# GREAT LAKES LEARNING

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

EPISODE 2201 | SPECTACLE REEF LIGHTHOUSE

# LIGHTING THE WAY

*Image Credit: Great Lakes Now*

## OVERVIEW

This lesson will introduce students to the phenomena of **light intensity** and the inverse-square law that governs it by helping them understand how a lighthouse functions to light the way for ships and boats,

## LESSON OBJECTIVES

- **Know** some of the history of Great Lakes lighthouses
- **Understand** the difference between light intensity and luminosity, as well as the inverse-square law of light intensity
- **Be able to** explain how lighthouses provide a lightsource for boats and ships on the waters nearby, and how that lightsource changes with distance

### 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
- Candles
- Magnifying glass
- File folders
- Flashlights
- Meter sticks
- Graph paper
- Paper clips
- Copies of the Student Handouts

## INTRODUCTION

In this lesson, students will be introduced to the phenomenon of light intensity, the inverse-square relationship it has to distance, and how lighthouses leverage the physics of light to help guide ships safely to shore.

They will learn what light intensity, luminosity, and brightness are, understand how the inverse-square law governs the intensity of light at various distances, and construct a model to explain how lighthouses function. The context for this lesson will be the Spectacle Reef Lighthouse.

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

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

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

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

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

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

## NGSS CONNECTIONS

Phenomenon: Light Intensity

- MS-PS4-2.
- SEP-6
- SEP-7
- SEP-1
- MS-PS4-2
- MS-PS4-3
- MS-PS4-4

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

- Class discussion to elicit or activate prior knowledge
- Teacher notes on how light travels
- Close reading a **video**
- Watch a *Great Lakes Now* segment on Spectacle Reef Lighthouse
- Class discussion to debrief video
- Conduct an experiment to measure relative light intensity
- Read about living in a lighthouse
- Create a lighthouse model

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

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

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

# TEACHER BACKGROUND INFORMATION

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

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

Have you ever seen on a show or movie a person using a magnifying glass with sunlight to start some leaves or sticks on fire? What was going on there?

We need to first keep in mind that light travels in straight line paths, called rays, and is made up of photons. That means the light from the sun entering the magnifying glass is really like a bunch of streams of photons—not all that unlike the water that comes out of a shower head.

In starting a fire with a magnifying glass and sunlight, the light from the sun was being concentrated on a certain area using the lens of the magnifying glass. This affected the **light intensity**, a measure of how concentrated light is shining on an area. You can think of it as how many photons reach an area.

But light intensity is separate from the light being emitted from the light source, known as **luminosity**—it's the amount of photons emanating from a light source, such as the sun.

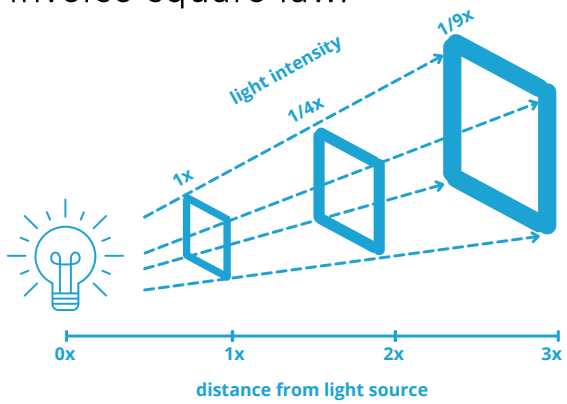
And though it appears brighter in the lens, **brightness** is actually a perception term dealing with how an observer describes the light they are seeing.

Concentrating light using a lens is the basic technique behind how lighthouses generate a light beam that ships or boats can see from a distance.

A magnifying glass near a candle can help to focus more of the light rays (e.g., photons) onto a particular surface, concentrating the light on a smaller area, thus increasing its intensity there. All the meanwhile, the candle is still giving off the same amount of light.

Early lighthouses used special candles or oil lamps to provide a light source, and then used powerful lenses to focus the light in certain directions to create an intense light beam for boats to see. Fire was eventually replaced by incandescent or vapor bulbs and eventually LED lights in modern times.

But light intensity decreases with distance. That's why lighthouses have a certain range at which they can be seen, and it's also why they appear brighter as ships approach them. In fact, that distance-light intensity relationship changes exponentially as we will see in this lesson—it's known as the inverse-square law.




*Light Intensity vs. Distance, Image Credit: Gary G. Abud, Jr.*

# LESSON LAUNCH

## A. Warm Up

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

1. Begin by darkening the room lights and then lighting a candle in front of students. Ask them to observe the light that emanates from the candle.
2. Ask them to draw a diagram of how the candle lights the room and they are able to see the light themselves.
3. Now, ask them to consider what would happen if you put a magnifying glass in front of the candle while it burns. Have them draw a diagram to illustrate their prediction.
4. Then hold the magnifying glass in between the candle and the wall. Ask students to discuss with a partner what they observed.
5. Ask for volunteers to share what changed about the candle light with the magnifying glass in place.
6. Call their attention to the fact that the candle was still the same candle, burning just as much as before, but the way the light was focused by the magnifying glass lens made more of the light reach a certain area.
7. Give them the terms luminosity, to describe the amount of light emitted, and intensity, to describe the amount of light reaching a certain point.
8. Explain to them that today we will be learning about how light travels and how lighthouses light the way for ships.

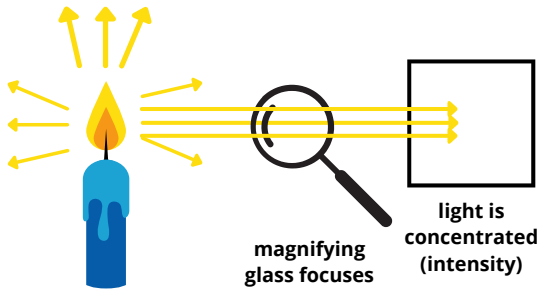



*Image Credit: Gary G. Abud, Jr.*

## 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 water comes out of a shower head and how it differs whether you are close or far away from the water spraying out of the shower head.
2. Ask them to draw a progression diagram in their notebooks to make their thinking visible to each other.
3. Have a few student pairs share out.
4. Draw a summary diagram on for all to see that captures the group consensus of what's happening.
5. Make sure that everyone understands the water spreads out as you get farther away from the sprayer and so you might feel less water pressure even though the shower head is spraying just as much. Connect this to luminosity and intensity of light and the light from the candle.

## C. Close Reading a Video

Inform students that they are about to observe a lighthouse in action in a short video clip. Their task is to pay close attention to what's going on with the light beam emanating from the lighthouse. Show them the **Lighthouse Beams video clip** from *PBS LearningMedia* and have them discuss with a partner and write out 4 sticky notes of observations about what they notice with the lighthouse beam and how it travels. Then, collect and display the stickies for all to see and discuss as a class. Last, ask students to make connections between the video, shower head, and candle demonstration.

## D. Background Information Notes

Explain that this video shows something very important about lighthouses—how they project light—and continue on to provide students notes about 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 video from *Great Lakes Now* that discusses the restoration of Spectacle Reef Lighthouse. 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 segment from episode 2201 of *Great Lakes Now* called, **Spectacle Reef Lighthouse**.

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 candle, asking them:

**How is what we saw in the video the same as what we discussed earlier in this lesson? How is it different?**

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

In this culminating discussion, the goals are to help students make connections between the way a lighthouse projects light for boats and ships to see and the way a candle's light can be concentrated on an area using the lens of a magnifying glass.

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 LIGHTHOUSE LIVING

This activity aims to provide students an understanding of what it's like to live in a lighthouse—and what lighthouse keepers have experienced throughout the history of active lighthouses in the Great Lakes.

They will read about Fairport Harbor West Breakwater Lighthouse in southern Lake Erie. They can also take a visual tour of the lighthouse in **this video version** of the story from *Great Lakes Today*.

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

First, distribute the article* entitled "**What's It Like to Live in a Lighthouse?**" by Elizabeth Miller from *Great Lakes Today*, giving students time individually to read the article, and ask them to jot down 3 things they learned in the article.

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

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

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

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

*Image Credit: Great Lakes Today*

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 do you think living in a lighthouse has changed from the mid-19th century (as described of the Spectacle Reef Lighthouse in the *Great Lakes Now* episode) as compared to modern times (as described of Fairport Harbor West Breakwater Lighthouse in the story of Sheila Consaul?)**

After giving the groups some time to discuss this question, invite conversation from the entire class to compare living conditions in a lighthouse then and now.

**This article is available as an audio podcast, and also a **video**, both linked on the article webpage. Students could listen or watch as a class while they follow the text along in the article on their own.*

***Further Reading on the Subject:***
*An additional article further discussing **the challenges lighthouses face from climate change** is available from* Great Lakes Now *for students to read and discuss with one another, again, using the **Think Pair Square Protocol**.*

# ACTIVITY 3: MEASURING LIGHT INTENSITY [LAB]

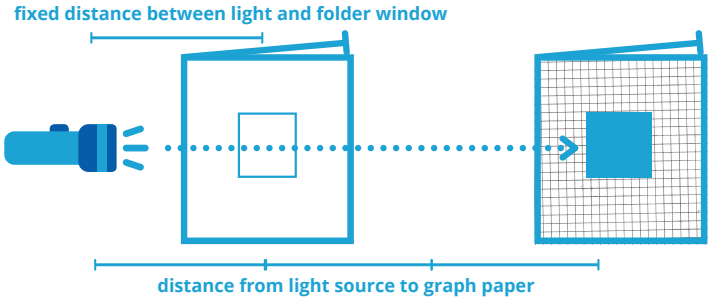



*Image Credit: Gary Abud, Jr.*

The purpose of this experiment is for students to model how light reaches boats from a lighthouse at different distances. They will change the distance from a light source and measure the area illuminated, which they will correlate to light intensity, at each distance.

**Students will need:**

- a file folder with a 5cm x 5cm square cut out of the middle of one side (*window*)
- a file folder with a piece of graph paper clipped onto one side (*ship*)
- a light source, like a flashlight (*lamp*)
- a meter stick or centimeter ruler

First, inform students that they will be working with a group to conduct an experiment to model the functionality of a lighthouse. Just as a lighthouse has a lamp and a window a fixed distance apart, and ships can be close or far away from the lighthouse, so this experiment will have a setup representing each of those components. Demonstrate the lab setup for the whole group, moving the grid close to and far away from the light source, asking students what they observe. Help them focus on how the size of the lit up area changes at each distance.

Ask them to inquire: **how might the illuminated area change with distance, e.g., if it were twice or three times as far away from the light source?** Have groups generate a hypothesis for how they think the illuminated area relates to the distance from the light.

Then, either provide them an experimental procedure or, alternatively, this lab can be done using inquiry approaches where students develop the procedure with teacher guidance. Either way, students can have similar procedure steps but can choose their own distances in cm.

**Sample Procedure:**

1. Choose a starting distance for the setup
2. Shine the light source through the window onto the grid and trace the illuminated area
3. Double the distance by moving the grid farther away, keeping the light source and window stationary.
4. Adjust the location of the grid at the new distance so that the upper left corner of the new lit up area lines up with the first area
5. Trace the new illuminated area on the grid
6. Repeat steps 2-5 for 3x, 4x, etc. distances until students have at least 3-5 traced areas
7. Students should measure the dimensions of each traced region and calculate the area
8. Organize data into a table and line graph of Area (square cm) vs. Distance (cm)

Next, have students come up with a conclusion statement about how the illuminated area changed with distance and compare it to their hypothesis. They should write their statements, table, and graph on chart paper to present their data as posters during the lab debrief.

Last, debrief the lab in a poster presentation format by selecting students to summarize their findings. Sequence student ideas to help them realize that the lit up area increases with the square of the distance, thus distributing the light over a greater area each time and making the light less concentrated, which means the light intensity is decreasing even though the amount of light being shined is staying the same, e.g., luminosity is constant.

Help students connect all these ideas and their findings together so that they arrive at an understanding of the inverse-square law of light intensity, meaning that the light intensity decreases proportionally with the square of the distance, e.g., as the distance doubles, the light intensity decrease by a factor of 4, etc.

Finally, invite them to make connections, between the lab results and the candle demo from the warm up, in order to understand how a lighthouse could increase the intensity of its beam for ships using a lens rather than a light source alone.

## ACTIVITY 4: MODELING LIGHT INTENSITY

The purpose of this activity is for students to create a model that will communicate how lighthouses function to light the way for ships and boats.

First, inform students that they will be working with their groups to create a light intensity model on chart paper that explains how light from a lighthouse is seen by sailors.

Elicit student ideas about what makes for a good model (e.g., a visual representation that explains how something works) and what aspects of light intensity or lighthouse design should be included in their models.

Then, provide students with chart paper and markers, or large dry-erase boards and whiteboard markers, to construct their models with their groups.

Monitor group activity as students work to ensure they are considering the following elements in their models:

- light intensity
- inverse-square law
- luminosity
- effect of using a lens

Guide and redirect students as they work to ensure they are considering all the important aspects of a good model to represent this situation.

Use small group monitoring time to check for student understanding, address their questions, and help students to make connections.

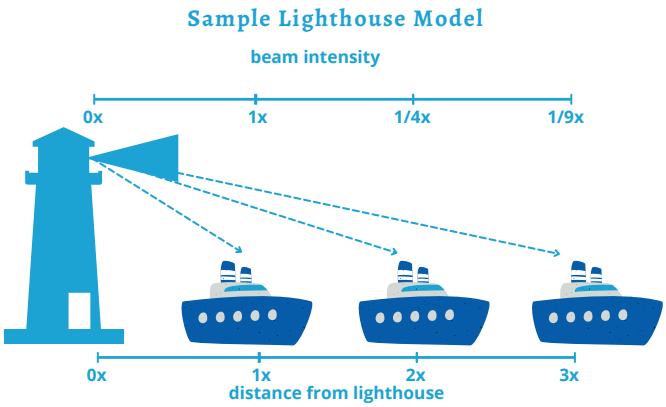



*Image Credit: Gary G. Abud, Jr.*

Next, have students display all of their models next to each other along a wallspace so that everyone can see all of the models. Provide students time to do a gallery walk and examine each group's model.

Last, engage students in a whole-group discussion about the models, getting them to compare, and make connections between, all of the models.

Try to arrive at what an ideal light intensity model for lighthouses would look like based on the best features of all the boards.

When finished, have students sketch the ideal model in their notebooks or make updates to their existing models to account for new learning following the gallery walk.

***Teaching Tip: Guide students to synthesize their learning from the previous activities in this lesson to help them construct their models.***

## 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.***

# STUDENT HANDOUT

**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?

- 

# STUDENT HANDOUT

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*