

# Example Answers

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Finding Epicenters and Measuring Magnitudes Worksheet

**Objective:** To use seismic data and an interactive simulation to triangulate the location and measure the magnitude of an earthquake.

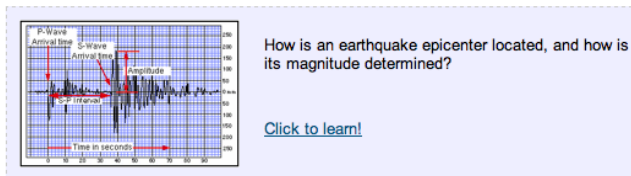
**Materials:** Work in pairs sharing one computer with Internet access.

### Engage:

1. You may have heard news coverage saying something like “the earthquake was a 6.3 on the Richter scale” or “the epicenter was located just outside the city.” Describe in your journal what you think these statements mean. **Student answers will vary.**

**Explore:** Navigate to the *Earthquakes Living Lab* at <http://www.teachengineering.org/livinglabs/earthquakes/>.

2. The Earthquakes Living Lab has four main components to it, each based on one of four historic earthquakes. For this activity, select the “Mexico” box.
3. Take a few minutes to read the information on the left side of this page for the 1978 earthquake at La Paz of Baja California Sur, Mexico. Then locate and click the link in the center of the page under the question: “How is an earthquake epicenter located and how is magnitude determined?”



Examine these four active



[Measuring and locating earthquakes](#)

4. This opens a new window to California State University’s Virtual Earthquake simulation from Geology Labs On-Line at <http://www.sciencecourseware.com/virtualearthquake/VQuakeExecute.html>. Read the first page and then answer the following questions:

- a. What is an earthquake?

An earthquake is a sudden release of stored energy that built up over time as a result of tectonic forces within the Earth. When one side of a fault moves rapidly relative to the other side of the fault, the sudden motion causes shock or seismic waves that travel through the Earth and produce ground motion.

- b. What is a seismic wave?

A seismic wave, also known as a shock wave, is the transferring of energy from one spot to another within the Earth.

- c. What is the difference between S waves and P waves?

P (primary) waves, which are similar to sound waves, come first. The S (secondary) waves, which are a type of shear wave, come second. Within the Earth, P waves can travel through solids and liquids, whereas S waves can only travel through solids.

5. At the bottom of the page, select the Mexico (number 4) location and “submit choices” to continue the simulation.
6. Follow the simulation instructions. As you read and complete the activity, take notes so you can complete the **Explain** questions next.

1.  San Francisco area
2.  Southern California
3.  Japan region
4.  Mexico

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**Explain:**

7. How is an earthquake located?

We locate earthquakes by looking at seismogram recordings of seismic waves, P waves and S waves, because they travel at different speeds and thus arrive at seismic stations at different times. P waves travel faster, so they arrive first. S waves travel at about half the speed of P waves, so they arrive later. The time between the arrival of a P wave and the arrival of an S wave, called the S-P time or S-P interval, measured at three seismic stations can be used to triangulate the epicenter location.

8. What is an epicenter?

The point on the Earth’s surface that is directly above where the earthquake originated, or where the tectonic plates along a fault-line slipped past one another. [In this activity, students find this point through triangulation.]

9. How are S waves and P waves used to determine how far away epicenters are?

To locate the epicenter of an earthquake, you must estimate the time interval between the arrivals of the earthquake’s P and S waves (the S-P interval) on the seismograms from three different stations. The interval is measured to the closest second and then a graph is used to convert the S-P interval to the epicentral distance. Using information from three stations, the epicenter is triangulated.

10. How does distance from the epicenter affect the S-P time interval?

With increasing distance from the earthquake, the time difference between the arrival of the P waves and the arrival of the S waves increases. Put more simply, the higher the time between the S and P waves (the S-P interval), the farther the distance.

| Actual Data  |                     |
|--------------|---------------------|
| S-P Interval | Epicentral Distance |
| 64 sec       | 622 km              |
| 43 sec       | 417 km              |
| 59 sec       | 582 km              |

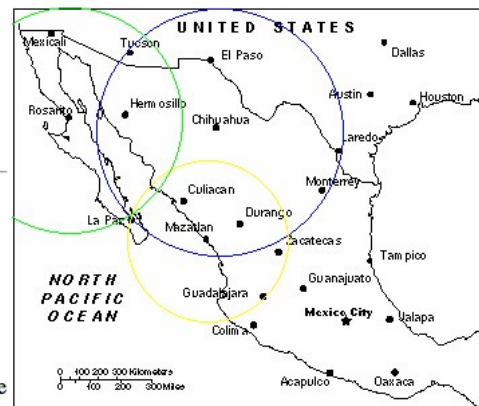
11. Describe the process of triangulation to locate an epicenter.

Triangulation requires seismic data from three centers. First the distance from each center is calculated using the S-P interval and this distance serves as the radius for a circle around the center.

**Triangulation of the Epicenter**

**Excellent work!**

The illustration to the right shows a map of the earthquake region. The three epicentral circles whose radii correspond to the distances you determined in the previous document are drawn around the seismic recording stations. You have successfully located (triangulated) the epicenter of this earthquake.



**More about the epicenter being an exact point.**

The location of the epicenter determined from your measurements of S-P intervals "should" be at the point intersection of the three epicentral circles. In general, using this method to determine an earthquake's epicenter may not result in a precise point. Discounting measurement errors, there are a number of factors that affect the speed of earthquake waves. Among other factors, variations in rock types through which the waves travel will change the actual travel times and hence the S-P intervals. We should not expect the method of triangulation to result in an exact point.

12. What is the “magnitude” of an earthquake? Describe it.

The magnitude of an earthquake is an estimate of the total amount of energy released during fault rupture. Since the 1930s, earthquakes have been measured using the Richter magnitude scale, and

now big earthquakes are measured using the moment magnitude scale; both scales essentially rank the power (energy release) of the earthquake.

13. What data is used to determine magnitude?

The magnitude determination is based on seismic data. A graphical device, called a nomogram, is used to estimate the magnitude from the earthquake's data. A nomogram requires two measurements: the S-P time interval (which yields distance) and the maximum amplitude of the seismic waves.

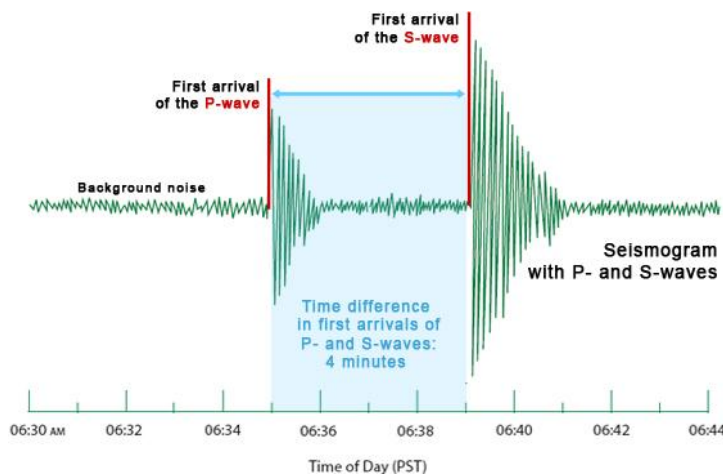
**Elaborate:**

14. Why might the triangulation method not always produce an exact point (other than any measurement errors)?

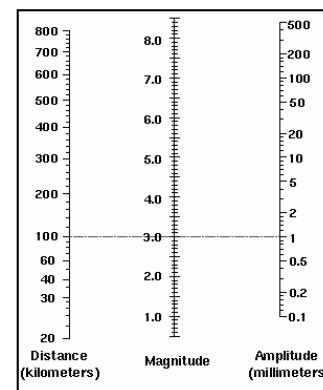
Triangulation assumes that the seismic waves traveled at the same velocities to all three seismic stations. In reality, ground material composition may differ between stations and the waves may travel at different speeds. As it states on the introduction page, the speed of an earthquake wave is not constant but varies with depth and rock type. Further, S waves can only travel through solids, and not through liquids, which is another factor to consider for stations near bodies of water.

15. How does distance from the epicenter affect the magnitude (height) of the seismograph reading?

The magnitude decreases as the distance increases. Thus, the distance must be calculated first, in order to calibrate the magnitude.



**Magnitude Scale**



This concept is explained on the Richter nomogram page: a 100 km-away earthquake of magnitude 4 produces 10 mm of amplitude, while a magnitude 5 produces 100 mm of amplitude; 10 and 100 are all powers of 10, a good example of why the magnitude scale is said to be exponential: a change of one unit in magnitude (say from 4 to 5) increases the maximum amplitude by a factor of 10.

**Evaluate:**

16. Some scientists and educators believe seismology (locating, measuring and predicting earthquakes) is a very reliable science and will one day allow us to predict future earthquakes. Other scientists and educators believe seismology is not a very exact science. Write a paragraph (or more) to express your opinion on this topic. Based on what you learned in this activity, is locating and measuring earthquakes a well-defined science? Be sure to include details from the **Explore** and **Elaborate** questions. Including some sketches and/or images is helpful, such as an image of a seismograph with key features labeled to support your explanation.

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This is an opinion-based question, but expect students to bring in what they know about triangulation/distance calculation, seismograms/nomograms and/or the magnitude scale.

17. How do you think engineers use seismic data? Include specific examples.

Engineers use seismic data in many ways: to possibly predict future earthquakes (at least general predictions, not very specific), to design buildings to withstand certain magnitudes, to locate particularly active fault planes, etc.

*Congratulations—you have completed this activity!* Feel free to complete the “virtual seismologist” information at the end of the simulation to get your virtual certificate. For more practice, return to the beginning of the simulation and complete the steps again for one or more of the other locations.