4. Investigating Seismic Waves

Damping Vibrations

Driving Question

Do earthquake vibrations continue forever?

Materials and Equipment

- ☐ For each student or group:
- ☐ Data collection system
- ☐ Light sensor
- ☐ Sensor extension cable
- ☐ Meter stick
- ☐ Lamp stand with clear, incandescent, 60 to 100 watt light bulb
- ☐ Table (same height as lamp stand)
- ☐ Books (if needed to raise lamp stand to height
- ☐ of table
- ☐ Tape
- ☐ Clay

Safety

Add this important safety precaution to your normal laboratory procedures:

- Do not look directly at the 60 to 100 Watt lamp. Permanent damage to your eyes may result.

Thinking about the Question

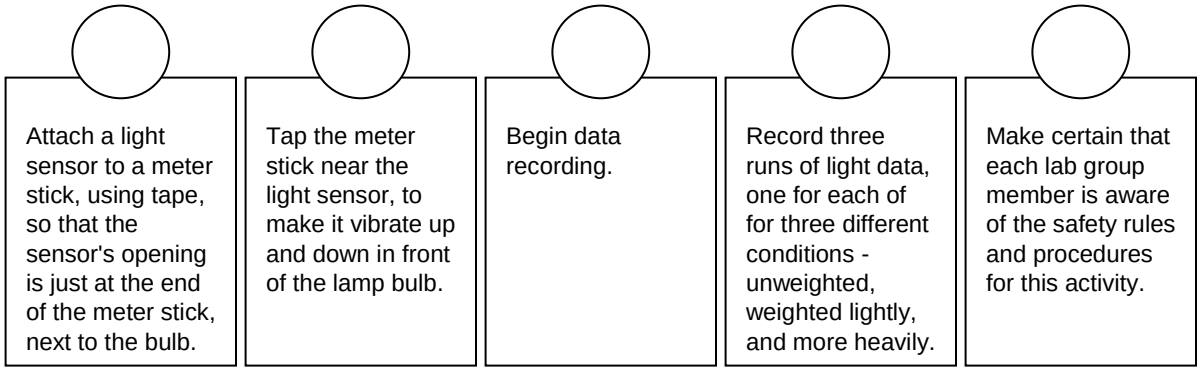
During an earthquake the shaking caused by the motion of the earth damages buildings and other structures. There are two major kinds of shock waves. Body waves that travel within the earth have the highest velocity, the lowest amplitudes, and cause the least amount of damage to human-made structures. Body waves may be compression waves called P-waves, or shear waves called S-waves. P-waves deform the earth's crust in the same way that a spring stretches and compresses. S-waves deform the earth's crust in the same way that an ocean wave "deforms" the smooth, calm surface of the water. Surface waves have the lowest velocity, the highest amplitudes, and cause the most damage.

Have you ever felt an earthquake? Whether an earthquake was small or strong, scientists can record and display the earth's vibrations.

Discuss with your lab group members what types of construction techniques may help to protect buildings from damage caused by an earthquake's vibrations.

Sequencing Challenge

☐ **The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.**



Investigating the Question

☐ **Note:** When you see the symbol "◆" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – Set up and earthquake simulation

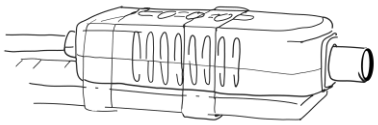
1. ☐ Start a new experiment on the data collection system. ◆(1.2)

2. ☐ Connect a light sensor to the data collection system using a sensor extension cable. ◆(2.1)

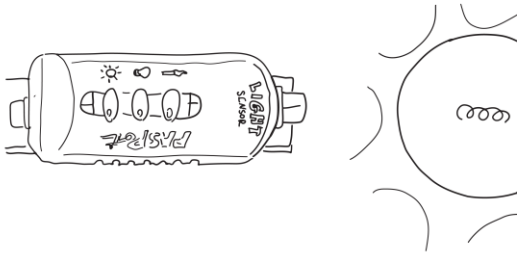
   ☐ Note: The light sensor should be set to the 0 – 26,000 Lux sensitivity.

3. ☐ Display Light intensity on the y-axis of a graph with Time on the x-axis. ◆(7.1.1)

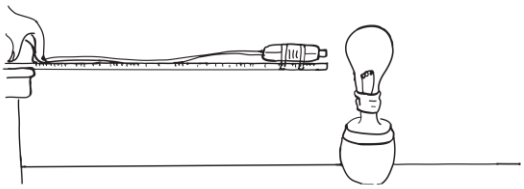
4. ☐ Attach the light sensor securely to the end of the meter stick with tape.



5. ☐ Extend the meter stick over the end of a table with the light sensor directed at the center of the incandescent bulb mounted in the lamp. If necessary, use some books to raise the lamp bulb to the proper height.



6. ☐ Place the meter stick on the table with around 50 centimeters extended toward the lamp. Support the meter stick with your hand. Make sure that all connecting cords to the sensor are free of the meter stick.



7. ☐ Make sure the meter stick is aligned with the center of the bulb. The distance separating the meter stick and the bulb should be around 10-20 centimeters depending on the wattage of the bulb.

8. ☐ Try practicing consistent jolting or tapping the meter stick at the end to produce a vibration on the meter stick to prevent any side-to-side movement.

9. ☐ Start monitoring live data. ◆(6.1)

10. ☐ Try several "earthquakes" on the same graph. Adjust the placement of the lamp if necessary, since the light sensor will show saturation or a flat line if it is too close. If this occurs, move the lamp further away from the light sensor.

11. ☐ Stop monitoring data. ◆(6.1)

12. ☐ Start data recording. ◆(6.2)

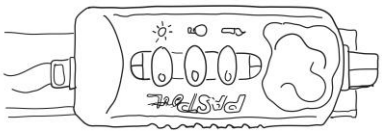
13. ☐ Tap the meter stick to begin an "earthquake." The meter stick should stop vibrating before 30 seconds have elapsed.

14. ☐ Carefully observe the motion of the meter stick.

15. ☐ Stop data recording. ◆(6.2)

Part 2 –Vibrations on light-weighted buildings

16. ☐ Add a clump of clay to the light sensor mounted on the meter stick. Be careful to avoid pushing the clay down into the buttons or into the opening.



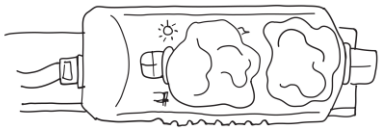
17. ☐ Start data recording on the same graph. ◆(6.2) The meter stick should stop vibrating before 30 seconds has elapsed.

18. ☐ Carefully observe the motion of the meter stick.

19. ☐ Stop data recording. ◆(1.2)

Part 3 – Vibrations on heavier-weighted buildings

20. ☐ Add another piece of clay to the top of the light sensor.



21. ☐ Start data recording on the same graph. ◆(6.2) The meter stick should stop vibrating before 30 seconds has elapsed.

22. ☐ Carefully observe the motion of the meter stick.

23. ☐ Stop data recording. ◆(6.2)

Answering the Question

Analysis

1. The light sensor taped on the meter stick is a model for a building undergoing vibrations during an earthquake.

   a. What part of this model represents the ground?

_____

   b. What part of this model represents a light-weight building? A heavy-weighted building?

_____

_____

   c. What does the tape represent?

_____

2. Describe the vibration of the meter stick. Did the vibrations remain the same, increase, or decrease? If the vibration increased or decreased, did it do this in a consistent manner?

3. Look back over your graph and find a region of data where you can count the number of vibrations in a 10-second period of time. How many vibrations occurred in this period of time in the first "earthquake" from Part 1?

4. How many vibrations occurred in a 10-second period of time in the "earthquakes" in Part 2 and Part 3?

5. How did the increase of mass from the addition of clay change the vibration?

6. Why did the vibrations die out?

True or False

☐ **Enter a "T" if the statement is true or an "F" if it is false.**

_____ 1. Seismic waves travel through the earth but not across the earth's surface.

_____ 2. A more massive building is affected by seismic wave vibrations in exactly the same way a much lighter building is.

_____ 3. Another way to say that vibrations "die out" is to say that they are damped.

_____4. Ten vibrations in one second is the same thing as ten seconds per vibration.

_____5. Earthquake vibrations travel differently through different types of material.

_____6. Energy may be transferred from the earth to a building, and then from the building back to the earth, during an earthquake.

_____7. One of the tools scientists use to gain more information about earthquakes is a seismograph.

Key Term Challenge

☐ **Fill in the blanks from the randomly ordered words below:**

vibrations	amplitude	seismic waves	ground
damped	seismograph	seismic	damage

1. Scientists monitor seismic activity using an instrument called a/an _____ which records vibrations at and beneath the earth's surface.

2. The _____ of a vibration or wave describes how big the vibration is, while the frequency tells how many times each second the vibration occurred.

3. Buildings that withstand earthquakes often have some means of damping _____.

4. Surface waves are a type of _____ that cause the ground to ripple during an earthquake.

5. If the amplitude of a vibration continues to get smaller as time goes on, the vibration is said to be _____. Such vibrations, then, do not continue forever.

6. One factor that can influence the size and frequency of vibrations a building experiences during an earthquake is the type of _____ on which it is built.

7. The waves that travel through the earth and across its surface during an earthquake are called _____ waves.