Name: ________________________________ Date: _______________ Period: _______

Seismic Waves Lab

Please write on this paper. Complete parts 1-3 and turn in your completed lab in the clear tray for a classwork grade!

Part 1: Read the following information about seismic waves and complete the concept map and wave labeling.

Types of Seismic Waves

There are several different kinds of seismic waves, and they all move in different ways. The two main types of waves are **body waves** and **surface waves**. Body waves can travel through the earth's inner layers, but surface waves can only move along the surface of the planet like ripples on water. Earthquakes radiate seismic energy as both body and surface waves. Traveling through the interior of the earth, **body waves** arrive before the **surface waves** emitted by an earthquake.

The first type of body wave is the **P wave** or **primary wave**. This is the fastest kind of seismic wave, and, consequently, the first to 'arrive' at a seismic station. The P wave can move through solid rock and fluids, like water or the liquid layers of the earth. Sometimes animals can hear the P waves of an earthquake. Dogs, for instance, commonly begin barking hysterically just before an earthquake 'hits'. Usually people can only feel the bump and rattle of these waves.

The second type of body wave is the **S wave** or **secondary wave**, which is the second wave you feel in an earthquake. An S wave is slower than a P wave and can only move through solid rock, not through any liquid medium.

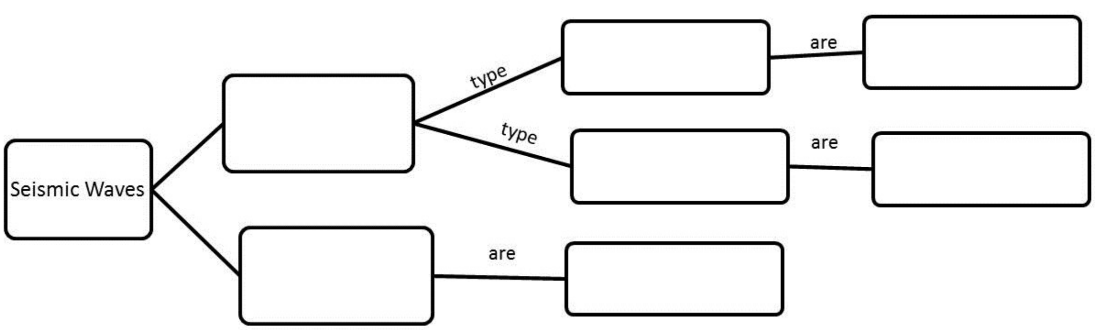
Travelling only through the crust, **surface waves** are of a lower frequency than body waves, and are easily distinguished on a seismogram as a result as a very large looking wave. Though they arrive after body waves, it is surface waves that are almost entirely responsible for the damage and destruction associated with earthquakes. This damage and the strength of the surface waves are reduced in earthquakes where the focus is deep underground.

Complete the *concept map* below by choosing one item from the item bank for each box. A *concept map* organizes information starting with more general (Seismic Wave) to more specific information as you read right to left.

Item Bank

Body Waves		Primary Waves		Only moving through solid rock		Responsible for damage
Secondary Waves		Surface Waves		The fastest wave		

Concept Map

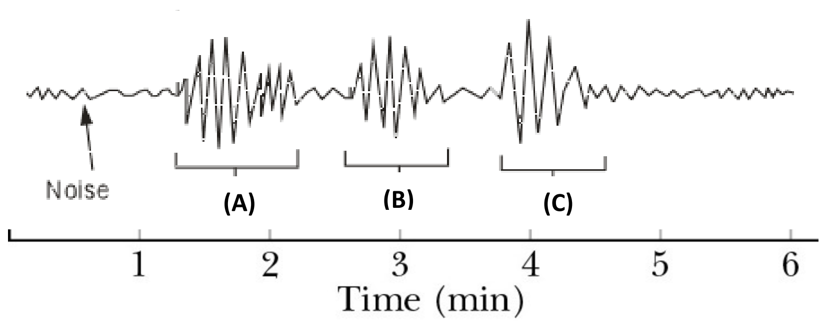


Label the parts of the wave by writing the appropriate letter in each blank.

_______ **Surface Wave**

_______ **Primary Wave**

_______ **Secondary Wave**



Part 2: Find the epicenter of the earthquake by using the date below and the provided reference information on the last page of the lab.

Introduction

The epicenter of an earthquake is determined by **triangulation**. This means that seismic data is needed from at least three different locations, and where this data intersects tells us the epicenter.

When an earthquake occurs, it is recorded on numerous seismographs located in different directions. The seismograms at these locations show when the first seismic waves, the P waves, arrive and then when the next waves, the S waves, arrive.

Knowing how fast each of these waves travel, scientists can calculate how far away the epicenter was from each seismograph. What they don't know is the precise direction the waves came from–the direction of the epicenter.

Scientists then must use a map. Around each of three seismograph locations, a circle is drawn on the map with a radius that equals the known distance to the epicenter. These three circles intersect at a single point. This point is the location of the earthquake's epicenter.

Data Table from Three Seismograph Stations

	Station 1 **Rochester, NY**	**Station 2** **San Diego, CA**	**Station 3** **Juneau, AK**
Intensity Description	Felt by almost no one.	Tremor noticed by many, but they often do not realize it is an earthquake.	Felt indoors by many. Feels like a truck struck the building.
Mercalli Scale Number			
Time of P-Wave Arrival	1 minute	30 seconds	15 seconds
Time of S-Wave Arrival	5 minutes	3 minutes & 30 seconds	3 minutes & 30 seconds
(S Arrival Time) - (P Arrival Time)			
Distance to Epicenter (km)			

Procedure

1. Using the reference pages, decide on the number for the earthquake felt at each station. Record the values in the proper row in the *Data Table*. Don't forget to write the numbers as Roman numerals!

2. Calculate the difference between the S-Wave arrival time and the P-Wave arrival time for each of the three stations. Record the values in the proper row in the *Data Table*.

3. Using the reference pages, determine the distance to the epicenter in kilometers for each of the three stations. Record the values in the proper row in the *Data Table*.

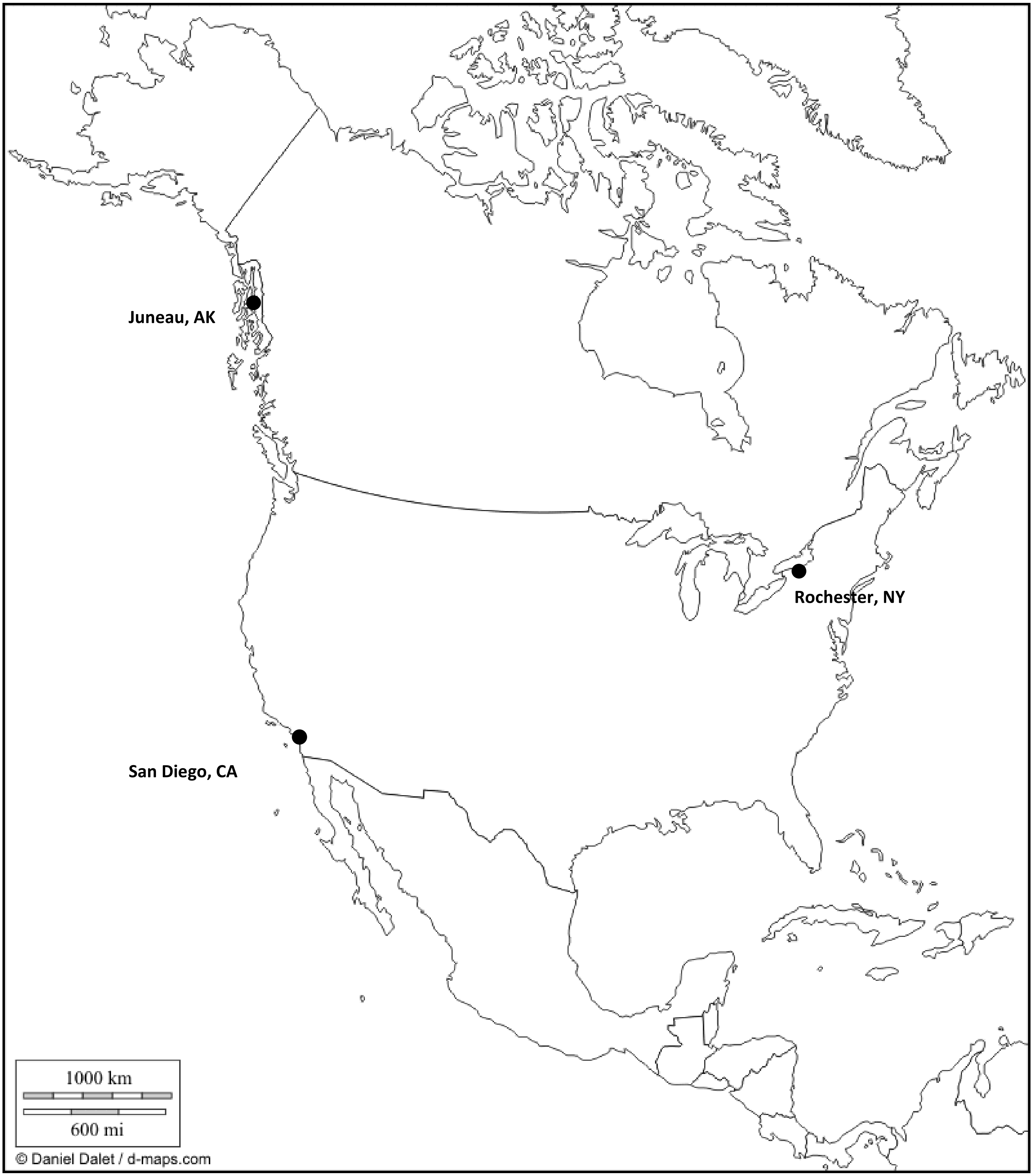
4. Using the map on the next page, draw a circle with a radius that matches the *distance to the epicenter* for each of the three stations. (For example, if you found that station 1 is 100km away from the epicenter, then you will draw a circle with a 100km radius around the city for Rochester, NY.) It is okay if the entire circle does not fit on the page.
Be sure to pay attention to the <u>scale of the map</u>! You may use any items on the front table to assist you.

5. The three circles intersect at a single point. This point is the location of the earthquake's epicenter. Label the epicenter on your map with an "X."

Conclusion Questions

1. The earthquake's epicenter could have been located at any point along the Rochester station's circle. Why was it necessary to use three seismograph stations to find the epicenter and not just one or two stations?

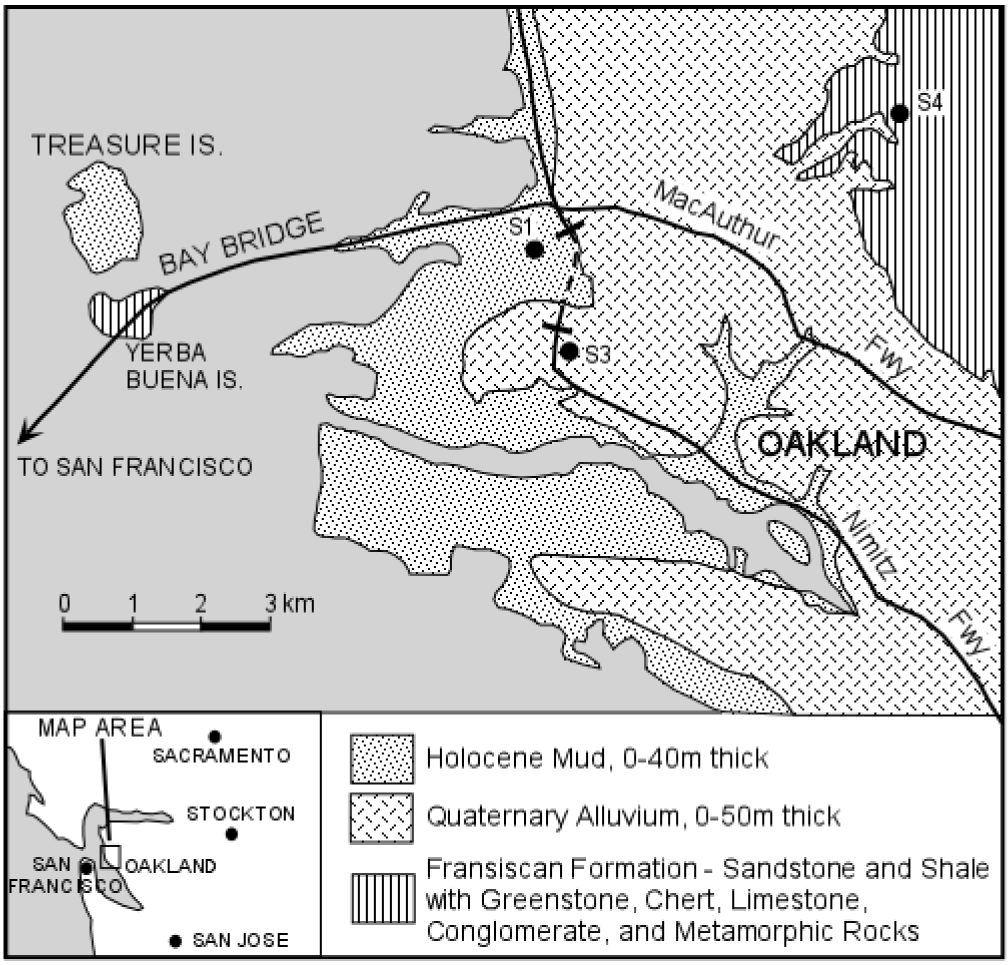
2. If you had data from a fourth seismograph station, how would this change your result for the location of the epicenter?


Juneau, AK
Rochester, NY
San Diego, CA
1000 km
600 mi
© Daniel Dalet / d-maps.com

Part 3: Read the following story and answer the discussion questions.

On October 17, 1989, just prior to game I of the World Series between the San Francisco Giants and the Oakland Athletics, a magnitude 7.1 Earthquake struck northern California (This earthquake is known as the Loma Prieta Earthquake). The earthquake occurred in the mountains west of San Jose California on the San Andreas Fault. As a result of the earthquake, 41 people were killed when a double-decked section of the Nimitz Freeway in Oakland collapsed, crushing people in the cars on the lower deck.

A geologic map showing the various rock types present in the Oakland area and the location of the collapsed portion of the freeway (shown as a short dashed line) is depicted below. Between the thick bars is the area where the freeway was double-decked.



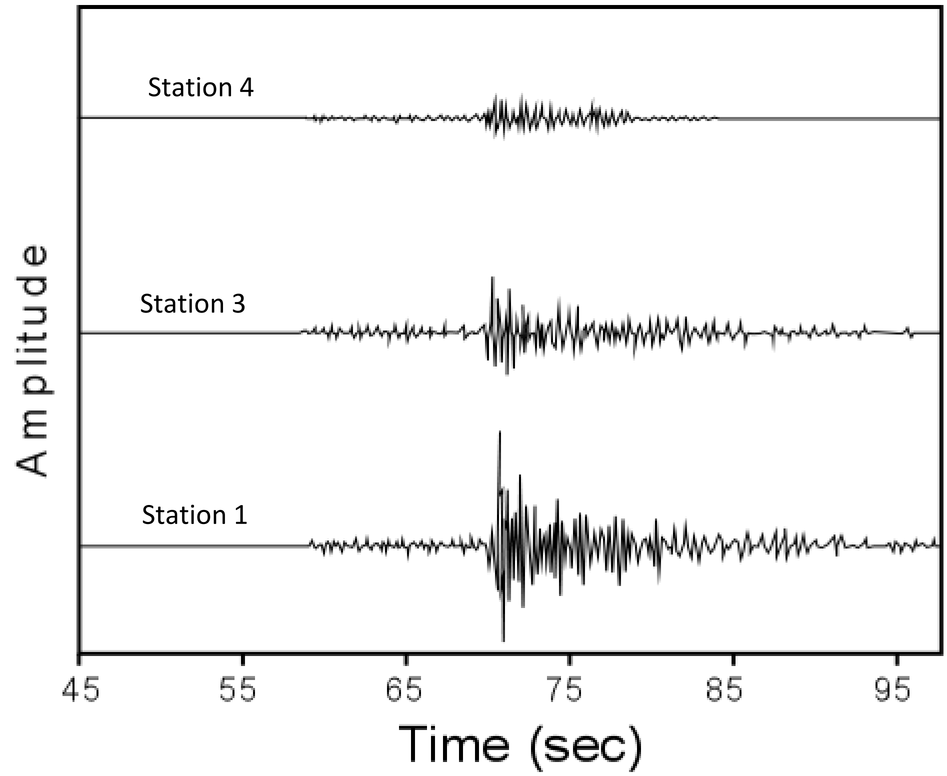
On the map, the areas marked as Holocene mud are areas that were formerly occupied by San Francisco Bay, but have been filled with loose sediment in the last 100 years, the mud contains lots of water in the pore spaces between the grains.

The areas marked Quaternary Alluvium are areas underlain by unconsolidated sediment deposited by streams over the last 2 million years.

The area marked Franciscan Formation is underlain by solid sedimentary, igneous, and metamorphic rocks with a thin cover of soil.

Several days after the magnitude 7.1 earthquake, small aftershocks shook the area. All had epicenters near the main shock of October 17. Seismologists placed several portable seismometers at stations S1, S2, and S3 (as shown on the map) and recorded these aftershocks.

Seismographic recordings for one of these aftershocks, a magnitude 4.1 earthquake, for each of the three stations are shown below. Note that the epicenter of the aftershock was far enough away that all of the recording stations could be considered to be about the same distance from the earthquake.



Discussion Questions: Please answer <u>in complete sentences</u>.

1. What observations can you make about the seismic response (degree of shaking) on the three types of materials underlying the area?

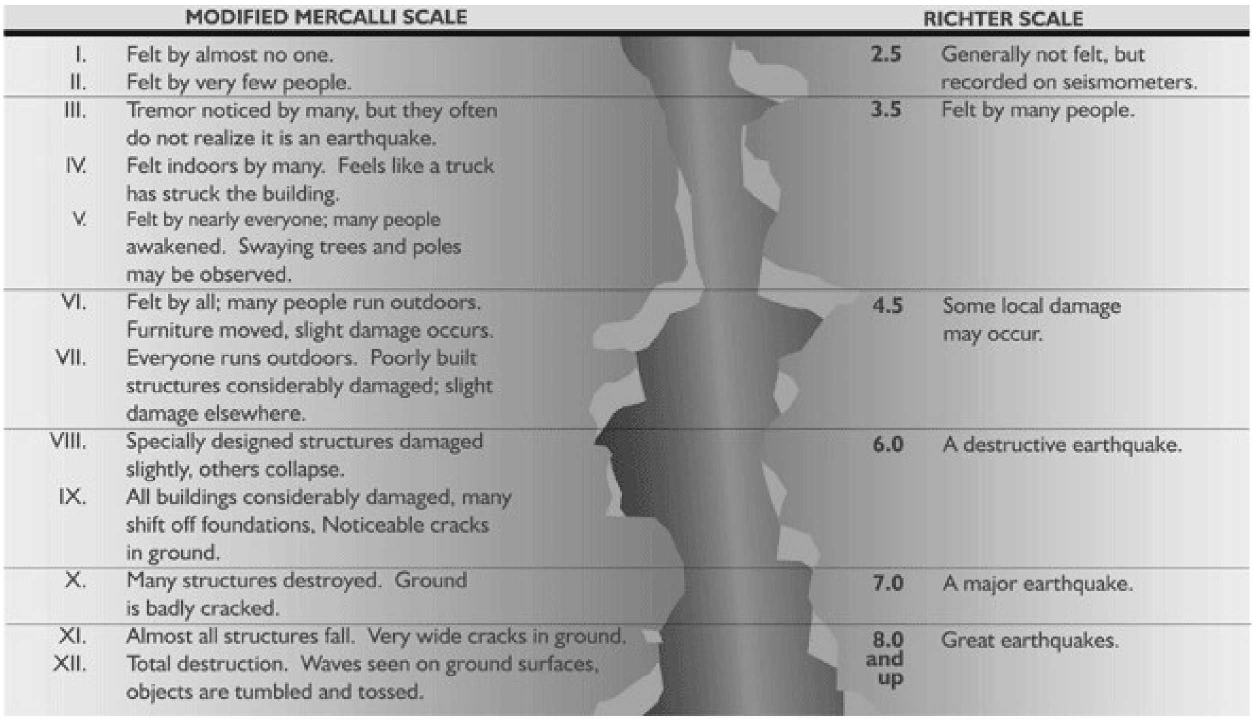
2. What conditions were likely responsible for the double-decked Nimitz Freeway freeway to collapse where it did?

3. Considering that New Orleans is built on water-saturated river muds, how do you think New Orleans would fare if there were a major earthquake nearby?

Seismic Waves Reference Information

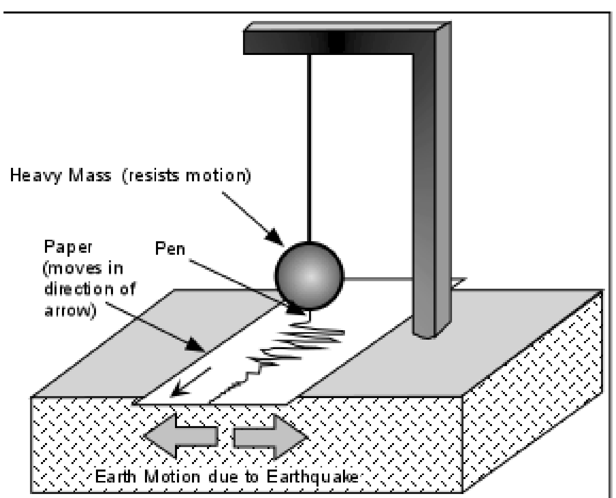
Measuring Earthquakes

Magnitude (Richter Scale)	Seismographs are the most reliable measures of earthquakes. Each increase in one unit of magnitude means a ten-fold increase in shaking.
Intensity (Mercalli Scale)	Based upon the reports of people who experienced the earthquake and observed the destruction.



MODIFIED MERCALLI SCALE		RICHTER SCALE	
I. II.	Felt by almost no one. Felt by very few people.	2.5	Generally not felt, but recorded on seismometers.
III. IV. V.	Tremor noticed by many, but they often do not realize it is an earthquake. Felt indoors by many. Feels like a truck has struck the building. Felt by nearly everyone; many people awakened. Swaying trees and poles may be observed.	3.5	Felt by many people.
VI. VII.	Felt by all; many people run outdoors. Furniture moved, slight damage occurs. Everyone runs outdoors. Poorly built structures considerably damaged; slight damage elsewhere.	4.5	Some local damage may occur.
VIII. IX.	Specially designed structures damaged slightly, others collapse. All buildings considerably damaged, many shift off foundations. Noticeable cracks in ground.	6.0	A destructive earthquake.
X.	Many structures destroyed. Ground is badly cracked.	7.0	A major earthquake.
XI. XII.	Almost all structures fall. Very wide cracks in ground. Total destruction. Waves seen on ground surfaces, objects are tumbled and tossed.	8.0 and up	Great earthquakes.

Seismograph



Earthquake P-Wave and S-Wave Travel Time

S-P Time (minutes)	Distance to Epicenter (km)
0	0
1	600
2	1200
3	1800
3 minutes & 15 seconds	2000
4	2600
5	3600
6	4400
7	5400
8	6600
9	7600
10	8800