

Lesson Plan: Trigonometry and Sea Level Rise

Teacher-contributed lesson plan by Chirag Dhara, IITM, Pune.

As a **High School Mathematics** teacher, you can use this set of computer-based tools to teach **basic trigonometry**.

Global warming is causing glaciers and ice sheets to melt thus causing sea levels to rise. The rate of sea level rise is a few millimeters per year. While this may seem inconsequential at first glance, it can produce significantly greater inland sea water intrusion over time especially in low lying coastal areas. This lesson plan will enable students to apply simple trigonometric functions to understand this phenomenon.

Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in **Mathematics**.

Use this lesson plan to help your students find answers to:

1. How are trigonometric functions used to study triangles?
2. How can trigonometric functions be used to study coastline retreat because of sea level rise?
3. How much land would be inundated due to sea level rise in the next 10 years? And by 2100?

About the Lesson Plan

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| Grade Level | High school |
| Discipline | Mathematics |
| Topic(s) in Discipline | Trigonometry, Sine Function, Cosine Function, Tangent |
| Climate Topic | Climate and the Hydrosphere |
| Location | Global |
| Access | Online, Offline |
| Language(s) | English |
| Approximate Time Required | 50 – 60 min |

Contents

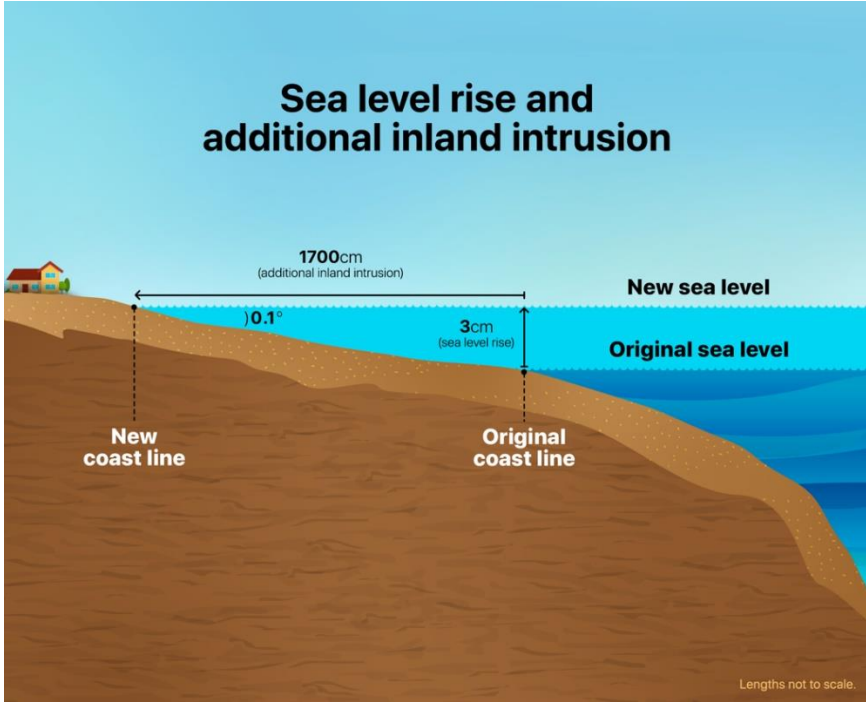
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| 1 | Reading (~25-30 min) | A reading that introduces basic trigonometry concepts and trigonometric ratios in right triangles. This can be accessed at: https://www.khanacademy.org/math/trigonometry/trigonometry-right-triangles/intro-to-the-trig-ratios/a/finding-trig-ratios-in-right-triangles?modal=1 |
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| 2 | Visualization (10 min) | <p>An interactive visualization of the variation in sea level height from 1993 to present day, as recorded by the NASA Goddard Space Flight Centre.</p> <p>This can be accessed at: https://climate.nasa.gov/vital-signs/sea-level/</p> |
| 3 | Classroom/Laboratory Activity (~15-20 min) | <p>A classroom/laboratory activity to use trigonometry to calculate how much the coastline has receded (and will recede in the future) because of sea level rise.</p> |
| 4 | Suggested questions/assignments for learning evaluation | <ul style="list-style-type: none"> • How are trigonometric functions used to study triangles? • How can trigonometric functions be used to study coastline retreat because of sea level rise? • How much land would be inundated due to sea level rise in the next 10 years? And by 2100? |

Step-by-step User Guide

(Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.)

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| 1 | Topic introduction and discussion | <p>Use the resource, 'Trigonometric ratios in right triangles' by Khan Academy, to introduce the simple trigonometric ratios and their relation to right angled triangles. First introduce the basic trigonometric functions like sine, cosine and tangent, and how they relate to the study of triangles and circles. Then, discuss the trigonometric ratios in right triangles and how to use them to solve for unknown sides and angles. Use the embedded video to discuss several examples to enable your students to understand these concepts better.</p> <p>This can be accessed at: https://www.khanacademy.org/math/trigonometry/trigonometry-right-triangles/intro-to-the-trig-ratios/a/finding-trig-ratios-in-right-triangles?modal=1</p> |
| 2 | Discuss further | <p>Use the interactive tool, 'Sea Level' by NASA, to visualize the satellite observations of global sea level rise over time. Explain that global warming is causing the rise in sea levels due to the melting of ice-sheets. Emphasize that the sea levels are rising globally by an average of about 3mm/year.</p> <p>This can be accessed at: https://climate.nasa.gov/vital-signs/sea-level/</p> |

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| 3 | Classroom/Laboratory Activity | <p>Use the following figure, 'Sea level rise and additional inland intrusion' by Chirag Dhara in Firstpost, to explain how sea level rise results in large-scale inundation of the coastline. Use this depiction to explain to your students how trigonometric functions can be used to calculate the extent of land intrusion by the rising sea levels.</p>  <p><i>Credit: Concept by Chirag Dhara. Graphic by Firstpost</i></p> <p>The gently sloping area adjoining the coast is called the Continental Shelf, where the average downward slope is only about 0.1° as shown in the graphic above. Recall the NASA estimate of sea level rise to be about 3cm in 10 years as noted from the previous tool. Now ask your students to calculate the coastline retreat because of sea level rise. Use the tangent trigonometric function to calculate coastline retreat.</p> <ul style="list-style-type: none"> • Discuss how the coastline retreat is disproportionately large for what would seem like a very small vertical rise in sea level. • What could be the implications of rising sea levels on the coastal regions globally? • How much has the coastline approximately receded since the 1850s to the present times? • How much do we expect it to recede by 2100? <p>Answer key: Sea levels have risen over 20 cm since 1850. Sea level is expected to rise further by 30 – 120cm by 2100 (Video; NASA's Earth Minute: Sea Level Rise).</p> |
| 4 | Questions/Assignments | Use the tools and the concepts learned so far to discuss and determine answers to the following questions: |

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| | <ul style="list-style-type: none"> • How are trigonometric functions used to study triangles? • How can trigonometric functions be used to study coastline retreat because of sea level rise? • How much land would be inundated due to sea level rise in the next 10 years? And by 2100? |
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Learning Outcomes

The tools in this lesson plan will enable students to:

- learn the definition of trigonometric functions
- use trigonometric functions to relate the lengths of the sides of a right-angled triangle
- apply trigonometry to understand why even a small sea level rise due to global warming can affect coastlines

Additional Resources

(If you or your students would like to explore the topic further, these additional resources will be useful.)

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| 1 | Visualization | <p>An interactive visualization of NASA's satellite measurements of ice melt from Greenland and Antarctica.</p> <p>This can be accessed at: https://climate.nasa.gov/vital-signs/ice-sheets/</p> |
| 2 | Reading | <p>A reading that describes the effect of rising sea levels due to climate change, in the Sundarbans in West Bengal, India.</p> <p>This can be accessed at: https://www.firstpost.com/india/west-bengals-climate-change-conundrum-part-iii-extraordinarily-rapid-sea-level-rise-in-sundarbans-turns-families-into-refugees-6120781.html</p> |

Credits/Copyrights

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| 1 | Reading; 'Trigonometric ratios in right triangles' | By Khan Academy |
| 2 | Visualization; 'Sea Level' | By NASA: Climate Change and Global Warming |

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| 3 | Image; 'Sea level rise and additional inland intrusion' | Concept by Chirag Dhara , graphic by Firstpost . |
| 4 | Video; 'NASA's Earth Minute: Sea Level Rise' | By Jet Propulsion Laboratory, NASA |
| 5 | Additional Resources | NASA: Climate Change and Global Warming Written by Chirag Dhara , published by Firstpost . |