



## Earthquakes

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## 1. Overview

This lesson covers some of the common mathematical elements required for basic seismology in an activity spanning two class periods. Although this lesson was intended as a supplement to a larger unit on earthquakes presented in Science class, it was structured for students with little to no prior content knowledge would be able to complete the activity. The lesson includes many components of mathematics including: velocity determination, unit conversion, graphing, triangulation, slope, and linear equations.

## 2. Purpose

The purpose of this lesson was to use actual seismic data to illustrate the mathematical component of earthquake studies through basic mathematical concepts and calculations. The incorporation of actual, local earthquake data should provide points of discussion for students in areas of relative seismic inactivity, such as Indiana, while maintaining scientific integrity and providing relevance to the lesson.

## 3. Objectives

The objectives for this project were to:

- Demonstrate the mathematical components of a scientific problem.
- Illustrate how “real-world” problems can be solved using math.
- Provide an opportunity to use critical eight grade math skills, such as rate calculation, graphing, and linear equations.
- Introduce new skills, such as triangulation.
- Illustrate that seismic activity is not confined to plate marginal areas.

## 4. Indiana Eighth Grade Standards Met

### 4.1. Math

#### 4.1.1. **Standard 2 – Computation**

8.2.1 Add, subtract, multiply, and divide rational numbers (integers, fractions, and terminating decimals in multi-step problems).

#### 4.1.2. **Standard 3 – Algebra and Functions**

8.3.1 Write and solve linear equations and inequalities in one variable, interpret the solution or solutions in their context, and verify the reasonableness of the results.

8.3.6 Find the slope of a linear function given the equation and write the equation of a line given the slope and any point on the line.

8.3.7 Demonstrate an understanding of rate as a measure of one quantity with respect to another quantity.

### **4.1.3. Standard 5 – Measurement**

8.5.1 Convert common measurements for length, area, volume, weight, capacity, and time to equivalent measurements within the same system.

8.5.2 Solve simple problems involving rates and derived measurements for attributes such as velocity and density.

### **4.1.4. Standard 6 – Data Analysis and Probability**

8.6.5 Represent two-variable data with a scatterplot on the coordinate plane and describe how the data points are distributed. If the pattern appears to be linear, draw a line that appears to best fit the data and write the equation of that line.

### **4.1.5. Standard 7 – Problem Solving**

8.7.9 Use graphing to estimate solutions and check the estimates with analytic approaches.

## **4.2. Science**

### **4.2.1. Standard 2 – Scientific Thinking**

8.2.1 Estimate distances and travel times from maps and the actual size of objects from scale drawings.

8.2.2 Determine in what units, such as seconds, meters, grams, etc., an answer should be expressed based on the units of the inputs to the calculation.

8.2.4 Use technological devices, such as calculators and computers, to perform calculations.

### **4.2.2. Standard 5 – The Mathematical World**

8.5.2 Show that an equation containing a variable may be true for just one value of the variable.

8.5.3 Demonstrate that mathematical statements can be used to describe how one quantity changes when another changes.

8.5.4 Illustrate how graphs can show a variety of possible relationships between two variables.

8.5.5 Illustrate that it takes two number to locate a point on a map or any other two-dimensional surface.

## **5. Methods**

### **5.1. Materials & Resources**

The materials required for this lesson are:

- Graph paper
- Calculators
- Rulers
- Compasses

## 5.2. Procedures

### 5.2.1. Preparation

Although extensive knowledge of earthquakes and seismology is not required for this activity, the students should have a basic understanding of seismic waves and their importance. If earthquakes have not yet been covered, a brief introduction during Day 1 will be sufficient.

### 5.2.2. Introduction to the Activity

Approximate Time: 15 minutes, depending on pre-existing knowledge. This activity is intended to complement seismic topics presented in Science, and as such, little introduction is needed. In order to convey the practical nature of this activity, it should be emphasized that the data used in this activity was derived from an actual earthquake. The importance of determining the epicenter of an earthquake should also be discussed. At the most basic level, students should be reminded of the definition of an epicenter, the difference between P- and S-waves, the role each plays in earthquake detection and damage, and how waves travel through the crust. A brief review of rate calculations, graphing, and best-fit lines could also be covered, depending upon the students' familiarity with these concepts.

### 5.2.3. Calculations

Approximate Time: 1.5 – 2 periods (75-100 minutes). Students in Algebra and Pre-Algebra should be able to complete the calculations in less than two class periods (~90 minutes). All of the mathematical concepts required for this lesson should have already been covered by the middle of eighth grade. Basic Math students will require additional time and may not have the experience to complete the lesson without teaching new material, such as finding the slope of the line and determining the equation of a line. All students should be able to graph the data and fit a line to the points with minimal review.

### 5.2.4. Discussion and Final Thoughts

Some points for a wrap-up discussion include:

- Location of epicenter (proximity to plate margins)
- Possible causes of earthquake
- Relationship of travel time and distance from epicenter
- Importance of multiple seismic stations

## 6. Scope

For most Pre-Algebra and Algebra classes, completion of the lesson should take no longer than two full class periods (~100 minutes). Additional discussion or introductory material could extend this to three periods. Basic math classes may require additional time or an abbreviated worksheet, as some of the concepts may extend beyond course material.

## 7. Activities, worksheets, and templates

The worksheet and map used in this lesson are attached as appendices at the end of this document.

## 8. Evaluation

This lesson did not utilize pre- and post-testing as students should already have the necessary mathematical background and skills to complete this lesson. The goal of the lesson was not to teach new math concepts; it was intended to serve as an application of basic mathematical concepts to “real world” scientific data. Evaluation in this lesson was based on the worksheet and graph completed by each student.

## 9. Reflection/Lessons Learned/Alterations for future use

- For increased local significance, the epicenter location can be altered by changing the travel times and distances in the given table. This information can be acquired from the IU PEPP Program website (given below).
- If Basic Math classes are not expected to complete the entire activity, the unanswered questions can be removed.
- Although students had a great deal of previous graphing experience, we found it helpful to review the fundamental requirements of a graph, especially in terms of setting the scales on the axes using the range of available data.

## 10. Resources

### 10.1. Indiana University PEPP Program

[HTTP://WWW.INDIANA.EDU/~PEPP/EARTHQUAKES.HTML](http://www.indiana.edu/~pepp/earthquakes.html)

### 10.2. United States Geological Survey

[HTTP://EARTHQUAKE.USGS.GOV](http://earthquake.usgs.gov)

### 10.3. Earthquake Activity

An earthquake with magnitude 5.0 was detected at seismograph stations throughout the United States on June 18, 2002. From the following data, you will determine the location of the earthquake epicenter.

#### **P-wave travel times to selected seismograph stations**

<b>Site</b>	<b>Distance (km)</b>	<b>Travel time (min:sec)</b>	<b>Travel time (sec)</b>
STL		0:36	
WDC		2:02	
MIA	1705	3:16	
SFC	3590	5:46	
NYC	1378		
DUL	1245	2:15	

- 1) Plot P-wave speed (Distance in kilometers vs. Travel time in seconds) on graph paper.
- 2) Using plotted data and best-fit line, interpolate to complete above chart.
- 3) Find and label the epicenter of the earthquake on your map.
- 4) What is the travel time and distance from epicenter to site SAN?

Travel time (min:sec): \_\_\_\_\_

Distance (km): \_\_\_\_\_

- 5) Calculate the speed of the P-wave to site MIA in kilometers per second, kilometers per hour, and in miles per second.
- 6) Determine the equation of the best-fit line. Use this equation to determine the travel time to site SEA.

10.4. Earthquake Map

