# Earthquake Waves Student Worksheet

## Earthquake Waves

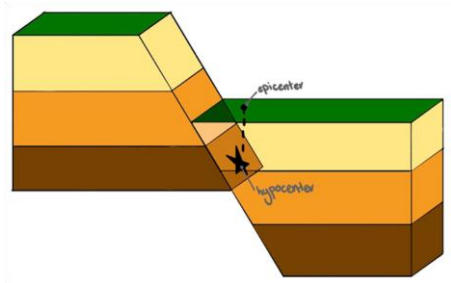

Figure 1: Diagram of earthquake epicenter and hypocenter

Earthquakes occur when two pieces of the Earth's crust suddenly slip past each other (Figure 1). The hypocenter is the point below the surface where the earthquake starts. The epicenter is the location where the earthquake has started from the surface and is directly above the hypocenter.

In an earthquake there are two broad types of seismic waves: body waves and surfaces waves. Body waves are produced first and travel through Earth's layers. There are two different types of body waves that form earthquakes, P-waves (primary waves) and S-waves (secondary waves).

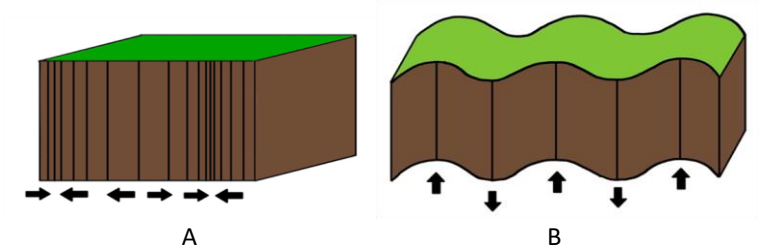

Figure 2: Diagram of (a) P-waves and (b) S-waves

**P-waves** are known as compression waves due to their push – pull nature (Figure 2a). These are the fastest waves produced by an earthquake. P-waves can travel through both solid rock and liquid; meaning they can travel through the Earth's core. When they hit the liquid and solid layers the waves reflect and refract throughout the Earth. Because of reflection and refraction, a shadow zone is formed where the earthquake can not be detected (Figure 3).

**S-waves** are slower than P-waves. The forces move up and down, perpendicular to the direction the wave is traveling (Figure 2b). These types of waves can only travel through solid rock and not through liquid. Thus, S-waves do not travel through the liquid outer core of the Earth (Figure 3).

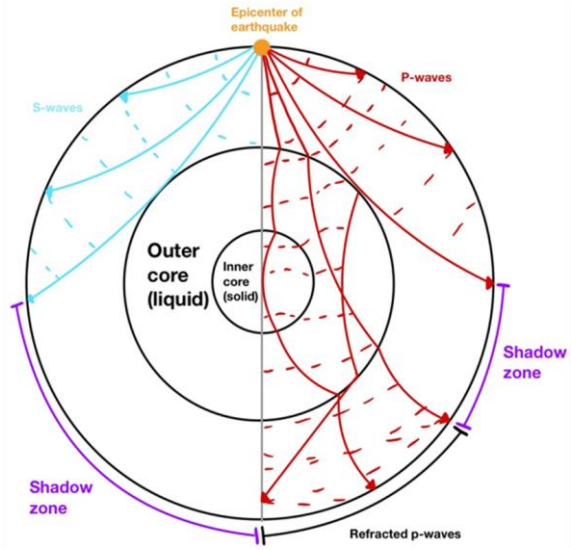

Figure 3: Diagram of P- and S-waves travelling through Earth's layers

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## Reflection and Refraction

Reflection occurs when energy waves bounce off a surface without being absorbed. When the wave is travelling in a medium of one density and hits another material of a different density, the reflection bounces back like it is hitting a mirror and does not continue through the new material (Figure 4). The intensity of the reflection depends on both the difference between the densities and the angle of the wave.

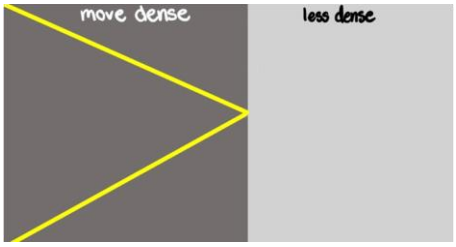


Figure 4: Reflection of a wave (yellow) within a denser material

Refraction occurs when an energy wave changes direction because it travels at different speeds in different media. In simple terms, when the wave hits something it bends when it enters a substance with a different density (Figure 5). P-waves refract when they hit the outer core and inner core, as seen in Figure 3.

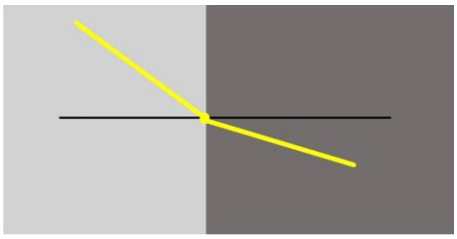


Figure 5: Refraction of a wave (yellow) when it enters a different density medium

## Earthquake Wave Reflection and Refraction

Watch this video from the Incorporated Research Institutions for Seismology (IRIS) that explains reflection and refraction of earthquake waves.

1. What is Snell's Law?

_____

_____

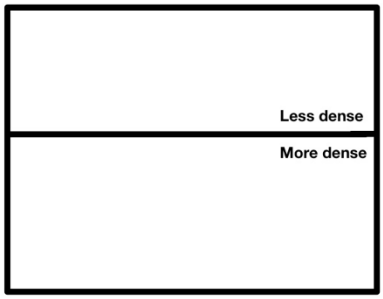
2. What happens when a wave travels at more than a critical angle?

_____

_____

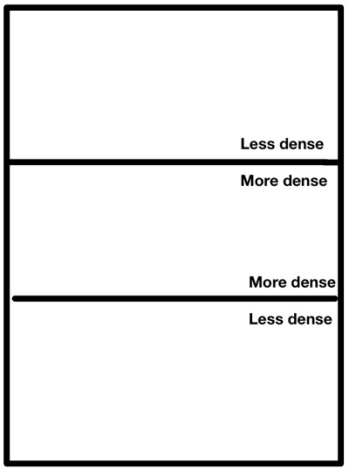
3. Complete these diagrams, based upon what you learned in the IRIS video.

1.

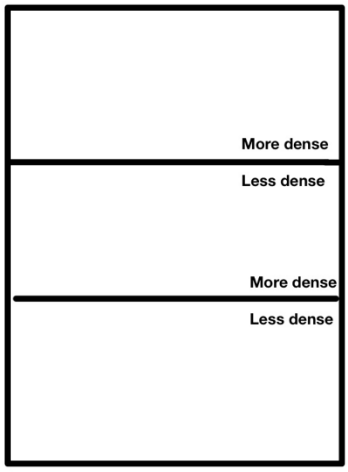



2.


3.




4.



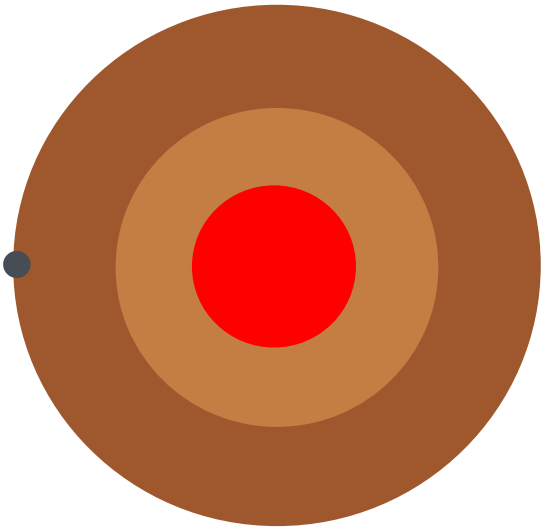

4. Is the mantle more or less dense than the outer core? _____

5. Given your answer to question 2, what will happen to earthquake waves travelling through the mantle toward the outer core? _____

_____

_____

6. Complete the earthquake diagram by adding P-waves from an earthquake at the grey dot.



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