EARTHQUAKE HAZARD INVESTIGATION

Observe • Measure • Calculate • Locate • Analyze • Recommend

Name: ________________________________	**Class Period:** __________	**Date:** ____________________

THE CHALLENGE You are part of a regional hazard team. Locate a mystery earthquake using three seismic stations, analyze simulated historical patterns, and recommend a technology or action that could reduce community impacts.

Driving Question

How can earthquake data help communities prepare when scientists cannot predict the exact time of an earthquake?

1 Read and Think

Build the background needed to interpret the model.

READING THE RECORD A seismogram records ground motion at one station. P waves travel faster and arrive first. S waves arrive later. As a station gets farther from an earthquake, the time between the P- and S-wave arrivals generally becomes larger. Scientists use measurements from multiple stations to estimate an epicenter. Historical patterns can help estimate where hazards are more likely, but they cannot identify the exact date and time of the next earthquake.

1. Which wave should appear first on each station record? ☐ P wave ☐ S wave ☐ They arrive together

2. A larger S-P time gap usually means the station is: ☐ closer ☐ farther away ☐ at the epicenter

3. In your own words, what is the difference between an earthquake focus and its epicenter?

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4. Why are records from several stations more useful than a record from only one station?

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5. Before opening the model, which evidence do you think will be most useful for deciding where a community should prepare? ☐ one earthquake ☐ historical patterns ☐ building and ground conditions ☐ all three

Explain your choice.

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KEY TERMS Seismogram: a record of ground motion. Epicenter: the point on Earth's surface above the focus. Mitigation: an action or technology used to reduce harmful effects.

2 Create and Record the Mystery Event

Choose the model settings, trigger the event, and preserve the starting information.

Event setting	Model selection or result
Scenario	
Magnitude	M ______
Focus depth	________ km
Guided mode	☐ On ☐ Off
Event notes	

WAIT FOR THE RECORDING Do not begin clicking until all three station records have finished.

3 Pick P and S Arrivals

Click the first small motion for P, then the later larger motion for S.

Station	Sensor setting	P arrival (s)	S arrival (s)	Pick check
A - Northwest	Bedrock			☐ Accepted
B - Northeast	Valley			☐ Accepted
C - Southern	Foothill			☐ Accepted

Which station appears to be closest to the earthquake before you calculate? Use the visible record as evidence.

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4 Calculate Station Distances

Use the same two-step process for every station.

MODEL EQUATIONS S-P gap = S arrival time - P arrival time • Distance = S-P gap × 8.4 km

Station	Show S - P calculation	S-P gap (s)	Show gap × 8.4	Distance (km)	Circle applied
A	______ - ______ = ______		______ × 8.4 = ______		☐
B	______ - ______ = ______		______ × 8.4 = ______		☐
C	______ - ______ = ______		______ × 8.4 = ______		☐

Which station is closest based on your calculations? ☐ A ☐ B ☐ C
Which station is farthest based on your calculations? ☐ A ☐ B ☐ C
Describe the relationship between S-P gap and calculated distance.

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5 Triangulate the Epicenter

Apply all three distance circles and place the estimate at their closest overlap.

Triangulation check	Your result
Distance circles applied	_____ of 3
Estimated map zone	☐ North ☐ Central ☐ South
Nearest community	
Near a fault zone?	☐ Yes ☐ No ☐ Unclear
Marker accuracy / error shown	________ km
Hidden epicenter revealed after check?	☐ Yes ☐ No

ROUGH MAP RECORD Make a quick sketch of the three circles, their closest overlap, nearby communities, and the fault zone. This does not need to be perfectly scaled.

Northwest Station A

Northeast Station B

Southern Station C

Why does one distance circle not identify a single epicenter?

Why does the overlap of three circles produce a stronger estimate?

MEASUREMENT ERROR A small error in a wave pick changes the radius of a distance circle. If an S-P gap is 2 seconds too large, the calculated radius will be ______ km too large. Show your work: $2 \times 8.4 =$ ______ km.

How could that radius error change the estimated epicenter?

After comparing your estimate with the revealed epicenter, your estimate was: ☐ very close ☐ somewhat close ☐ far away

Identify one specific change that would improve your estimate on another trial.

6 Analyze Hazard Patterns

Filter the simulated historical record twice and compare the evidence.

IMPORTANT Patterns can help estimate locations and likelihoods. They do not predict an exact date or time. All historical records in this model are simulated for learning.

Measurement	Dataset A	Dataset B
Minimum magnitude	M ______	M ______
Time window		
Events shown		
Largest magnitude	M ______	M ______
Events near fault		
North zone count		
Central zone count		
South zone count		

Which filter did you change between Dataset A and Dataset B? ☐ minimum magnitude ☐ time window ☐ both

What changed in the number or distribution of events after you changed the filter?

Which zone is most strongly supported as a higher-hazard zone? Use at least two numbers from your table.

Do these records prove that the next earthquake will occur in that zone? ☐ Yes ☐ No

Explain what the pattern supports without claiming an exact prediction.

FORECAST LANGUAGE Strong: "The filtered records suggest that…" or "This zone may have a greater likelihood because…" Avoid: "The next earthquake will definitely happen…"

7 Compare Community Risk

Combine hazard evidence with exposure and vulnerability.

RISK IS MORE THAN LOCATION A community can face greater consequences because of population, buildings, utilities, and ground conditions. Soft sediment may increase shaking compared with firm rock.

Community	Information from model	Hazard evidence from map/data	Vulnerability or consequence	Priority rank
Ridgeview	Older buildings • Firm rock • Moderate population			
Riverbend	Soft river sediment • Dense utilities • High population			
Pine Junction	Newer buildings • Firm rock • Lower population			

Which community should receive the highest priority? Do not use only one factor.

8 Plan a Risk-Reduction Recommendation

Choose one action or technology from the model and connect it to the community's needs.

Planning decision	Your response
Priority community	
Mitigation technology or action selected	
Hazard pattern evidence	
Community vulnerability evidence	
How the action could reduce impacts	
Possible cost, trade-off, or limitation	

Why is the highest-magnitude event not automatically the only evidence that should guide the decision?

What additional real-world information would a hazard team need before spending money on this plan?

9 Make the Final Recommendation

Write a claim, support it with evidence, and explain the science behind the decision.

PROMPT Which community should be prioritized, and which technology or action should it use to reduce earthquake impacts?

CLAIM Name the community and the recommended action.

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EVIDENCE Include at least three pieces of evidence: one from the epicenter investigation, one from the hazard-pattern data, and one from the community information.

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REASONING Explain why the evidence supports the priority and how the action could reduce impacts even though it cannot stop or exactly predict an earthquake.

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10 Critique the Model

Identify what the simulation represents and what it simplifies.

1. Are the map locations and historical events real records? ☐ Yes ☐ No - they are simulated

2. Does the model use constant wave speeds and a simplified Earth? ☐ Yes ☐ No

3. Identify one real-world factor the model leaves out or simplifies.

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4. Explain how that limitation could affect an epicenter estimate or hazard recommendation.

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NGSS FOCUS 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. Science and Engineering Practice: Analyzing and Interpreting Data. Disciplinary Core Idea: ESS3.B Natural Hazards. Crosscutting Concept: Patterns.

Science sources: U.S. Geological Survey, “The Science of Earthquakes,” “Locating Earthquakes in the Yellowstone Region,” and “The 2023 National Seismic Hazard Model”; Next Generation Science Standards, MS-ESS3-2. Model data and communities are simulated for classroom learning.