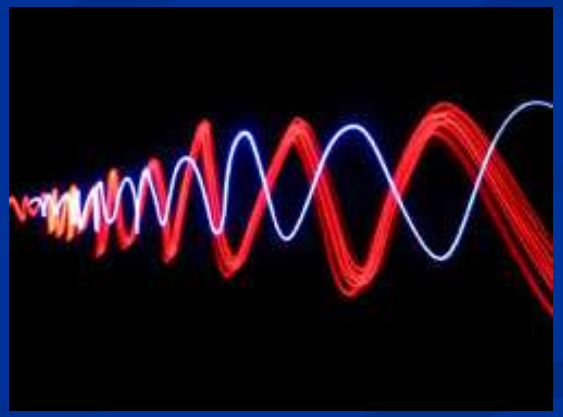
Chapter 17: Mechanical Waves and Sound

Jennie L. Borders

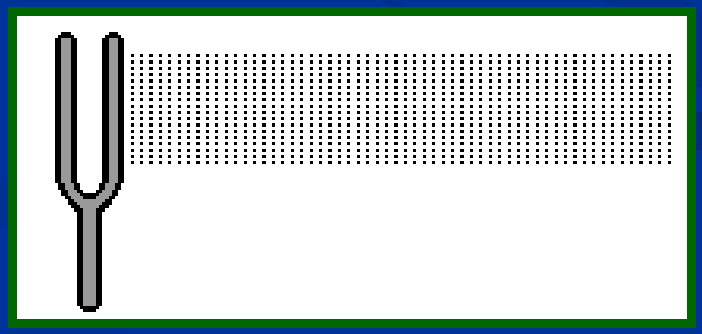


Warm-Up Nov. 4

1. What is a wave?
2. What is the highest point on a wave called?
3. What is reflection?

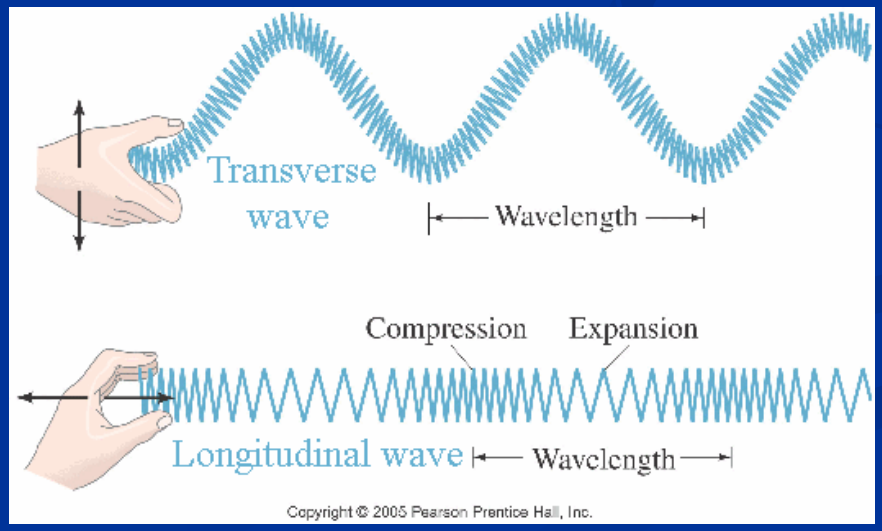
Section 17.1 – Mechanical Waves

- A mechanical wave is a disturbance in matter that carries energy from one place to another.
- Mechanical waves require matter to travel through.
- The material through which a wave travels is called a medium.
- A mechanical wave is created when a source of energy causes a vibration to travel through a medium.



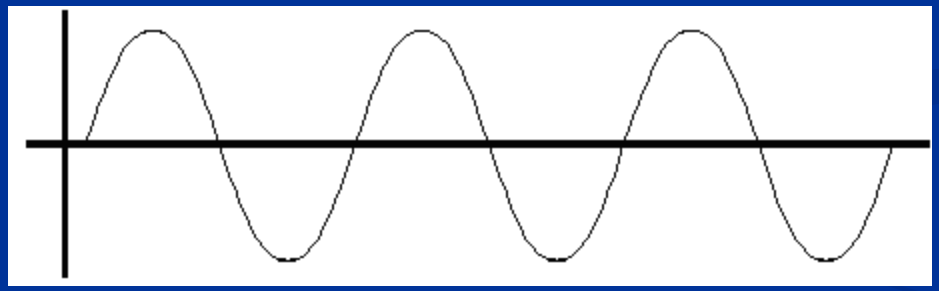
Types of Mechanical Waves

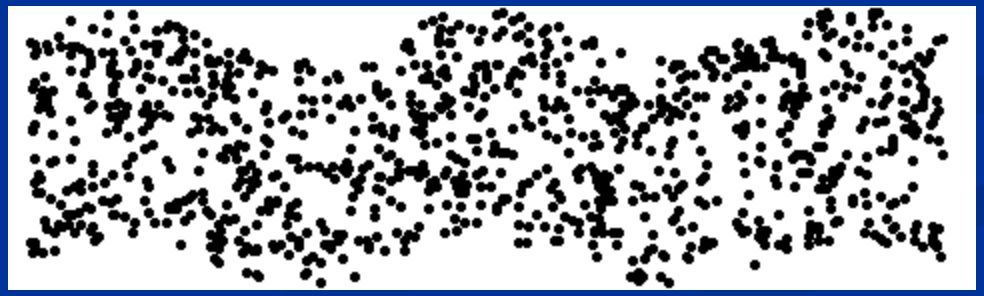
- The three main types of mechanical waves are transverse waves, longitudinal waves, and surface waves.
- A point on the wave vibrates up and down between a maximum and minimum height.



Transverse Waves

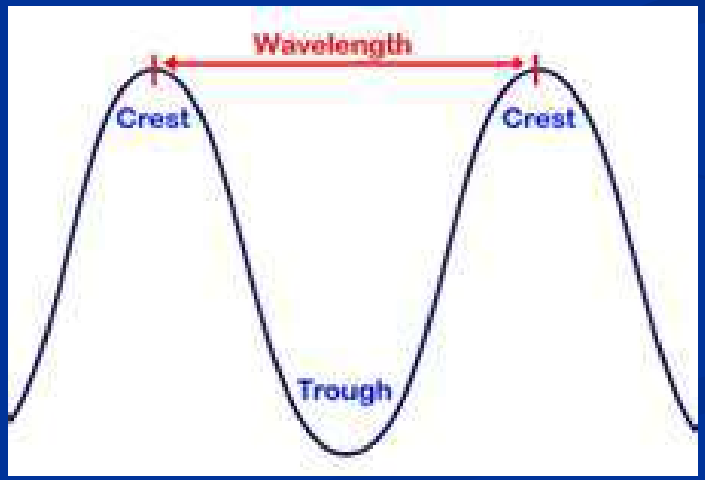
- A transverse wave is a wave that causes the medium to vibrate at right angles to the direction in which the wave travels.





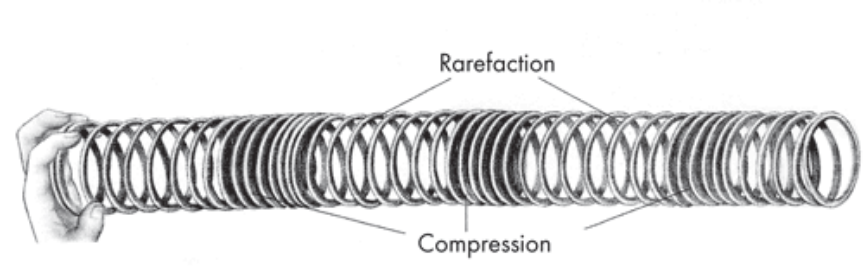
Transverse Waves

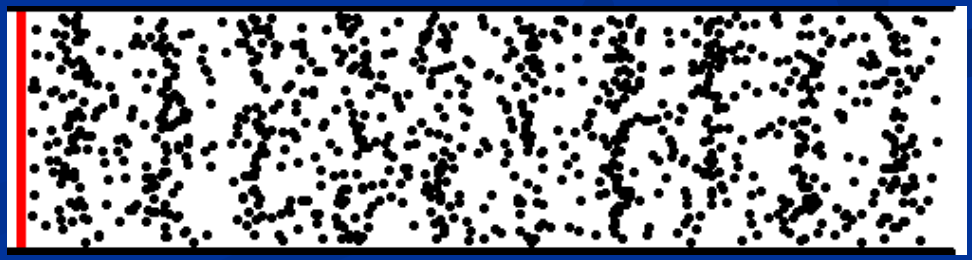
- The highest point of the wave above the rest position is the crest.
- The lowest point below the rest position is the trough.



Longitudinal Waves

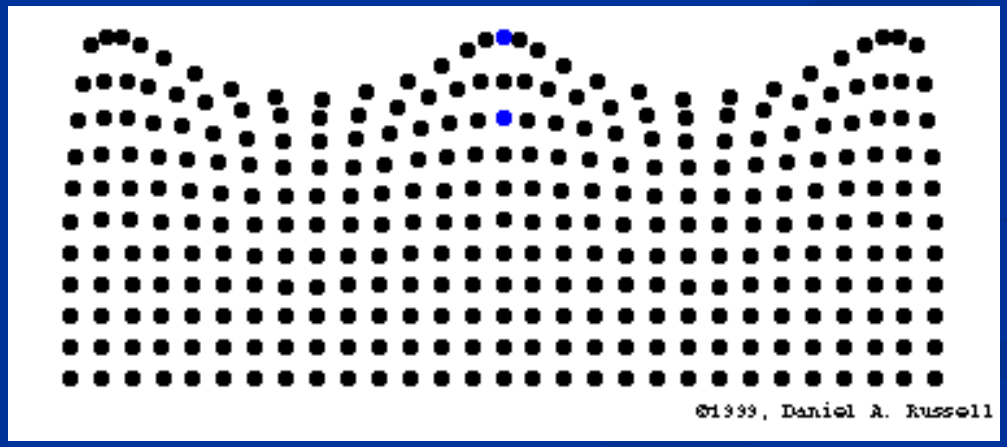
- A longitudinal wave is a wave in which the vibration of the medium is parallel to the direction the wave travels.
- An area where the particles in a medium are spaced close together is called a compression.
- An area where the particles in a medium are spread out is called a rarefaction.





Surface Waves

- A surface wave is a wave that travels along a surface separating two media.
- The motion of the particles is in a circle.



Section 17.1 Assessment

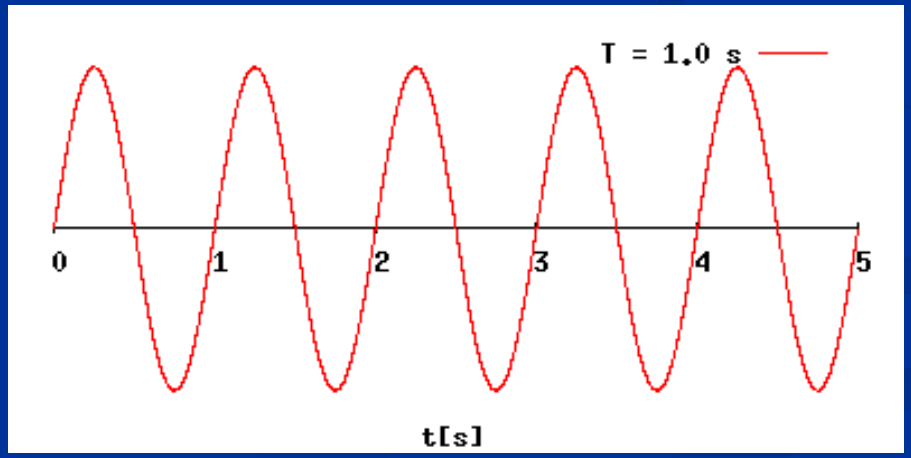
- List the three main types of mechanical waves.
- For each type of wave, compare the vibration of the medium to the direction of the wave.

Warm-Up Nov. 6

1. What are the 3 types of waves?
2. How is a wave made?
3. What is the lowest point of the wave called?

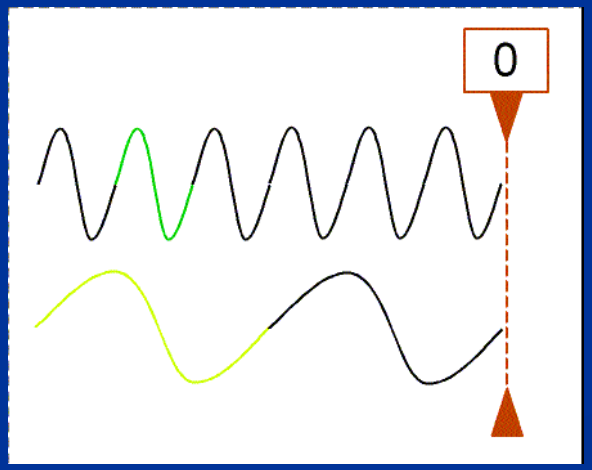
Section 17.2 – Properties of Mechanical Waves

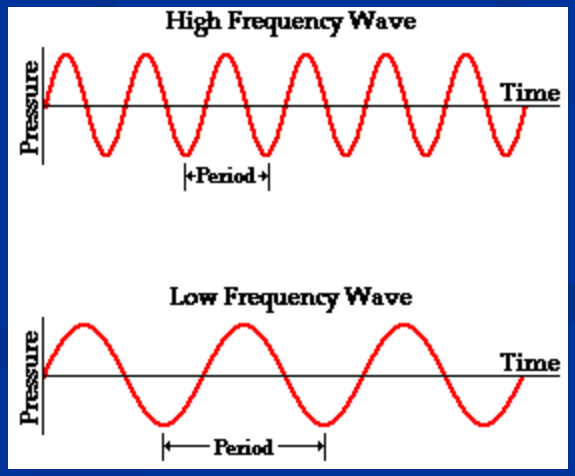
- Any motion that repeats at regular time intervals is called periodic motion.
- The time required for one cycle, a complete motion that returns to its starting point, is called the period.



Frequency

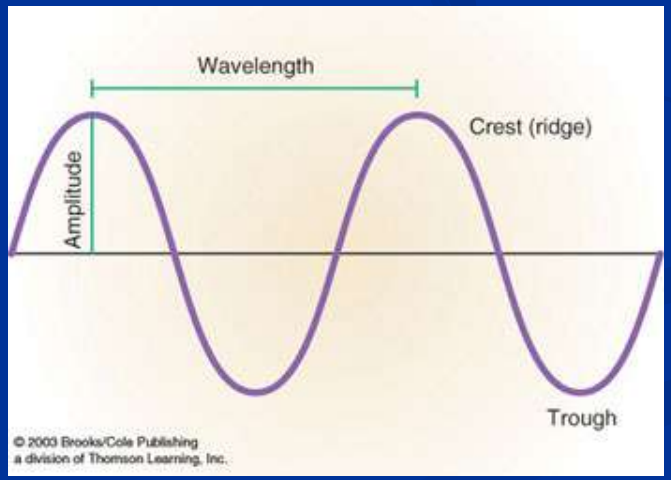
- Any periodic motion has a frequency, which is the number of complete cycles in a given time.
- Frequency is measured in cycles per second, or hertz (Hz).
- A wave's frequency equals the frequency of the vibrating source producing the waves.





Wavelength

- Wavelength is the distance between a point on one wave and the same point on the next cycle of the wave.
- Increasing the frequency of a wave decreases the wavelength.



Wave Speed

- Formula for the speed of waves

Speed = Wavelength x Frequency

$v = \lambda \times \upsilon$

SKIP!

Speed = m/s

Wavelength = m

Frequency = 1/s or Hz

Sample Problem

- One end of a rope is vibrated to produce a wave [illegible] wavelength of 0.25m. The frequency of the wave is 3.0Hz. What is the speed of the wave?

$v = \lambda \times \upsilon$

$v = \lambda \times \upsilon$

$\lambda = 0.25mv = 0.25m \times 3.0(1/s)$

$\upsilon = 3.0Hzv = 0.75m/s$

SKIP!

Practice Problems

- A wave on a rope has a wavelength of 2.0m and a frequency of 2.0Hz. What is the speed of the wave?

  $v = \lambda \times \upsilon$ $v = 2.0m \times 0(1/s) = 4m/s$

- A wave in the water has a frequency of 4Hz and a wavelength of 0.1m. What is the speed of the wave?

  $v = \lambda \times \upsilon$ $v = 0.1m \times 4(1/s) = 0.4m/s$

SKIP!

Practice Problems

- What is the wavelength of an earthquake wave if it has a speed of 5km/s and a frequency of 10Hz?

$v = \lambda$ x υ $\lambda = v/\upsilon$ $\lambda =$ km/ (1/s) = 0.5km

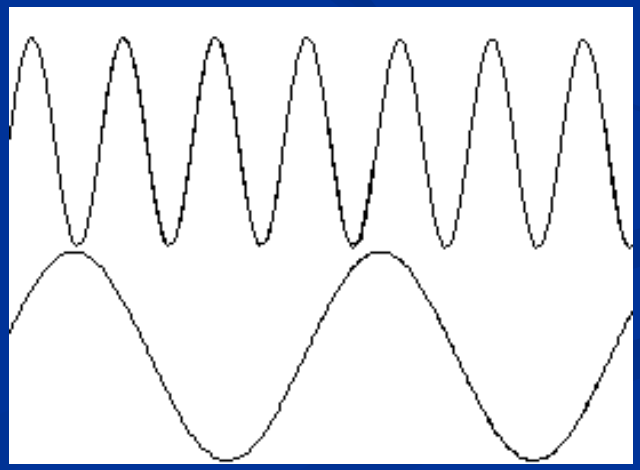
- A wave travels at 1.8m/s and has a wavelength of 1.2m. What is the frequency of this wave?

$v = \lambda \times \upsilon$ $\upsilon = v/\lambda$ $\upsilon = 1.8\text{m/s} / 1.2\text{m} = 1.5\text{Hz}$

SKIP!

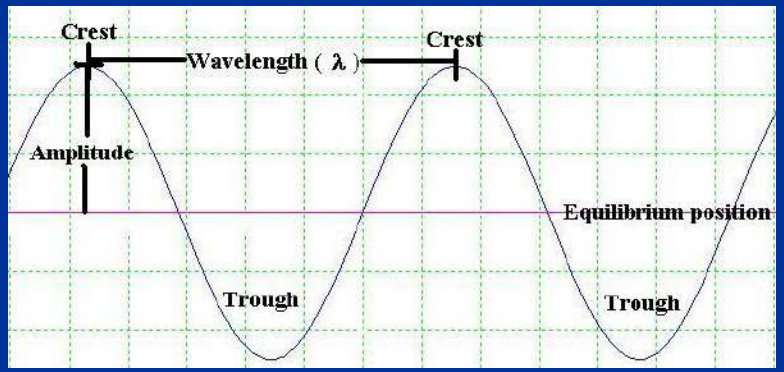
Speed

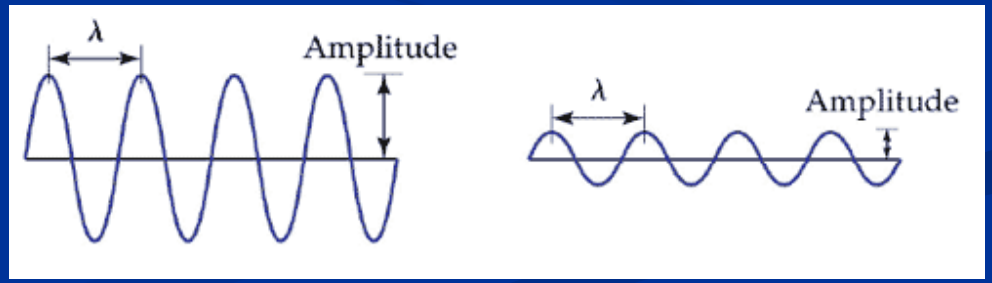
- If you assume that waves are traveling at a constant speed, then wavelength is inversely proportional to frequency.
- If wavelength increases, then frequency decreases.
- If wavelength decreases, then frequency increases.



Amplitude

- The amplitude of a wave is the maximum displacement of the medium from its rest position.
- The more energy a wave has, the greater is its amplitude.





Section 17.2 Assessment

- How is wavelength related to frequency for waves moving at a constant speed?
- How is the energy of a wave related to its amplitude?
- If you double the frequency of a wave, what is the effect on its wavelength?

Section 17.2 Assessment

- A wave on a rope has a frequency of 3.3Hz and a wavelength of 1.2m. What is the speed of the wave?

$v = \lambda \upsilon$ $v = 1.2m \times 3.3(1/s) = 4.0m/s$

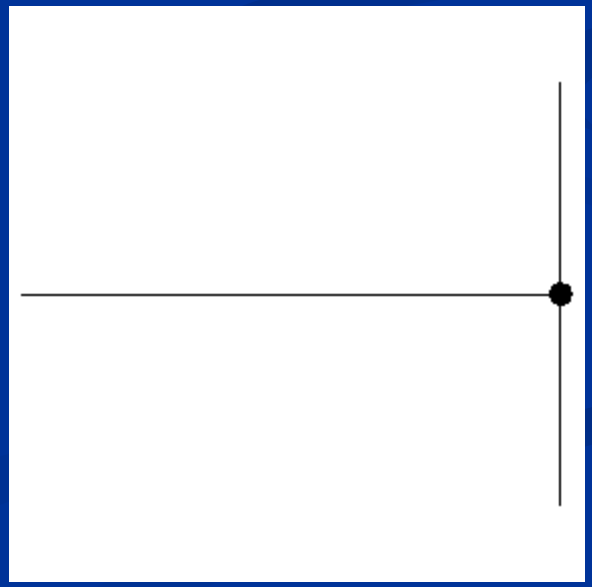
SKIP!

Warm-Up Nov.7

1. What is the area of a longitudinal wave where the particles are close together?
2. How do the particles of a surface wave move?
3. What is the lowest point on a transverse wave called?

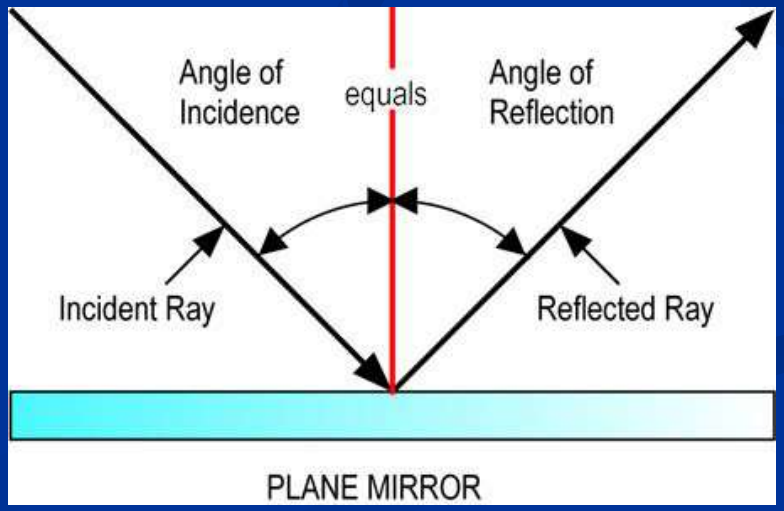
Section 17.3 – Behavior of Waves

- Reflection occurs when a wave bounces off a surface that is cannot pass through.
- Reflection does not change the speed or frequency of a wave, but the wave can be flipped upside down.



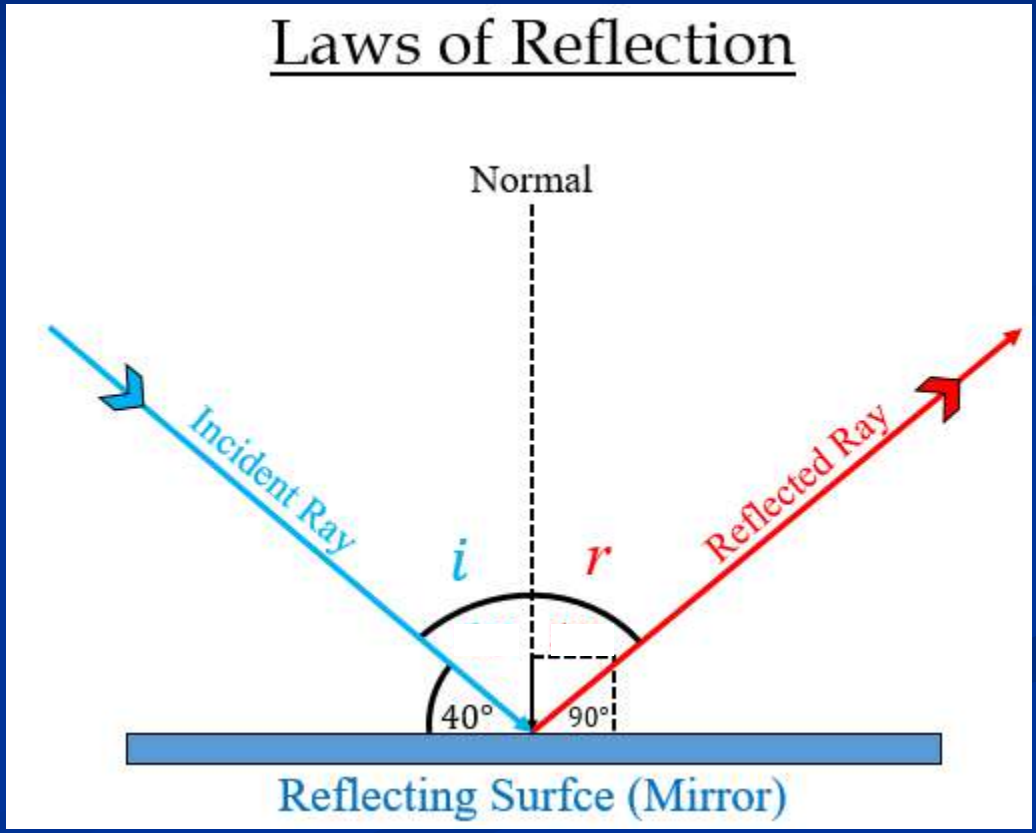
Reflection

- An incident ray is the incoming light wave.
- A reflected ray is the light wave that has bounced off of the surface.
- The normal is an imaginary line perpendicular (at a right angle) to the surface.
- The angle of incidence always equals the angle of reflection.



Sample Problem

- What is the angle of incidence and what is the angle of reflection?



Angle of Incidence = 50°
Angle of Reflection = 50°

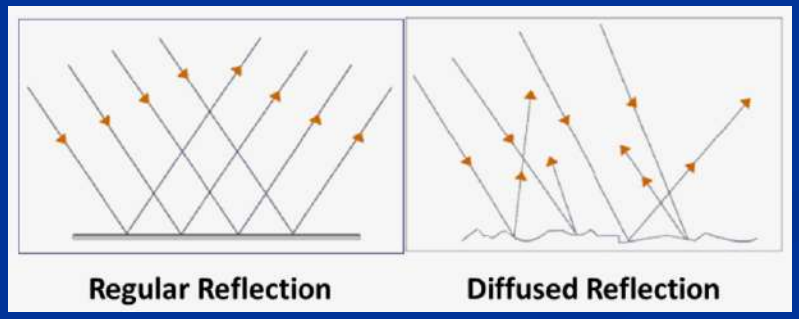
Practice Problem

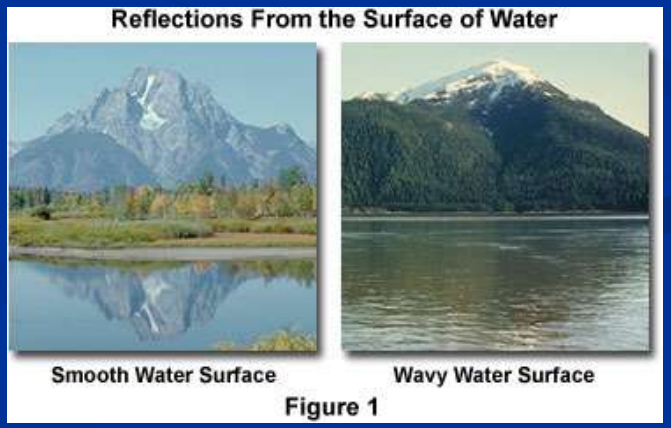
- If the angle on the incoming ray is at a 35^{o} angle to the normal, then what is the angle of reflection?

35^{o}

Regular vs Diffuse Reflection

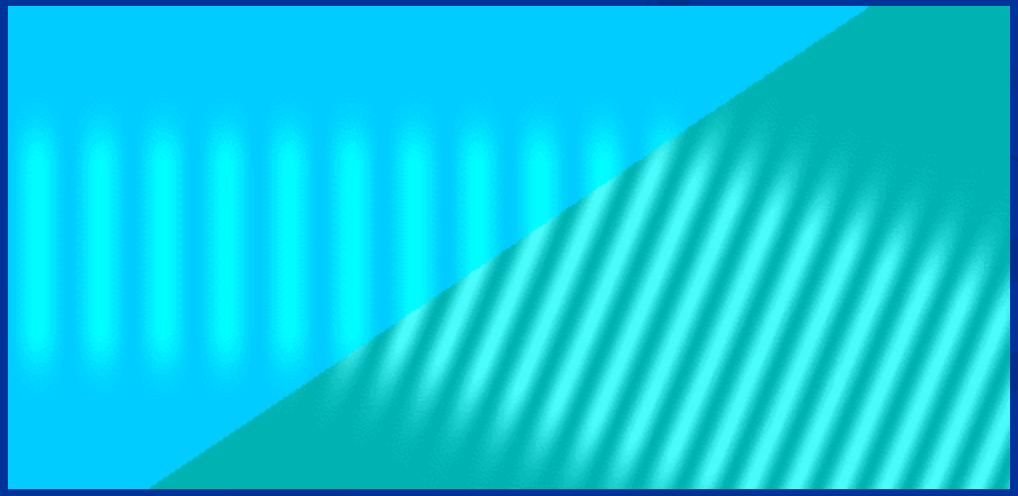
- A regular reflection is a clear image that is produced when light waves hit a smooth surface and the waves are reflected together at the same angle.
- A diffuse reflection is a blurry image that is produced when light waves hit a rough surface and the waves are reflected in different directions (scattered).





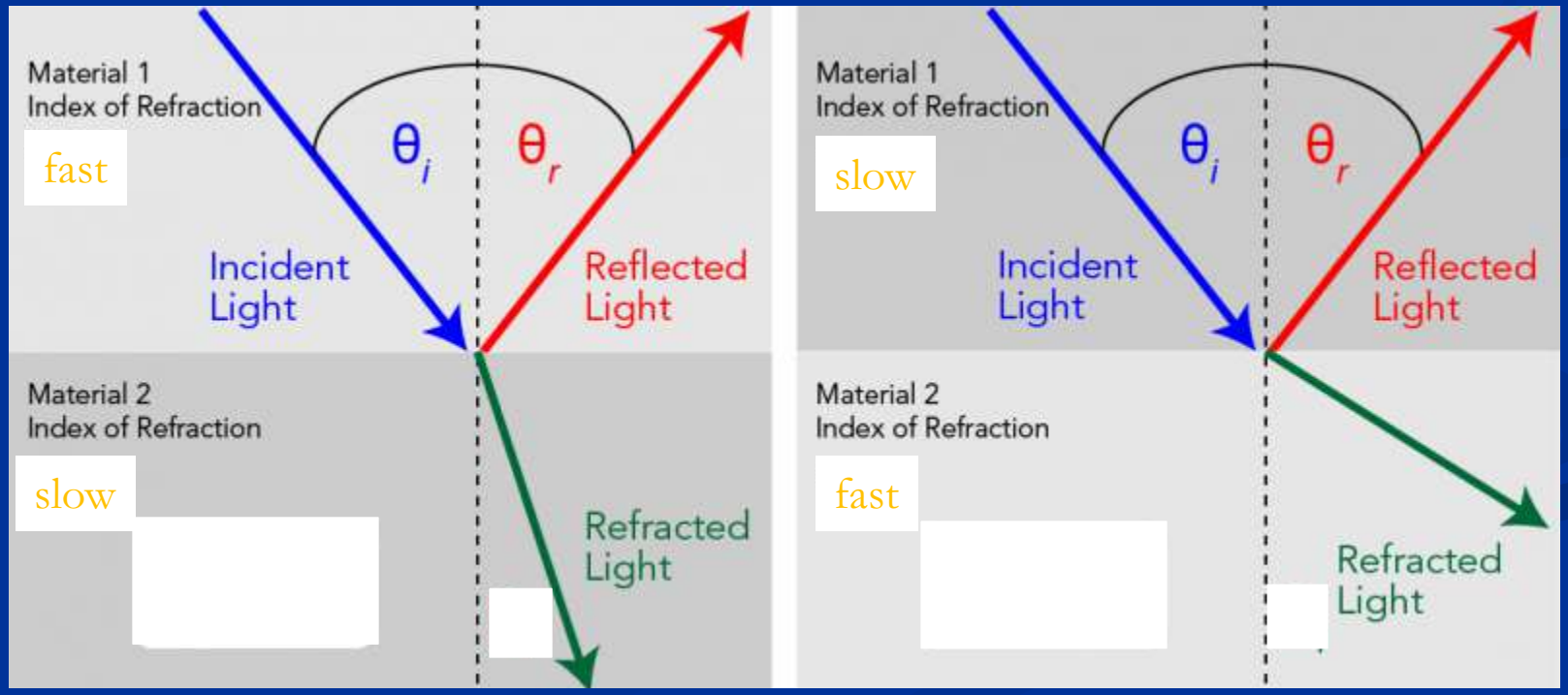
Refraction

- Refraction is the bending of a wave as it enters a new medium at an angle.
- When a wave enters a medium at an angle, refraction occurs because one side of the wave moves more slowly than the other side.



Refraction

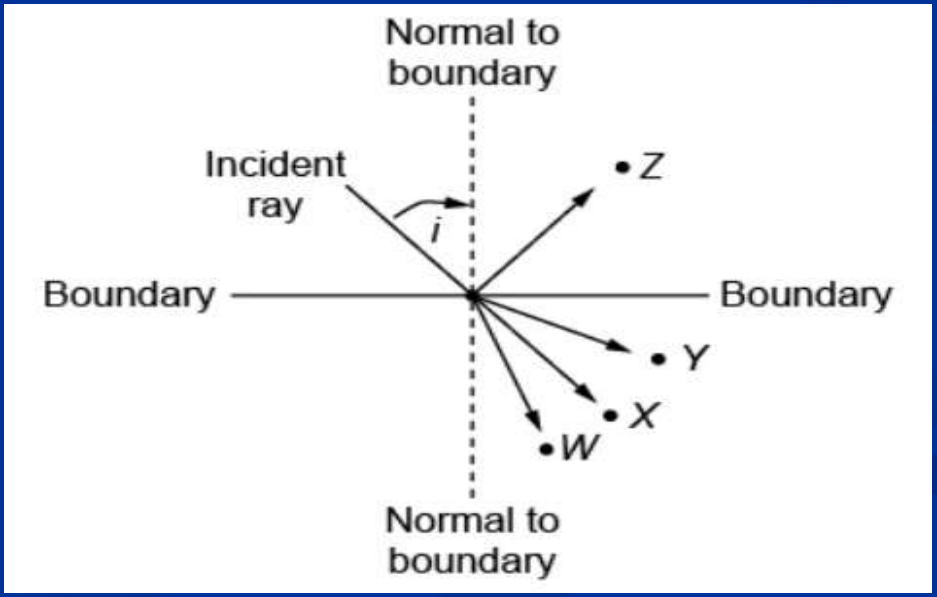
- The angle changes when refraction occurs depending on whether the waves speed up or slow down.



Sample Problem

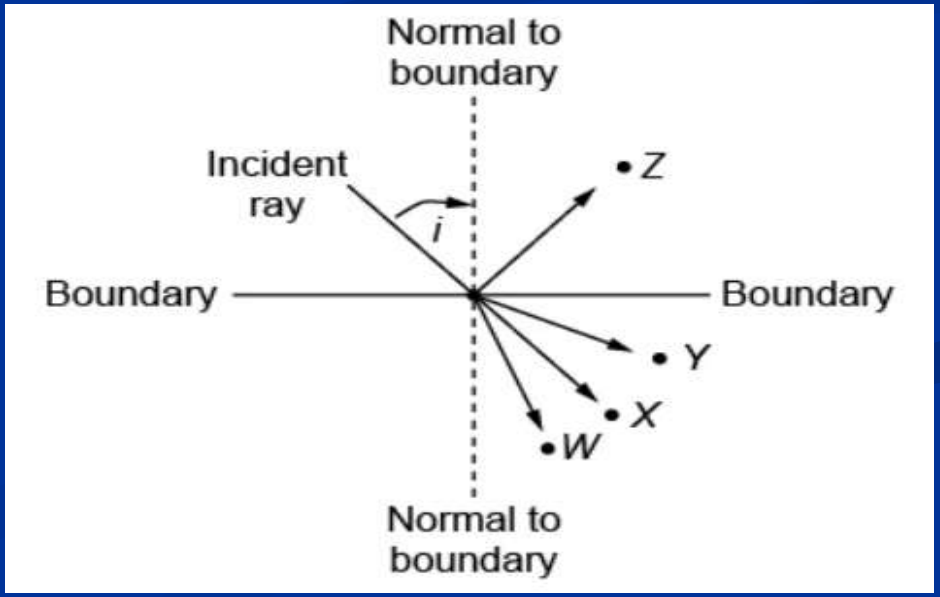
- Which of the following could be the refracted ray of light of a wave that passes into a new medium and speeds up?

Y



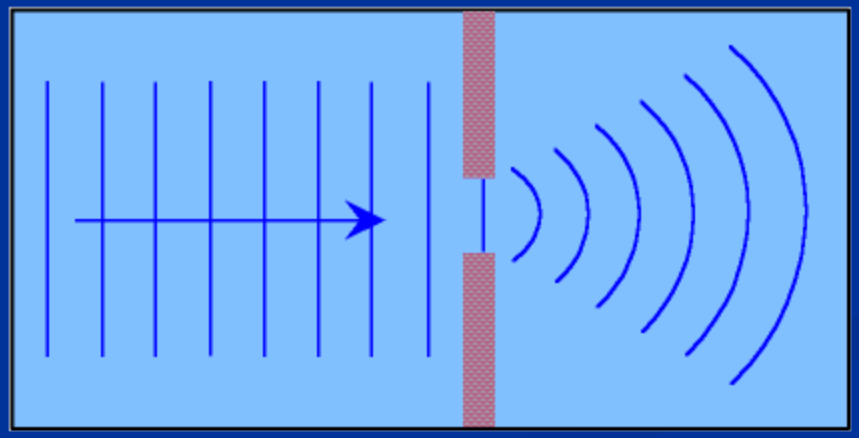
Practice Problem

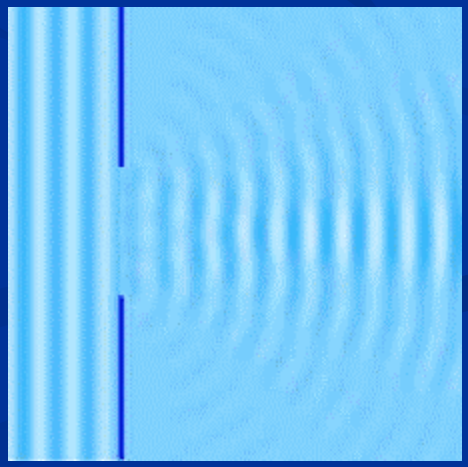
- Which of the following could be the refracted ray of light of a wave that passes into a new medium and slows down? **W**
- Which of the following is the reflected ray of light? **Z**



Diffraction

- Diffraction is the bending of a wave as it moves around an obstacle or passes through a narrow opening.
- A wave diffracts more if its wavelength is large compared to the size of an opening or obstacle.



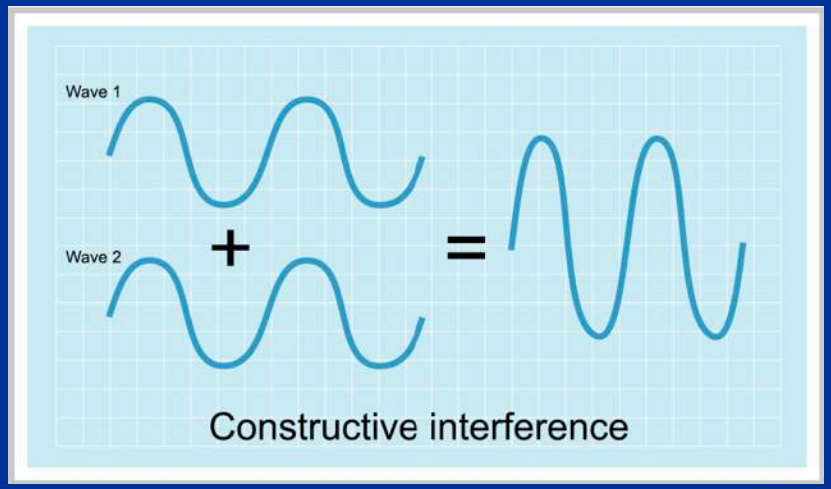


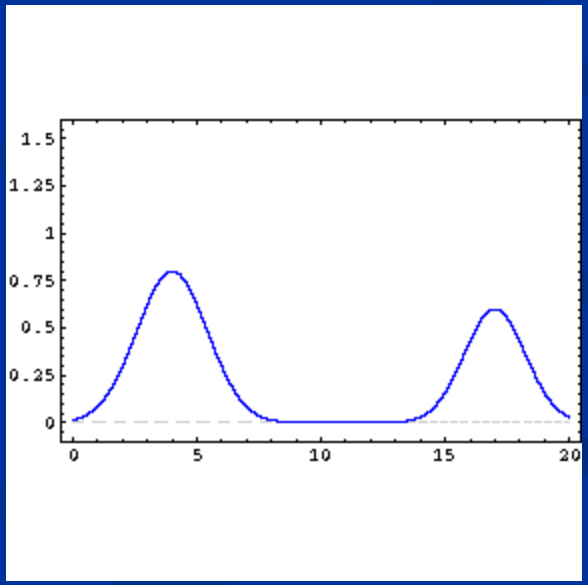
Interference

- Interference occurs when two or more waves overlap and combine together.
- Two types of interference are constructive interference and destructive interference.

Constructive Interference

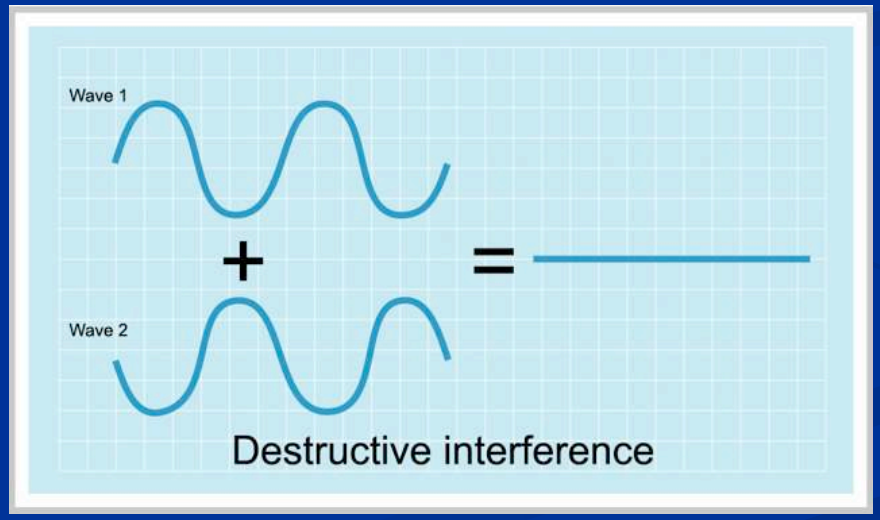
- Constructive Interference occurs when two or more waves combine to produce a wave with a larger displacement.





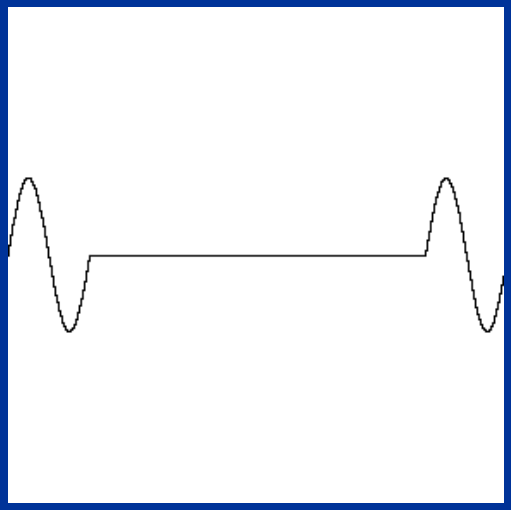
Destructive Interference

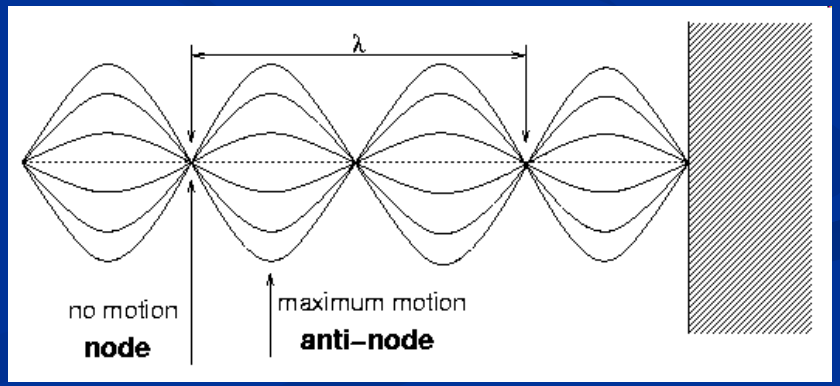
- Destructive interference occurs when two or more waves combine to produce a wave with a smaller displacement.



Standing Waves

- A standing wave is a wave that appears to stay in one place.
- A node is a point on a standing wave that has no displacement from the rest position.
- An antinode is a point where a crest or trough occurs midway between two nodes.





Section 17.3 Assessment

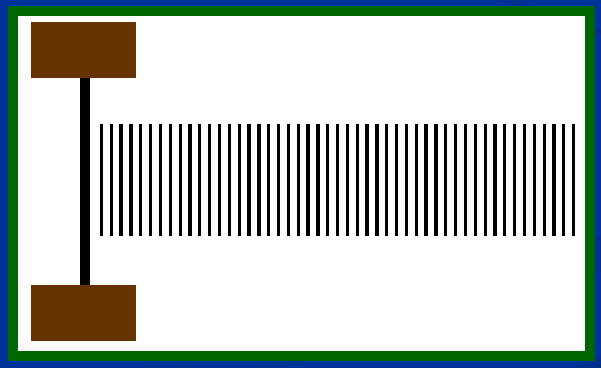
- How is a wave changed by reflection?
- What causes refraction when a wave enters a medium at an angle?
- What determines how much a wave diffracts when it encounters an opening or an obstacle?
- How does the frequency of a reflected wave compare with the frequency of the incoming wave?
- What is the amplitude of a wave that results when two identical waves interfere constructively?

Warm-Up Nov. 11

1. What is reflection?
2. What is refraction?
3. What is diffraction?

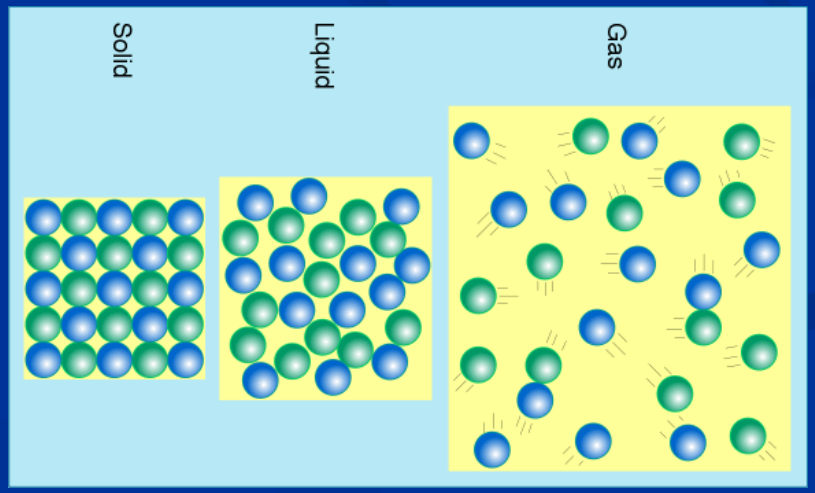
Section 17.4 – Sound and Hearing

- Sound waves are longitudinal waves that travel through a medium.
- Many behaviors of sound can be explained using a few properties – speed, intensity and loudness, and frequency and pitch.



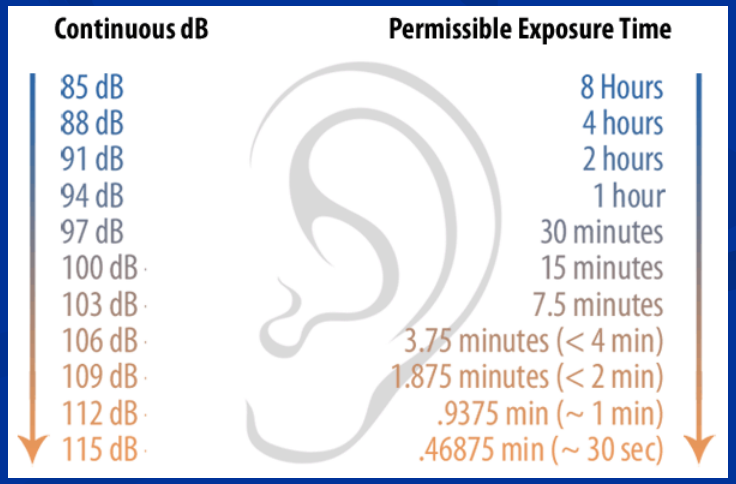
Speed

- In dry air at 20°C, the speed of sound is 342 m/s.
- In general, sound waves travel fastest in solids, slower in liquids, and slowest in gases.
- This is due to the fact that particles in a solid tend to be closer together than particles in a liquid or a gas.



Intensity and Loudness

- Intensity is the rate at which a wave's energy flows through a given area.
- Sound intensity depends on both the wave's amplitude and the distance from the sound source.
- The decibel (dB) is a unit that compares the intensity of different sounds.
- Loudness is a physical response to the intensity of sound.



Frequency and Pitch

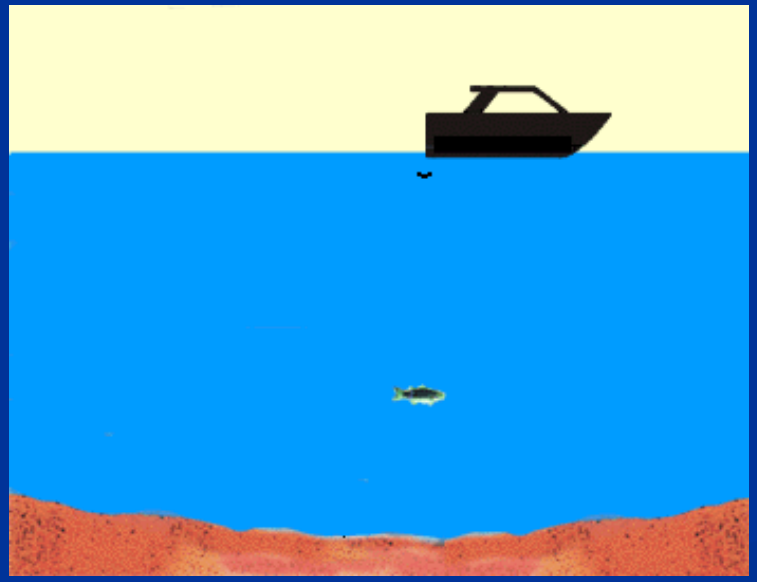
- Pitch is the frequency of a sound as you perceive it.
- High-frequency sounds have a high pitch, and low-frequency sounds have a low pitch.

Ultrasound

- Ultrasound is sound at frequencies higher than most people hear.
- Ultrasound is used in a variety of applications, including sonar and ultrasound imaging.

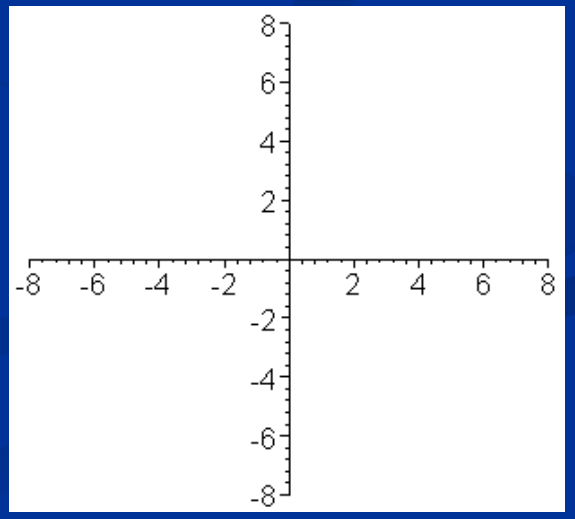
Sonar

- Sonar is a technique for determining the distance to an object underwater.
- Sonar stands for sound navigation and ranging.



Doppler Effect

- The Doppler effect is a change in sound frequency caused by motion of the sound source, motion of the listener, or both.
- As a source of sound approaches, an observer hears a higher frequency. When the sound source moves away, the observer hears a lower frequency.



Section 17.4 Assessment

- List five properties used to explain the behavior of sound waves.
- Names two uses for ultrasound.
- What is the Doppler effect?
- If workers in a distant stone quarry are blasting, why can you feel the explosion in your feet before you hear it?