Teacher Guide: Seismic Waves: Locating the Epicenter

Series Gizmos Investigation

Overview



Grade Level: 6–8

Subjects: Physical Science, Earth & Space Science

Time: 90 min

Topic: Earthquakes, Waves

Arjun is a student who lives in San Francisco. After experiencing a strong earthquake, he starts an internship at the US Geological Survey. Under the mentorship of seismologist Dr. Robles, Arjun learns about wave characteristics, how to interpret a seismogram, and how to use data from multiple seismograph stations to find the z of an earthquake.

Student Learning Objectives

By the end of this lesson series, students will be able to:

- Identify wave characteristics, including wavelength and frequency.
- Compare particle motion in transverse, longitudinal, and combined waves.
- Describe how changes in amplitude and frequency affect wave power.
- Determine how changes in tension and density affect wave speed.
- Identify P and S waves on a seismogram.
- Use the P–S wave time difference to determine the distance to the earthquake epicenter.
- Use information from three seismograph stations to determine the epicenter location.

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Summary

Lesson 1

Driving Question	Practices	Learning Outcomes
What are seismic waves?	Planning and carrying out investigations, analyzing and interpreting data	Connect seismic waves to types of wave motion, identify P and S waves on a seismogram.

Connection to next lesson: In Lesson 2, students will use the speed differential between P and S waves to determine the distance of an epicenter to a seismograph station.

Lesson 2

Driving Question	Practices	Learning Outcomes
How do we determine the distance to an epicenter?	Planning and carrying out investigations, analyzing and interpreting data	Determine the distance to the epicenter based on the P–S wave time difference.

Connection to next lesson: In Lesson 3, students will use data from three seismograph stations to locate the epicenter.

Lesson 3

Driving Question	Practices	Learning Outcomes
How do we locate the epicenter?	Planning and carrying out investigations, analyzing and interpreting data, constructing explanations	Understand that earthquakes occur along faults, locate the epicenter.

NOTE: Need additional support implementing this Gizmos Investigation in your classroom? Check out our other resources under the "Supplemental Resources" section of this Investigation on our website!

Standards Alignment

Gizmos Investigations are designed to align with the Next Generation Science Standards. This is achieved through addressing the three dimensions of disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs). These correlations should also apply to other states' standards that similarly reference DCIs, SEPs, and CCCs or their equivalents (although individual states' numbering schemes will likely differ).

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Please note that our alignment is specifically to the **middle grades (grades 6-8)** level learning goals for the below-listed DCIs, SEPs, and CCCs.

Disciplinary Core Ideas (DCI)	Science and Engineering Practices (SEP)	Crosscutting Concepts (CCC)
PS4.A Wave Properties A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. **ESS3.B Natural Hazards** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.	**Planning and Carrying Out Investigations** Collect data to produce data to serve as the basis for evidence to answer scientific questions. **Analyzing and Interpreting Data** Analyze and interpret data to provide evidence for phenomena. **Using Mathematics and Computational Thinking** Apply mathematical concepts and/or processes to scientific problems and questions. **Constructing Explanations** Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.	**Patterns** Graphs, charts, and images can be used to identify patterns in data. **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Scale, Proportion, and Quantity** Proportional relationships among different types of quantities provide information about the magnitude of properties and processes. **Energy and Matter** Energy may take different forms.

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The *Seismic Waves: Locating the Epicenter* Series builds toward the following NGSS Performance Expectations (PEs):

- **MS-PS4-1:** Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
- **MS-PS4-2:** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
- **MS-ESS3-2:** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Prior Knowledge

Prior to completing this Gizmos Investigation, students should know the following:

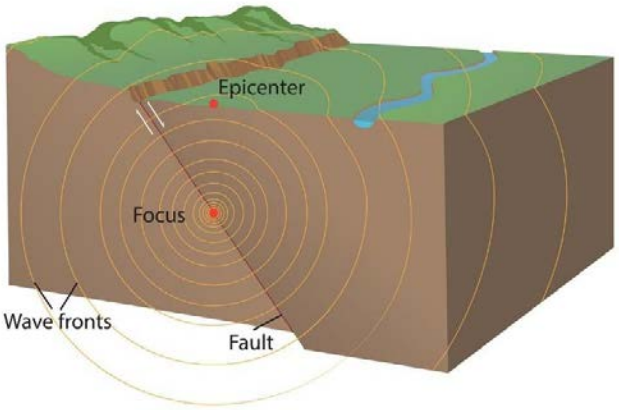
- Waves can differ in amplitude and wavelength.
- A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions, severe weather, floods, coastal erosion). Humans cannot eliminate natural hazards but can take steps to reduce their impacts.

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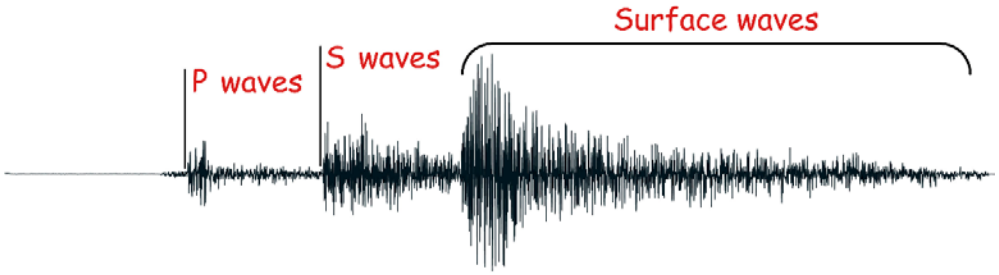
Seismic Waves: Locating the Epicenter—Scientific Background

Most earthquakes occur along cracks in the ground called *faults*. Faults (and earthquakes) are common where plates meet, such as along California's San Andreas Fault, which runs from San Francisco to Los Angeles. Plate movements cause the rock on either side of the fault to move very slowly. If the rock becomes stuck along part of the fault, tension can build up until the rocks move violently and suddenly. This is an earthquake.

When an earthquake occurs, *seismic waves* emanate outward from the *focus* of the quake, where the rocks moved below Earth's surface. The *epicenter* is the point on Earth's surface directly above the focus where the shaking is first felt.



There are three types of seismic waves. The first type are primary waves, or P waves. Along the P wave, the bedrock moves back and forth, parallel to the direction of the wave. This is an example of a longitudinal wave. Next are the secondary waves, or S waves. As an S wave passes, the bedrock moves side to side at a right angle to the direction of the wave. When P and S waves reach the surface, they combine to form rolling surface waves, causing the ground to move in a circular motion as the waves pass. Because they combine the energy of P and S waves, surface waves are the largest and most destructive waves. The three types of waves can be identified on a seismogram, which shows the level of shaking over time.



Because P waves travel through bedrock more quickly than S waves, the time difference between the P- and S-wave arrival times increases with distance from the epicenter. This can be used to measure the distance from the epicenter to the seismograph station. By using data from three seismograph stations, the exact location of the epicenter can be triangulated.

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Seismic Waves: Locating the Epicenter—Key Vocabulary

Students: Draw pictures to support your learning of key vocabulary words from the Gizmos Investigation.

Glossary Term	Definition	Picture
Earthquake (URTH kwayk)	An **earthquake** is shaking and vibration of Earth's surface. Most earthquakes are caused by sudden motion of rock near a *fault*.	
Fault (FAWLT)	A **fault** is a fracture, or crack, in Earth's crust where the rocks on either side have moved.	
Focus (FOE kuhs)	The **focus** is the place in Earth's crust where an earthquake begins.	
Epicenter (EH puh sen ter)	The **epicenter** of an earthquake is the spot on Earth's surface directly above the focus.	
Seismic waves (SIZE muk wayvz)	**Seismic waves** are vibrations produced by earthquakes.	
Seismograph (SIZE muh graf)	A **seismograph** is an instrument that measures and records ground vibrations.	
Seismogram (SIZE muh gram)	A **seismogram** is a graphical record of ground vibrations produced by a seismograph.	
Wave (WAYV)	A **wave** is a repeating motion that travels through a medium such as a spring or rock.	

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Glossary Term	Definition	Picture
Transverse wave (TRANZ vurs wayv)	In a **transverse wave**, the motion of the medium is at right angles to the direction of the wave.	
Longitudinal wave (lon juh TOO dun nuhl wayv)	In a **longitudinal wave**, the motion of the medium is parallel to the direction of the wave.	
Amplitude (AM pluh tood)	**Amplitude** is the maximum distance a particle in the medium moves from its rest position as the wave passes.	
Frequency (FREE kwen see)	**Frequency** is the number of waves that pass through in a given period of time.	
Rest position (rest puh ZI shun)	The **rest position** is the original position of a particle of the medium before the wave passes through.	
Power (POW ur)	**Power** is the rate at which work is done. Wave power increases with amplitude, frequency, and density of the medium.	
Primary waves (PRY meh ree wayvz)	**Primary waves**, or P waves, are longitudinal seismic waves. They are the fastest-moving seismic waves.	
Secondary waves (SEH kuhn deh ree wayvz)	**Secondary waves**, or S waves, are transverse seismic waves. They move more slowly and are more powerful than P waves.	
Surface waves (SUR fuhs wayvz)	**Surface waves** are large, destructive seismic waves that form when primary and secondary waves reach the surface and combine.	

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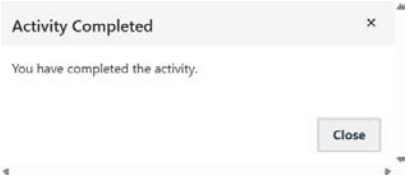
Seismic Waves: Locating the Epicenter—Usage Guide

This guide provides recommendations for using the *Seismic Waves: Locating the Epicenter* Investigation Series in your classroom and offers general information about Gizmos Investigations for new users.

In this Investigation, students explore the properties of seismic waves. In the first lesson, students study transverse and longitudinal wave motion, explore how amplitude, frequency, and tension affect wave power and wave speed, and determine the wave properties of primary and secondary waves. In the next two lessons, students identify P and S waves on a seismogram, use the time difference to estimate distance to the epicenter, and use data from three seismograms to determine the epicenter location.

Classroom Pacing Schedule (Series)

This Investigation Series should take approximately three class periods (about 90 minutes). Each lesson has an "End of Lesson" screen that can serve as a pause point for students.

Period	Minutes	Investigation Section	Heatmap Questions*	Students STOP when they see this screen
1	30	Lesson 1 Students explore the properties of seismic waves.	1–12	
2	30	Lesson 2 Students identify P and S waves on a seismogram and determine the distance to the epicenter.	13–22	
3	30	Lesson 3 Students use data from three seismograms to locate the epicenter of an earthquake.	23–32	

**Question numbers are not visible to students; questions are numbered only in the Heatmap for teachers.*

Series vs. Standalone Lessons

Our lesson platform offers both **series** and **standalone** lessons to support flexible use in a variety of classroom contexts. Teachers can choose to implement an entire sequence of lessons or use a single lesson independently, depending on instructional goals, student readiness, and available time.

Series Lessons

- Designed to be taught in a specific order, with each lesson building on the ideas, models, and evidence from previous lessons.
- Students revisit and revise models, refine explanations, and apply their learning to new scenarios over time.

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- Encourage deeper understanding of disciplinary core ideas, crosscutting concepts, and science and engineering practices through a coherent storyline.
- Ideal for comprehensive instruction, sustained engagement, and performance-based assessments.

Standalone Lessons

- Fully self-contained and can be used independently from other lessons in the series.
- Include necessary background or recap content to ensure all students can engage meaningfully, even without completing prior lessons.
- Useful for targeted instruction, intervention, enrichment, or aligning to specific standards or pacing needs.
- Designed to deliver meaningful learning outcomes in a single class or unit without requiring prior knowledge from other lessons.

Recommendation

Use **series lessons** when you want students to explore a phenomenon over time, develop and revise models, and connect concepts across multiple lessons. Use a **standalone lesson** when you're focusing on a specific concept, skill, or standard—or when time constraints require a more flexible instructional approach.

Teacher Preview Version

We highly recommend that teachers complete a preview version of an Investigation before assigning it to their class. In the teacher version, each page functions as it would for your students, so you can preview feedback, scaffolding, and other support tools. You can use this version to familiarize yourself with the activities that students will complete. You can also use it to review concepts with your class by presenting them via a projector or smartboard.

Heatmap

The heatmap is a tool available for all Investigations that allows teachers to observe their students' current thinking and monitor student progress in real time. It can also be used to determine what additional support students might need in the content and practices involved, individually or as a class.

Some questions are automatically graded and instantly populate the heatmap with a score and color, while others are categorized as "teacher graded." These questions require a teacher to grade a student's response for points to be awarded. All teacher-graded questions are provided with rubrics to support grading.

Prior Knowledge

Throughout the Investigation, students are encouraged to share their current thinking and preconceptions to help relate new information they explore to their prior knowledge and experiences. These questions are shown on the heatmap with a purple lightbulb and labeled as "Conversational Questions."

Formative Assessment

Students are assessed on their learning by answering questions and receiving feedback as they progress through the Investigation. Students can check their understanding and receive targeted feedback when answering questions to discover if they have a misunderstanding. Students receive three tries on a formative question, listed to the left of the submit button.

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Formative questions are color-coded within the heatmap to help teachers best support students. Detailed "scoring criteria" within the question view explains how colors were assigned for the heatmap question. The heatmap color codes are based on colors distributed across three percentage categories:

Mastered	Developing	Below Expectations
75–100%	50–75%	0–50%

Summative Assessment

Additionally, some questions within the Investigation are labeled as summative. These questions reflect moments where students have had ample opportunity to practice their understanding of a concept or skill and are thus assigned points after a single attempt to judge their current knowledge. These questions are color-coded in the heatmap using the same percentages described above. The only difference here is that students are only given one attempt to answer a summative question. Summative question point values are the only points included in the total on the heatmap. Teachers can use these question types to assess students' knowledge or skills to better support learning in their classroom.

While rubrics are provided for teachers to score free-response summative questions, we recommend considering your own understanding of student abilities when assigning points.

Student Support and Accessibility

Investigations include the following supports to help students further their learning.

Vocabulary Support

- The Key Vocabulary handout provides definitions and phonetic pronunciation for all key vocabulary terms used in the Investigation. The handout also includes space for students to draw pictures to help them learn these terms.
- Teachers can preview vocabulary using the handout to help support students before starting the Investigation.

Writing Support

- Where applicable, sentence stems are provided for open-response questions to help students structure their writing.
- For some open-response questions, key vocabulary terms are automatically highlighted in green when included in student responses. This helps reinforce student vocabulary usage.
- Validation feedback is triggered for open-response questions when students submit vague answers or skip important vocabulary. This feedback guides students toward complete and meaningful responses. There is a checkbox at the bottom of this type of feedback so that students can move forward if they choose without getting stuck.

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