Dangerous tsunami threat off U.S. West Coast
Earthquakes

• What is an Earthquake?
  – It’s the shaking and trembling of the Earth’s crust due to plate movement.
• The plates move, rocks along the edge break from the pressure building up along the fault line
• When rocks break energy is released as seismic waves
  – this creates the shaking effect
• Although rocks may be under a lot of stress at a fault, friction prevents them from moving past each other.
• As stress builds up at the fault, the crust (rocks) deform
• The rocks fractures and then snaps back into its un-stressed state
Earthquakes

• This is called: **Elastic Rebound**

• Elastic Rebound – **friction** (stress) builds up between two **locked plates** and once the **stress exceeds the shear strength** of the rock **rupture** (earthquakes) occurs and the rock **rebounds** (recovers)

• Occur near plate boundaries and fault lines deep in the Earth
Earthquakes

- **Focus** – the point where the earthquake starts in the Earth
  - The deeper the focus, the less effect it will have on the surface
- **Epicenter** – point directly above the focus on the surface of the Earth
  - The most violent shaking is found at the epicenter
Earthquakes

- Earthquakes generally produce two main types of seismic waves:
  1. **Body Waves** – waves that travel through a medium (the Earth)
     a. Includes P waves and S waves
  2. **Surface waves** – waves that travel along the surface of a medium (the Earth)
     a. Includes Love and Rayleigh
• Travel time graphs show arrival times of P and S waves
• They are used to determine how far away the seismic station is from the epicenter.
Earthquakes

• **Primary or P-waves**
  – *Compression waves*
  – *Start from the earthquakes focus*
  – They travel very *fast*
  – Can travel *through solids, liquids, and gases*
Earthquakes

• Secondary waves or S-waves
  – Transverse waves
  – Also spread out from the focus
  – Travel at a slower speed
  – Can only travel through solids
  – Generated from the Earth’s entire mass shaking
Earthquakes

• Two types of surface waves
  1. **Love waves** – cause rocks to move side to side (only) and perpendicular to the direction of motion
  2. **Rayleigh Waves** – cause the ground to move in an elliptical, rolling motion
• Slowest but cause the most destruction of the Earth’s surface
Earthquakes

• By studying the speed of seismic waves, scientists have been able to locate boundaries between the internal layers of the Earth.

• Shadow zones – locations on the Earth’s surface where no body waves can be detected
  – Exist because materials that make up Earth’s interior are not uniform in rigidity.
Studying Earthquakes

• **Seismology** – the study of earthquakes and seismic waves

• Seismologists have developed special equipment to record, locate, and measure earthquakes
Studying Earthquakes

- **Seismograph:**
  - An instrument that records vibrations in the ground
Studying Earthquakes

– Seismograph records the arrival times of seismic waves onto a seismogram

1. P-waves are the 1\text{st} to arrive
2. S-waves are the 2\text{nd} to arrive
3. Surface waves (Love and Rayleigh) are the last to arrive
Studying Earthquakes

- These recordings are traced onto a seismogram.
- Seismogram: A tracing of earthquake motion that is recorded by a seismograph.
Studying Earthquakes

- To locate or determine the distance to an epicenter, scientists analyze the difference in arrival times of P and S waves.
- The longer the lag time between the two waves, the farther away the earthquake.
- Seismologists find the exact location by taking readings from at least 3 different recording stations and drawing their data on a map.
Studying Earthquakes

• **Magnitude**
  – A *measure of the strength of an earthquake*
  – Determined by *measuring the amount of ground motion*
  – Measurements are analyzed using a magnitude scale like the Richter Scale and Moment Magnitude scale
Studying Earthquakes

• **Moment Magnitude**
  
  – The measurement of an earthquake's strength based on the size of the area of the fault moves, the average distance the fault blocks move and the rigidity of the rocks in the fault zone

• More accurate than the Richter Scale for large magnitude earthquakes

• Moment magnitude is expressed as a number, the larger the number the stronger the earthquake

<table>
<thead>
<tr>
<th>Earthquake</th>
<th>Moment Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco, California, 1906</td>
<td>7.7</td>
</tr>
<tr>
<td>Southern Chile, 1960</td>
<td>9.5</td>
</tr>
<tr>
<td>Anchorage, Alaska, 1964</td>
<td>9.2</td>
</tr>
<tr>
<td>Loma Prieta, California, 1989</td>
<td>7.2</td>
</tr>
<tr>
<td>Northridge/Los Angeles, California, 1994</td>
<td>6.7</td>
</tr>
</tbody>
</table>
Studying Earthquakes

- **Intensity**
  - Measures the effects the earthquake has on the Earth
  - The Modified Mercalli scale is used for measuring intensity

<table>
<thead>
<tr>
<th>Category</th>
<th>Effects</th>
<th>Richter Scale (approximate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Instrumental</td>
<td>Not felt</td>
<td>1-2</td>
</tr>
<tr>
<td>II. Just perceptible</td>
<td>Felt by only a few people, especially on upper floors of tall buildings</td>
<td>3</td>
</tr>
<tr>
<td>III. Slight</td>
<td>Felt by people lying down, seated on a hard surface, or in the upper stories of tall buildings</td>
<td>3.5</td>
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<tr>
<td>IV. Perceptible</td>
<td>Felt indoors by many, by few outside; dishes and windows rattle</td>
<td>4</td>
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<tr>
<td>V. Rather strong</td>
<td>Generally felt by everyone; sleeping people may be awakened</td>
<td>4.5</td>
</tr>
<tr>
<td>VI. Strong</td>
<td>Trees sway, chandeliers swing, bells ring, some damage from falling objects</td>
<td>5</td>
</tr>
<tr>
<td>VII. Very strong</td>
<td>General alarm; walls and plaster crack</td>
<td>5.5</td>
</tr>
<tr>
<td>VIII. Destructive</td>
<td>Felt in moving vehicles; chimneys collapse; poorly constructed buildings seriously damaged</td>
<td>6</td>
</tr>
<tr>
<td>IX. Ruinous</td>
<td>Some houses collapse; pipes break</td>
<td>6.5</td>
</tr>
<tr>
<td>X. Disastrous</td>
<td>Obvious ground cracks; railroad tracks bent; some landslides on steep hillsides</td>
<td>7</td>
</tr>
<tr>
<td>XI. Very disastrous</td>
<td>Few buildings survive; bridges damaged or destroyed; all services interrupted (electrical, water, sewage, railroad); severe landslides</td>
<td>7.5</td>
</tr>
<tr>
<td>XII. Catastrophic</td>
<td>Total destruction; objects thrown into the air; river courses and topography altered</td>
<td>8</td>
</tr>
</tbody>
</table>
Studying Earthquakes

- Destruction to property and buildings is dependent on the type of soil or ground it is build upon
- Stronger soils and foundations provide better support for property and tall buildings
- Liquefaction of soil happens when saturated soil loses strength in response to the stress from shaking during and earthquake causing it to behave like a liquid
Studying Earthquakes

• Earthquake warnings and forecasts
  – Currently it is not possible for seismologists to accurately predict when and where an earthquake will happen
  – They can make approximate forecasts of future risks by studying past and present earthquake events