Tsunami: Catching the Ultimate Wave!

Students use math to gauge tsunami traveling rates and arrival times.

**Author**
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**Grade Level**
6

**Duration**
1 class period

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**National Geography Standards**

<table>
<thead>
<tr>
<th>Element One: The World in Spatial Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information.</td>
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<table>
<thead>
<tr>
<th>Arizona Geography Strand</th>
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<tbody>
<tr>
<td>CONCEPT 1 World in Spatial Terms</td>
</tr>
<tr>
<td>GRADE 6 PO 3 Interpret maps, charts, and geographic databases using geographic Information.</td>
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<tr>
<td>CONCEPT 3 Physical Systems</td>
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<td>Science Strand 3 Concept 1</td>
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<tr>
<td>GRADE 6 Evaluate the effects of, and describe how people plan for and respond to natural disasters.</td>
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</tbody>
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**Other Arizona Standards**

<table>
<thead>
<tr>
<th>Mathematics Common Core Standards</th>
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<tbody>
<tr>
<td>The Number System</td>
</tr>
<tr>
<td>6.NS.3. Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.</td>
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<table>
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<tr>
<th>Extension Idea</th>
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<tr>
<td>Expressions and Equations</td>
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<tr>
<td>6.EE.6. Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.</td>
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</tbody>
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**Overview**

Tsunamis are triggered by earthquakes or underwater landslides and can travel rapidly across even the largest bodies of water. Protecting humans living along the coast requires accurate prediction of the expected arrival of the wave (among other factors). In this lesson, students will determine the length of time for the arrival of a wave from a given point.

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**Purpose**

In this lesson, students will math and geography skills to determine how long it will take for a tsunami to arrive at a given point on a coast.

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**Materials**

- World map or student atlas
- Student Worksheet
- Ruler

**Objective**

The students will be able to accurately calculate the length of time between a tsunami-causing event and the arrival of the tsunami at a coastal point.

**Background Information**

Tsunami is the currently accepted term for the oftentimes very destructive ocean waves that were formerly known as “tidal waves.” That term was dropped in 1963 because the
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The size of the wave out in open ocean may be as little as a few inches or feet over the course of minutes or even hours and ships may not even note its passing.

Coastal areas are always most at risk, but in areas of low topography (such as Florida and many islands), this risk can extend far into the interior. The highest elevation in Florida, for example, is only 105 meters above sea level. One of the dangers of tsunamis is that they are often followed by a second or third wave. Before the first wave and between subsequent waves, the water may withdraw far out to sea, luring people to venture into the exposed shoreline or lulling people into a false sense of security, only to be hit by a second or third wave. Indeed, this sudden withdrawal of water should be used as a serious warning sign of an impending tsunami. A few mega-tsunamis have been postulated that would have generated waves of perhaps 200 meters height or more. One potentially very worrisome event could involve the collapse of the Cumbre Vieja volcano on the western side of the Canary Island of La Palma. One scientist for the USGS has calculated that 100 cubic miles of material could slide into the Atlantic at a speed of up to 200 miles per hour. This could devastate much of the East Coast of the U.S. and Caribbean with waves of 40 feet and up to 300 feet on the nearby coast of Africa. This last appears to have happened 500,000 years ago and is thought by some to be likely in the not so distant geologic future.

In the December 26, 2004 tsunami originating off the island of Sumatra, Indonesia, the tsunami was triggered by a 9.0 scale earthquake as the Indian Plate was subducted (pulled under) the Burma Plate, moving the island of Sumatra an estimated 66 feet and lifting the edge of the overlying Burma Plate by 15 feet.

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Tsunami is a Japanese word that means ”harbor wave”--which, unfortunately, is hardly an improvement over the former term.

Tsunamis are generated by earthquakes, plate movements, volcanic eruptions, underwater landslides, and even asteroid impacts. Imagine lifting one side of a shallow basin of water several inches. Dropping the basin would be analogous to an earthquake and some of the other events. The resulting wave action would correspond to the reaction of the water in the basin. The speed of a tsunami depends on the depth of the water, being fastest in deep water and slower in shallow water (such as when passing over shallow areas or when approaching shore). A tsunami in very deep waters may reach 600 miles per hour. The average speed for the Pacific Ocean is thought to be about 440 miles per hour. But to keep calculations simpler we will use a speed of 500 miles per hour in this lesson. This figure is often used in the literature.

As a tsunami approaches shore and slows to an estimated 30 miles an hour, the height of the wave increases rapidly. The size of the waves generated by tsunamis varies with the strength of the event, but can range between 5 and 15 meters in height when they reach shore. It's difficult to overestimate the power of a wall of water moving at 30 miles per hour, especially when augmented with debris being swept along with the wave. The pressure on a building can exceed millions of pounds.

The wavelength of a tsunami may reach 100 miles or more. The pressure of a tsunami passing through an area extends all the way to the bottom of the deepest oceans. This is the basis for the tsunami warning systems, which utilize pressure sensors on or near the bottom, to detect passing waves.

The pressure of a tsunami when augmented with debris being swept along water moving at 30 miles per hour, especially fast, can exceed millions of pounds.
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An interesting fact is that the tsunami generated by the 1883 blast at Krakatoa (in what is now Indonesia) was phenomenally destructive in the immediate area, but propagated all the way across the Indian Ocean, rounded the Cape of Good Hope, and was detected all the way to Atlantic France, albeit in a much reduced height.

**Procedures**

1. Students will measure the distance from the indicated tsunami generating sites (for example, A1) to the indicated coastal areas (for example, A2) on the map. For this age group, I recommend reviewing measurement skills and map scale skills beforehand. I also recommend instructing them to round distance on the map to the nearest 1/4 inch.

2. Convert distance on the map to miles using the map scale and enter that distance on the student worksheet.

3. Calculate the length of time for the first wave to arrive at the coast by dividing the distance by an average speed of 500 miles per hour and enter the number of hours on the student worksheet.

**Assessment**

Students will be assessed using the student worksheet. Students will be able to successfully calculate travel times for tsunamis within a reasonable margin of error with 80% or higher as seen as mastery.

**Extensions**

1. Research various aspects of the recent December 26, 2004 earthquake and tsunami in the Indian Ocean.

2. Research historic tsunami events. These might include the 1883 Krakatoa, the 1946 Hilo (Hawai‘i), the 1964 Anchorage, the 1998 New Guinea tsunamis, and the 1700 tsunami along the Pacific Northwest coast.

3. Research warning systems, current zoning, evacuation and other regulations for tsunami preparedness.

4. Research innovative architectural techniques for building in tsunami prone areas

5. Point out that the 500 miles per hour rate given in the lesson is a variable. The time could be more or less. Have students recalculate the travel time with different amounts of miles per hour.

**Sources**

These sites give some good background information on tsunamis:

- [http://armageddononline.tripod.com/tsunamis.html](http://armageddononline.tripod.com/tsunamis.html)
- [http://projects.edtech.sandi.net/hoover/tsunamis/](http://projects.edtech.sandi.net/hoover/tsunamis/)
- [http://www.pmel.noaa.gov/tsunami/Faq/x006_speed](http://www.pmel.noaa.gov/tsunami/Faq/x006_speed)
- [http://www.tsunami.org/faq.htm](http://www.tsunami.org/faq.htm)