Exploring Earthquakes

Activity-Stations Kit

Activity A. Modeling Faults

Most earthquakes occur along tectonic plate boundaries. These boundaries create cracks or *faults* in the Earth's crust. At divergent plate boundaries, or areas where plates are spreading apart, rocks are subjected to stretching forces known as *tension*. Tension can pull apart rocks and create *normal faults*. A normal fault occurs when a portion of rock drops downward relative to another portion of rock (see Figure A1). Normal faults are the result of the expansion of the Earth's crust.

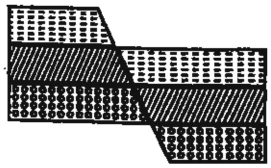

Figure A1. Normal Fault

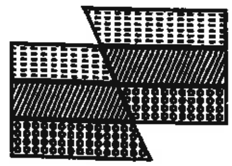

Figure A2. Reverse Fault

Reverse faults occur when one portion of rock is pressed upwards relative to another portion of rock (see Figure A2). Compression forces at convergent plates (areas where plates are being pushed together) are responsible for reverse faults. The compression pushes on rocks causing them to bend and break and move along a reverse fault surface.

A *transform* or *strike-slip fault* occurs where two portions of rock slide past one another without much upward or downward movement (see Figure A3). Rocks exposed to strike-slip faults are subject to *shearing*. Shearing forces push on rocks from different directions. As the rocks move past each other, their surfaces rub against each other and cause a large amount of strain or twisting. In these areas stress is increased, and as the rocks reach their elastic limit, they break and an earthquake results. Strike-slip faults may be categorized as either left-lateral or right-lateral. If the portion of rock on the opposite side of the fault from the viewer is displaced to the left, a left-lateral strike-slip fault results, and when the rock is displaced to the right it is a right-lateral strike-slip fault.

Figure A3. Strike-Slip Fault

Pre-Lab Questions *(Answer on a separate sheet of paper.)*

Read through the *Background* section for Activity A.

A1. Describe the forces that are responsible for divergent plate boundaries and the type of fault that results.

A2. Describe the forces that are responsible for convergent plate boundaries and the type of fault that results.

A3. How is a strike-slip fault different than a normal or reverse fault?

Type of Fault	Sketch	Description of Forces and Observations
Normal		
Reverse		
Strike-slip		

Post-Lab Questions *(Answer on a separate sheet of paper.)*

1. What is the relationship between faults and earthquakes?
2. What happened to the river as the land sections shifted along the strike-slip fault? How would this affect the course of the river?

Activity B. Elastic Rebound

The rocky plates that make up the Earth's crust are in constant motion. The interactions of these plates create *faults*, or cracks, that offset the Earth's crust. Continuous movement of the plates builds up pressure until the rocks along a fault shift or break, releasing energy that causes an *earthquake*. The cycle of gradual build-up and release of stress along a fault is known as the *elastic rebound* theory, first proposed by American geologist Henry Fielding Reid (1859–1944). Reid was part of a task force commissioned by the state of California to investigate the 1906 San Francisco earthquake. Reid closely examined the surface ground displacement caused by the 1906 earthquake. By investigating data from surveying records, he realized that some ground displacement occurred away from the fault before the earthquake. He concluded that stress built up slowly along the fault until the strain was suddenly released by slippage of the fault. Reid compared the energy released by the rebound of the fault to that of a rubber band breaking when it was stretched too far. Even though the theory of continental drift was proposed by German scientist Alfred Wegener (1880–1930) shortly after Reid's theory, it would be more than a half century later before the movement of the Earth's plates would be connected to earthquakes along fault lines.

Pre-Lab Questions *(Answer on a separate sheet of paper.)*

Read through the *Background, Safety Precautions,* and *Procedure* sections for Activity B.

B1. What does the movement of the chain of rubber bands represent? What does the block of wood represent?

B2. What safety precautions are necessary for this activity?

Data Table B

Block Slippage	Pencil Position (cm)	Leading Edge of Block (cm)	Distance Block Slipped (cm)	Distance Rubber Band Chain Stretched (cm)
Start			N/A	N/A
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Post-Lab Questions and Analysis *(Answer on a separate sheet of paper.)*

1. Determine how far the block moved for each slippage event and fill in the third column of the data table for *Distance Block Slipped*. For example, if the starting position for the block was 10 cm, and when the block slipped the first time it came to rest at 15 cm, the block slipped 5 cm. This is recorded in the second row of the third column for block slippage #1.
2. Determine how far the rubber band chain was stretched for each slippage event and fill in the last column of the data table. For example, if the pencil point started at 35 cm and had been moved to 45 cm when the block slipped for the first time, the rubber band chain stretched 10 cm. This is recorded in the second row of the last column for block slippage #1.
3. What caused the block to slip? Describe the forces involved and the transfer of energy that took place from one slippage event to the next.
4. For each block slippage event, compare the distance the rubber band chain stretched to the corresponding distance the block slipped. Describe any relationship between the two distances. *Optional:* Create a graph that shows the stretch of the rubber bands compared to the distance the block slipped.
5. How is this model similar to the elastic rebound cycle of faults created by the Earth's tectonic plate movement? How is it different?
6. How does this activity explain the unpredictability of earthquake occurrence and magnitude? How are seismologists able to forecast the probability that an earthquake is likely to occur and how great it might be?

Activity C. Seismic Waves

When the rocks along a fault shift or break, energy is released that causes an earthquake. This is similar to what happens when you snap your fingers. The force between your fingers increases until the fingers suddenly slide past each other. The "snap" is caused by the release of energy in the form of sound waves. Energy from an earthquake is transmitted through the Earth in the form of vibrations known as seismic waves (from the Greek word *seismos,* to shake or quake). Seismologists determine the magnitude of an earthquake—the energy released at the source of the earthquake—by studying seismograms which detect and record the vibrations of seismic waves. Two types of seismic waves travel outward from the focus (origin within the Earth) of an earthquake. The primary wave, or P-wave, is a compression wave that forces rock to compress and expand in the same direction the wave travels. P-waves travel through the Earth at an average speed of about 5 kilometers per second. Secondary waves travel at a slower rate, averaging about 3 km per second. Secondary or S-waves are transverse waves in which the vibrations displace matter perpendicular to the direction the wave is moving.

Pre-Lab Questions *(Answer on a separate sheet of paper.)*

Read through the *Background* and *Safety Precautions* sections for Activity C.

C1. Compare and contrast primary and secondary waves.

C2. What safety precautions are necessary when working with thc Slinky?

Data Table C

	Wave Motion	Movement of String	Comparing Lesser vs. Greater Compression
Compression Wave			
	Wave Motion	**Movement of String**	**Comparing Lesser vs. Greater Displacement**
Transverse Wave			

Post-Lab Questions *(Answer on a separate sheet of paper.)*

1. How does the string show that the coils of the spring do not move from one end of the string to the other but that energy is being transferred along the spring?
2. How does a greater displacement of the spring relate to the magnitude of an earthquake?

Activity D. Resonance

An earthquake with a magnitude of 8.5 struck Mexico on September 19, 1985. Mexico City, 250 miles from the epicenter, sustained considerable damage. A high percentage of 6- to 12-story buildings suffered damage while a very small number of one- and two-story buildings were damaged. A 48-story building experienced only minor damage—a few broken windows. While many variables affect the amount of damage a building suffers as a result of an earthquake, the natural frequency of a building is a contributing factor.

All objects including buildings have a *natural frequency* or set of natural frequencies at which they vibrate. The frequency of a vibration is the number of back and forth cycles *(oscillations)* that occur per second. The natural frequency of an object depends on its size and composition. Seismic waves traveling through the ground cause the ground to vibrate at its natural frequency. If the natural frequency of the ground matches the natural frequency of a structure built on that ground, then the motion of the building will be amplified, resulting in a vigorous oscillating movement. This higher amplitude oscillation is known as *resonance*. A common occurrence of resonance is a child being pushed on a swing. If the push is given in rhythm with the natural frequency of the swing, the child will swing higher and higher.

Pre-Lab Questions *(Answer on a separate sheet of paper.)*

Read through the *Background* and *Safety Precautions* sections for Activity D.

D1. Define the following terms.

a. Frequency

b. Resonance

D2. Why should safety glasses be worn during this activity?

Frequency	Observations
Low	
Medium	
High	

Post-Lab Questions

1. Summarize the observed relationship between the resonance frequency and the length of the wire.

2. Based on your observations, do any of the wires share the same natural frequency? Give reasons for your answer.

3. Based on your observations, explain why a high percentage of the 6- to 12-story buildings described in the Activity D *Background* section suffered considerable damage during the 1985 Mexico earthquake, while shorter and taller buildings did not.

Name: ______________________________

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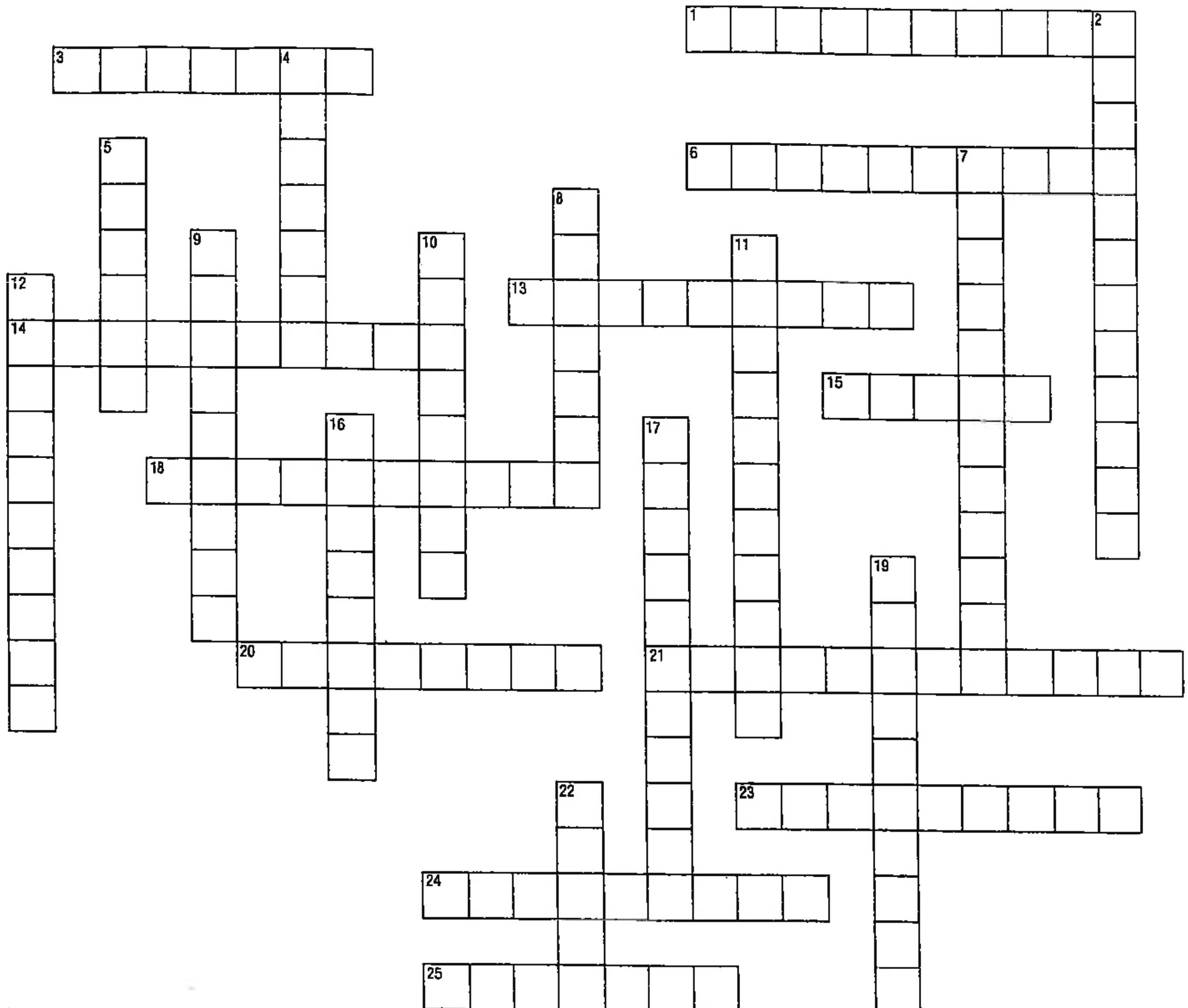

Across

1 Motions created within the Earth that release energy when rocks along a fault exceed their elastic limit.
3 The type of seismic wave that reaches a seismograph station first.
6 Famous strike-slip fault in California. (2 words)
13 The rate of vibrations.
14 When a crowd at a stadium does "the wave," they are modeling this type.
15 A fracture within the Earth where rock movement occurs.
18 The phenomenon studied by seismologists.
20 Force that resists movement along a fault.
21 How much stress an object can withstand and still return to its original shape. (2 words)
23 A transverse seismic wave.
24 Determined by triangulation from the arrival of seismic waves for at least three seismograph stations.
25 Force that creates a normal fault.

Down

2 Vibrations that spread out from the focus of an earthquake. (2 words)
4 A fault where one portion of rock is pressed upwards relative to the adjacent rock.
5 A fault caused by pulling forces.
7 A type of strike-slip fault that causes objects to move to the right of their original position. (2 words)
8 The most destructive of the seismic waves; they spread out from the epicenter.
9 Two or more objects vibrating together at the same natural frequency.
10 Builds up as a result of friction along a fault.
11 Looking across a fault line, you see an old river bed that has moved to the left of its original position. (2 words)
12 Type of fault formed when plates slide past each other with little vertical movement.
16 Strike-slip faults experience this type of force.
17 A pushing force.
19 The study of earthquakes and the vibrations they produce.
22 The origin of an earthquake within the Earth.