GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 1031 | SUSTAINABLE SHIPPING

(POLLUTION) FREE SHIPPING

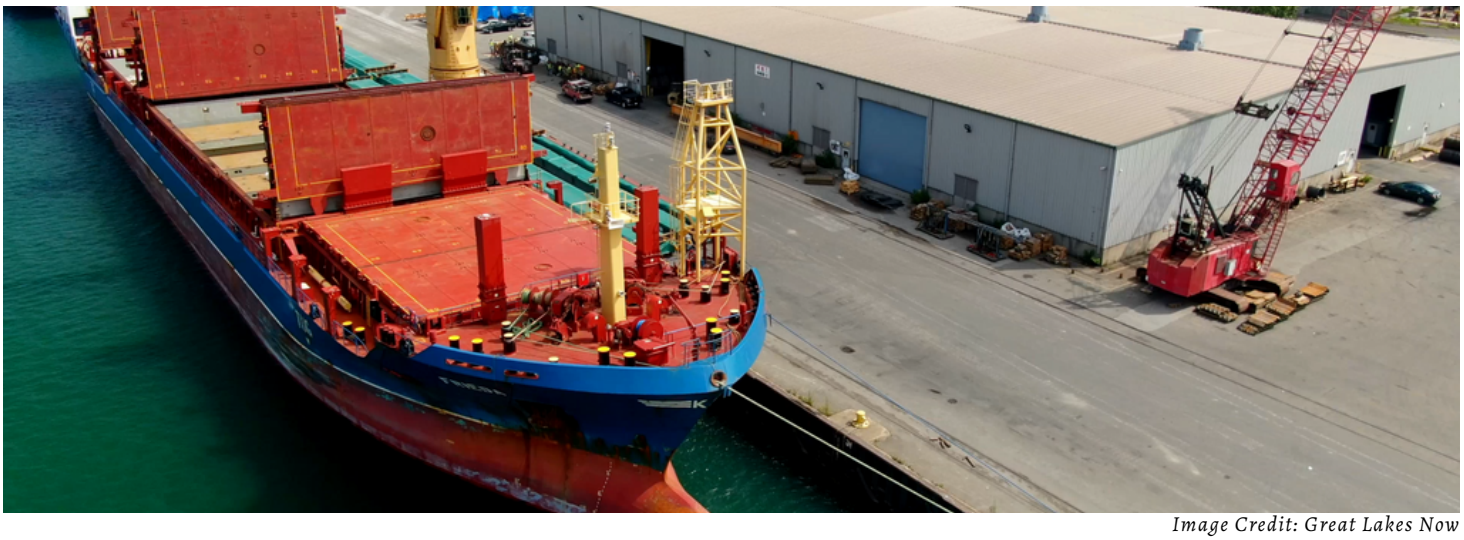


Image Credit: Great Lakes Now

OVERVIEW

This lesson will expose students to the science and engineering practice of **developing and using models**. Through an exploration of measures that the shipping industry is taking to reduce environmental impact, students will investigate possible solutions and mathematically model how they might work.

LESSON OBJECTIVES

- **Know** the problems facing the shipping industry with regard to environmental impact
- **Understand** the measures shipping companies are taking to make their processes "greener"
- **Be able to** develop and use mathematical models to evaluate potential solutions to a problem

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
- Dry erase boards
- Dry erase markers
- Calculators
- Circle-shaped objects
- String
- Meter sticks
- Copies of the Student Handouts

INTRODUCTION

In this lesson, students will be introduced to the phenomenon of industrial pollution, including carbon emissions from idling vehicles, as a basis for using mathematical modeling to evaluate potential solutions to address the problem.

They will learn what a mathematical model is, understand how to develop and use models, and evaluate solutions for minimizing industrial pollution near Indiana Dunes National Park.

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:

- Measurement and graphing data
- slope and y-intercept
- line of best fit
- slope-intercept form of a line

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: Industrial Pollution

- MS-ESS3-3
- SEP-6
- SEP-7
- SEP-1
- ESS3.C
- HS-ESS3-4
- HS-ESS3-1

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 mathematical modeling
- Close reading a **graph**
- Watch a *Great Lakes Now* segment on sustainable shipping
- Class discussion to debrief video
- Read about the certification organization called Green Marine
- Conduct an experiment to develop a mathematical model for circles
- Research solutions to the pollution issues Burns Harbor is addressing
- Use models to simulate the effects of various solutions on pollution

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 lesson closure.

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

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

TEACHER BACKGROUND INFORMATION

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

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

When most people hear "model" they might think of a double-helical figurine of DNA, a diorama of the southwest desert, or a piece of foam that's shaped like a brain. While all of these are examples of models, the term model can also refer to a lot more. In fact, *what you think of* when you hear the word "model" is itself a model for what "model" is in your mind.

Generally speaking, a model is any representation of something else that gives us the power to explain, understand, or predict something else using it. Models can be useful to understand things that are too small to see, too far away to reach, or too large to observe directly. Models can be:

- cognitive (such as a metaphor)
- diagrammatic (such as a weather map)
- graphical (such as a growth chart)
- mathematical (such as the conversion between degrees Celsius and Fahrenheit)
- physical (such as an anatomical skeleton)

Mathematical modeling is a particular way of representing a certain phenomenon, system, or relationship using quantities, variables, or functions.

Essentially, a mathematical model is an equation where the variables stand for physical quantities and allow one to predict the value of a given quantity based off of the others in the equation. Modeling allows for predicting and calculating, or it can numerically show how two quantities are related, and it enables one to **extrapolate** or **interpolate** data—that is, calculate values outside of or in between measured values within a range. Often, a mathematical model represents graphical data.

Take for instance the how temperature in degrees Fahrenheit varies with temperature in degrees Celsius, This relationship between these two temperature scales is mathematically modeled as:

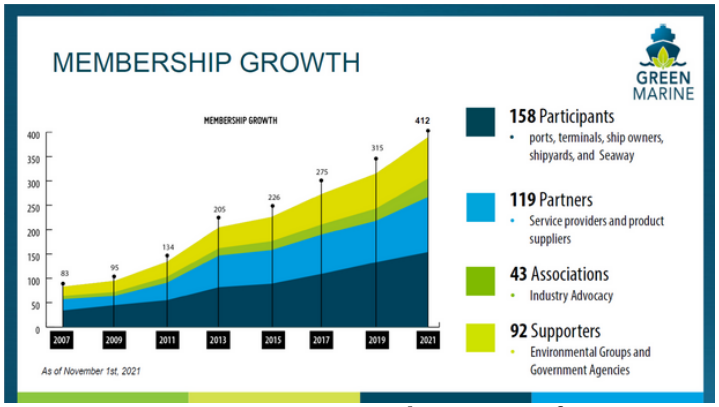
$$°F = (°C \times 9/5) + 32$$

When data is modeled using a graph, it also takes on a mathematical nature, because equations represent the relationships visually depicted in graphs.

Just as using an equation can allow one to *calculate* any value for a given quantity based on the other parameters, a graph can allow one to *look up* values within a range, or even in between measured values, or to use the trends to predict values outside of the given range.

Each of these approaches to mathematical modeling empowers scientists and researchers to make reliable predictions, determine calculations with confidence, and forecast future outcomes based on past ones.

In today's lesson, students will explore a graphical model from Green Marine and try to use it to extrapolate or interpolate data trends.



Graphic Courtesy of Green Marine

They will also develop a model for the relationship between the circumference and diameter of a circle and use it to make predictions about circles that they did not actually measure in their data collection. Finally, they will create models to simulate the conditions, and evaluate the outcomes, of different potential solutions to the industrial pollution problems that are facing the Burns Harbor shipping port.

Ultimately, the skill of developing and using mathematical models is a key skill for students in their work collecting and analyzing data, especially in considering the potential of solutions to address the impact of problems.

LESSON LAUNCH

A. Warm Up

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

1. Begin by asking for a show of hands of how many students have ever heard of someone tracking their height on a wall or door in their home using pencil markings.
2. Invite a couple of students to explain their experience with this. Draw a sketch of this basic height chart for everyone to see.
3. Indicate to them that marking height over time on the wall is a form of something called modeling*—a way of representing information that can be used to explain or predict something about the situation.
4. Show students a clinical growth chart like **this one from the Centers For Disease Control**
5. Have students compare the way that the clinical growth chart maps height to that of the informal height chart on the wall.
6. Point out that both of these are models and can be used to explain or predict the height of a child at a certain age, as well as to indicate how well a child is growing for their age as compared to peers.
7. Explain to them that scientists regularly develop and use models to explain and predict situations that they investigate, and in this lesson they will be exploring the way that models can be used to help address industrial pollution near southern Lake Michigan.

Image Courtesy: 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 using a modified Frayer Model activity to organize their thinking.

1. Distribute the Bridge to Learning handout, asking students to look at the photo from *Great Lakes Now* on it with a partner in order to complete the following in the four corners of the model:
   a. What are the **features** of what you observe in the photo?
   b. What possible **explanations** do you have for what you observe?
   c. What are some possible **causes** for what you observe?
   d. What are other **examples** of what you observe that are similar?
2. Have a few student pairs share out.
3. Summarize student responses in each of the four areas of the model

C. Close Reading a Graph

Provide students a copy of this **graph** from *Green Marine*, which is **also available here** from *Great Lakes Now*, and have them write out 4 sticky notes to answer the following questions with their partner:

1. What do you notice in this graph?
2. What do you wonder?
3. What levels would you expect each category to reach in the year 2023?
4. What is overall trends do you notice in each category over time?

Then, collect and display the stickies for all to see and discuss as a class.

D. Background Information Notes

Explain that this graph is going to be explained more later in this lesson and then provide students notes about mathematical modeling from the Teacher Background Information connecting it to the graph.

Note: use **this math modeling interactive from PBS LearningMedia as a primer if needed.*

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 measures being taken to address industrial pollution in the shipping industry at Burns Harbor by Indiana Dunes National Park. During the video they need to jot down four things they took away from watching 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 1031 of *Great Lakes Now* called, **Sustainable Shipping**.

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 activities, with the discussion of models and growth charts, close reading the graph, and examining the Burns Harbor photo, asking them to discuss how what they saw in the video relates to what they discussed earlier in the lesson.

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

In this culminating discussion, the goals are to help students make connections between the the use of models to organize ideas and explain or predict situations.

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 GREEN MARINE

This activity aims to provide students a better understanding of just what is involved in the measures being taken to achieve sustainable shipping practices.

They will read more about the voluntary efforts that Burns Harbor is involved with through the independent certification organization Green Marine.

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 "**Green Marine: Are voluntary efforts enough to improve port sustainability?**" by Kari Lydersen from *Great Lakes Now*, 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 about the most important point from their discussion and ask for a volunteer in each group to share that most important point with the whole group.

As student groups share out their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks.

Inform them that they will be using some of the information from this article and discussion in a later activity to evaluate solutions to pollution.

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

How does Green Marine utilize mathematical modeling?

After giving the groups some time to discuss this question, open up the conversation to the entire class to discuss the ways that Green Marine might gauge participation and success with various efforts using models.

Further Reading on the Subject:

*Three other additional articles on sustainable shipping are available in this same series by Kari Lydersen from Great Lakes Now. They **are linked at the episode 1031 landing page here** and can be used as further research sources, or an extension activity, for students to read and discuss with one another, again, using the **Think Pair Square Protocol**.*

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

ACTIVITY 3: DEVELOPING A MATHEMATICAL MODEL

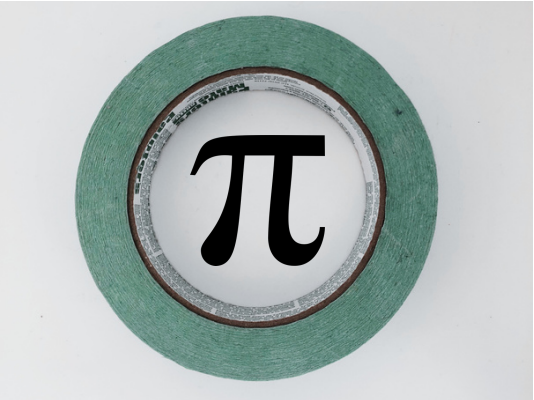


Image Credit: Gary Abud, Jr.

The purpose of this activity is for students to develop a mathematical model for the relationship between the circumference and diameter of a circle. They will accomplish this by taking measurements of several different circles, graphing the circumferences by the diameters of each, and deriving an equation that algebraically represents their graph data.

First, inform students that they will be working with their groups to collect and plot data for the measurements of some different circles. They will need a meter stick, one meter of string, at least five different circles of varying size, and a notebook to record their measurements.

Show them one of the circles and ask them if they could measure the circumference or diameter of the circle. Have them discuss a procedure using the available supplies. Invite a few students to share. Ask them now if they notice any relationship between circumference and diameter for circles.

Help them to notice that the larger the diameter, the larger the circumference seems to be. Ask them to hypothesize how many times bigger it might be and whether that is true for all circles.

Next, allow students time to take the measurements of their circles' circumference and diameter using the string and meter stick. They should record their measurements in a data table.

Then, give students time to graph their data (on chart paper or large dry erase boards) with circumference on the y-axis and diameter on the x-axis. Monitor students to see if they need help scaling their graph or drawing a best-fit line for their data. Have students determine the slope of their best-fit line, as well as the y-intercept value, and then write an equation in slope intercept form (e.g., y=mx+b) with the correct units to represent their line of best fit.

Last, give students a chance to do a gallery walk and see other groups' graphs and equations. Engage students in a discussion about what their graphs and equations, including the slope* and y-intercept, tell us about the relationship between circumference and diameter of circles. Help students to draw a class consensus from all groups' data about this relationship. Inform them that what they've done here is modeled the relationship, and their graph or equation can be used to explain or predict something about circles in general.

Have students test their models by predicting the circumference of a circle that has a diameter five times as big as their largest circle they measured, or what the diameter would be for a circle that had a circumference half as big as the smallest circle that they measured.

Revisit their hypotheses about how many times bigger they predicted the circumference would be compared to the diameter of a circle. Ask how many groups thought their hypothesis was supported by their data. Explain that this is one way scientists use mathematical models.

**Note: the slope value should come very close to 22/7 or ~3.14 (e.g., the number π). You can explain to students that pi is the ratio of circumference to diameter of a circle.*

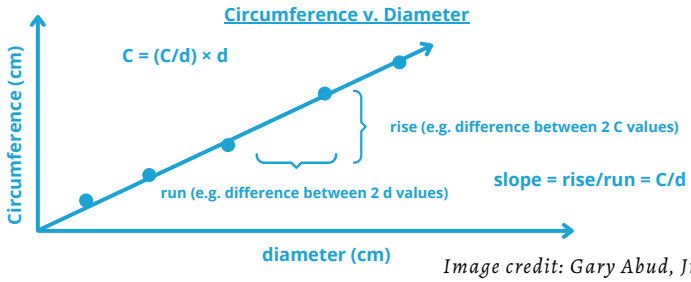


Image credit: Gary Abud, Jr.

ACTIVITY 4: RESEARCHING THE IMPACT OF SOLUTIONS

Image Credit: Great Lakes Now

In this activity, students will further research the solutions being taken by at Burns Harbor to reduce industrial pollution in the shipping industry and investigate the potential of each.

In the *Great Lakes Now* segment, "**Sustainable Shipping**," we saw that Burns Harbor is taking several measures to reduce the industrial pollution on their premises from shipping activity. Measures included:

- planting Jack Pine trees to catch dust and soak up excess stormwater runoff
- using water cannons to reduce dust in the air from the movement and loading of coal
- transporting more cargo by ship/water than by truck/land
- creating "marshaling yards" to reduce the number of idling trucks** generating diesel emissions into the air

First, inform students that they will be working in groups to research possible solutions to the industrial pollution happening at Burns Harbor in the shipping industry. Have groups number off 1-4 and assign each numbered group a different one of the four potential solutions listed above to research and investigate. Let students know that they will need to create a model to show the impact of their solution either using a graph, equation, chart, or some combination of each.

Next, allow students time to research their potential solution. Encourage them to create fictitious data based on what they learn in their research to create a "mock" scenario* that can be mathematically modeled to show possible impact of the solution they are researching.

Then, give students time to create posters (either digital ones using a slide deck creation tool or analog ones on chart paper or large dry erase boards) to showcase their research and mathematical models. Monitor students as they work to help ensure they include a full array of information and correctly model their "mock" scenarios with consistent data in their graphs.

Last, give students a chance to present their posters to one another. Start by having groups who researched similar solutions present to each other and discuss their findings. After, allow groups with different solutions to present to each other and discuss their findings. Once all the groups have presented to each other, engage students in a whole group discuss about which solution they thought had the greatest potential. Invite them to back their claims with evidence and reasoning until a whole-group consensus is reached.

**For example, they could model:*

- *the approximate amount of dust (in kg) that a single Jack Pine tree could catch in a year and then model how that would change with the number of trees.*
- *the amount of carbon emissions a diesel truck gives off per minute and model the amount of emissions saved by having trucks park in a marshalling yard and turn off their engines while waiting.*
- *the number of trucks that would not have to be on the roads for every one additional freighter ship that were used and project that out for more and more ships.*
- *an estimate of the pounds of dust that could be eliminated from the air per pound of water using water cannons.*

***Note: in the video segment, they mentioned figures related to this solution: with 350,000 trucks per year coming through, the marshalling yard could reduce annual emissions on the scale of a single truck running continuously for 13 years.*

LESSON CLOSURE

After the conclusion of all the activities, help students to make connections* between everything they did in the lesson and what they learned overall by:

A. Compare and Connect

Initiate a discussion with students where you ask them to identify ways in which each activity corresponded to the other activities. This could be in terms of what was done, what was learned, or specific moments of the activities that corresponded with others. Guide students to refer to each other's thinking by asking them to make connections between specific features of the activities and how they all connect to the big ideas of the lesson. Make sure to invite students to connect other students' responses to their own ideas in the discussion.

B. Lesson Synthesis

Give students individual thinking and writing time in their notebooks to synthesize their learning, by jotting down their own reflections using the **Word, Phrase, Sentence Protocol.**

In the Word-Phrase-Sentence Protocol, students write:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

C. Cool Down

After the individual synthesis is complete, students should share their synthesis with a partner.

After sharing their syntheses, have students complete a **3, 2, 1 Review** for the lesson with their partner, recording in their notebooks or, optionally, on exit ticket slips to submit, each of the following:

- **3 things** that they liked or learned
- **2 ideas** that make more sense now
- **1 question** that they were left with

Invite several students to share aloud what they wrote in either the synthesis or 3, 2, 1 Review.

Lastly, ask one student volunteer to summarize what has been heard from the students as a final summary of student learning.

**Optionally here, the teacher can revisit the learning objectives and make connections more explicit for students.*

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

NAME: _____

A Word, Phrase, Sentence Protocol

What is a **word** that you thought was most important from this lesson?

What is a **phrase** that you would like to remember from this lesson?

What is a **sentence** that sums up what you learned in this lesson?

3, 2, 1 Review Protocol

What are **3 things that you liked or learned** from this lesson's activities?

-
-
-

What are **2 ideas that make more sense** now to you?

-
-

What is **1 question that you were left with** after this lesson?

-

NAME: _____

Bridge to Learning Activity: Modified Frayer Model

Burns Harbor, Image Courtesy Great Lakes Now

Features of What I Observe

Possible Causes of What I Observe

Other Examples Like This

My Explanation

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