ball for each trial based on the averages for each measurement. Use different colors for each trial.
5. Lead a class discussion focusing on interpreting the graphs, including analyzing the slopes of the graph for each time interval (e.g., 0s-1s, 1s-2s, 2s-3s, etc.) and understanding the physical significance of these slopes (their units). Emphasize that cm/s represents the velocity of the ball, e.g., how many cm it travels for every one second, and discuss how the graph's changing shape demonstrates changing velocity, e.g., acceleration with units cm/s/s.

ACTIVITY 4: ENGINEERING A SLOW MARBLE RUN



In this engineering challenge, students will simulate the experience of a smooth mountain bike trail ride, by building a series of interconnected ramps using household materials to guide a marble from one spot in the classroom to a distant location. The goal is to create a track that allows the marble to travel at the slowest, smoothest speed

Materials:

- 1/2" diameter Reusable metal drinking straws (Straight)*
- 1/2" diameter reusable metal drinking straws (Bent)*
- 1/4" diameter steel ball bearings
- Clear plastic tape
- Wooden cubes of varying sizes (e.g. 1" or 2")
- Scissors
- Ruler
- Stopwatch or timer

Alternatively, you can get straight and bent milkshake straws instead

First, inform students that they will be designing and building a track to get a marble to move from one area of the classroom to another in the longest possible amount of time. Have them form groups of 3-4 and gather materials.

Next, specify the starting/ending locations for the track and give students time to plan their designs.

Then, give students a chance to explore the materials and begin building their tracks. Let them know they have a set period of time for testing and refining their designs. Encourage students to time how long it takes for the marble to travel from the start to the finish, and then refine their designs by making modifications that slow down the marble's speed while maintaining a smooth ride. Once the allowed time period is finished, they must stop building their marble runs.

Last, hold a competition where each group will run their marble down their track, and a designated timer will measure the "official" time it takes for the marble to reach the finish. The group with the slowest time wins the competition.

Following the competition, have a class discussion about the engineering process and the factors that affected the marble's speed and smoothness. Emphasize the importance of considering the different gradients at each point in the track they designed and how that related to the marble's acceleration and affected its motion. Ask students to share their thoughts on what worked well in their designs and what challenges they faced. Discuss the importance of friction, slope, and obstacles (such as if any groups made an upward-running part of their track) in slowing down the marble. Finish with discussing what challenges mountain bike trail engineers would face in doing designing a smooth trail ride for bikes.

ACTIVITY 5: GREAT LAKES TRAIL EXPLORATION & DEBATE

The purpose of this activity is for students to research and analyze new and planned trails in the Great Lakes Region in order to develop persuasive argumentation skills through a debate about which trail is, or will be, the best in the region.

Materials:

- Notebooks and pens
- A word processing app or program
- Access to the Internet and research materials
- Digital presentation tools
- Classroom or meeting space

First, inform students that they will work with a partner to research and participate in a debate about the best new and planned trails in the Great Lakes Region. Have students partner up with a classmate. Each pair will be responsible for selecting one trail out of all the trails in the region to argue is the best new or planned trail. Some examples might include the **Michigan Dragon Trail**, Minnesota's Superior Hiking Trail or **Redhead Mountain Bike Park**, the Ice Age Trail in Wisconsin, or a planned trail like the Great Lake-to-Lake Trail in Michigan.

Next, allow students time to research trails and provide them with the following resources to aid in their research:

- **New and Planned Trails Map**
- **Great Lakes Trails List**

Then, guide students to narrow their research and debate planning by emphasizing specific trail features: natural beauty, location, accessibility, amenities, and unique traits. Each group must create a digital presentation or poster with visuals like pictures, maps, and interesting trail facts, regardless of whether the trail is planned or existing.

Last, upon completing research and creating presentations, students should present their trails to the class and make the case for why their selected trail is the best. Counterpoints and questions from the audience are welcome. All students should take notes on each trail they hear about and then vote on the most compelling trail presentations. The top 4 enter into a structured tournament-style debate.

Debate:

Two trails will face off against each other at a time.

- **Format:** The order of the debates will be predetermined (e.g., Trail A vs. Trail B, Trail C vs. Trail D). Debates follow a structured format. During the debate, there will be three timed rounds:
    - presentation (5 min)
    - rebuttal (2.5 min)
    - questions (5 min)
- **Process:** Each pair of trails will take turns presenting their research and making persuasive arguments for why their chosen trail is (or will be) the best to visit in the Great Lakes Region. It's crucial for students to highlight the unique features and attractions of their trail, but they must also point out how their trail directly compares to the trail of their opponent in the debate. Their opponent gets to present their trail in the same way, before each gets a chance for a rebuttal and then in the final round to ask their opponent three questions.
- **Voting:** The winners of the semi-final debates will be determined by popular vote. The winners of the semi-final debates will then proceed to the final debate using the same format. Remind students before voting that factors such as accessibility, natural beauty, trail conditions, recreational opportunities, and uniqueness should be included in their decision of the winner.

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: _____

Notice & Wonder Protocol

NOTICE	WONDER
Things that you noticed about the topic	*Things that you wondered about the topic*

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

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: _____

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.