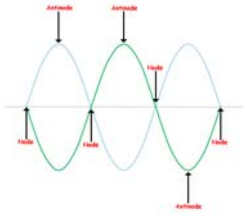
Wave Behaviors

Interference

- The addition of two or more waves that results in a new wave pattern.
- Two types
  - Constructive
  - Destructive

Standing Waves

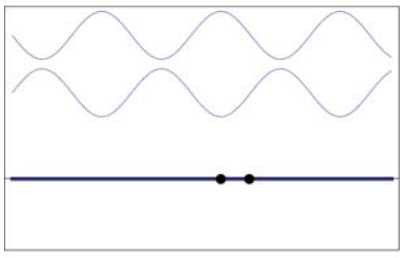
- Occur because of interference!
- A standing wave is a wave that appears to stay in one place.



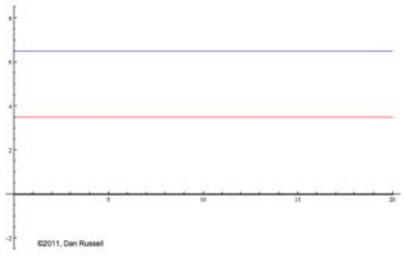
Parts of a Standing wave

- Node – Where there is no displacement of the medium in a standing wave
- Antinode – Where there is maximum displacement of the medium in a standing wave

Standing Wave

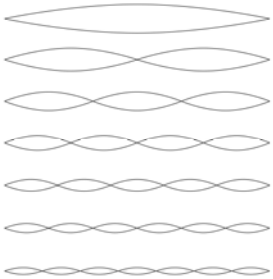


Standing Wave



How do standing waves fit on a string?

- Standing waves only form if a half a wavelength or a multiple of half a wavelength fits exactly into the length of a vibrating string

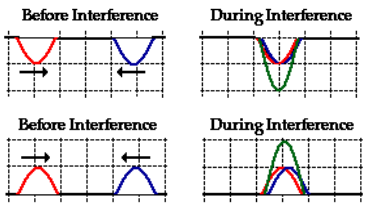


Constructive Interference

- Occurs when positive amplitudes of waves meet.
- Amplitude of the resulting wave will be higher
- Total Constructive Interference
  - The crest (or compression) of one wave meets exactly (same λ, amplitude, and frequency) with the crest (or compression) of another wave
  - One wave results
  - Doubles the sound

Constructive Interference

- Two or more waves combine to produce a wave with a larger displacement

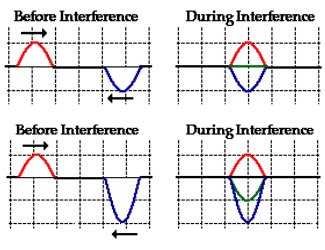


Destructive Interference

- Occurs when a positive amplitude of one wave meets with a negative amplitude of another wave.
- Amplitude of the resulting wave will be smaller
- Total Destructive Interference
  - The crest (or compression) of one wave meets exactly (same λ, amplitude, and frequency) with the trough (or rarefaction) of another wave.
  - Cancels the sound.

Destructive Interference

- Two or more waves combine to produce a wave with a smaller displacement



Beats

- Created by constructive and destructive interference
- . . .periods of loud sounds followed by soft sounds. . .
- when two waves of different frequencies interfere with one another.

Beats Frequency

- Determined by the difference between the two frequencies
- $f_b = f_1 - f_2$
- What is the beat frequency between a 300 Hz sound wave and 302 Hz?
- f_b = 300 Hz – 302 HZ = 2 Hz

A wave meets a hard surface like a wall?

- Reflection
  - A wave bounces off a surface that it can not pass through
- Reflection does not change the speed or frequency of the wave, BUT the wave can be flipped upside down!

How?

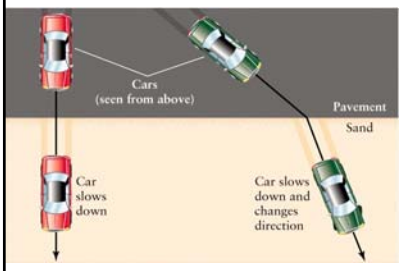
Hard Boundary

Soft Boundary

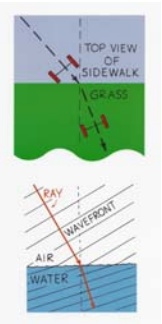
A wave enters a new medium?

- Refraction
  - The bending of a wave as it enters a new medium
- The wave bends because as it enters a new medium it either speeds up or slows down!

Refraction

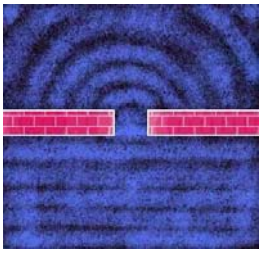


Refraction



A wave moves around an obstacle?

- Diffraction
  - the bending of a wave as it moves around an obstacle or passes through a narrow opening



Doppler Effect

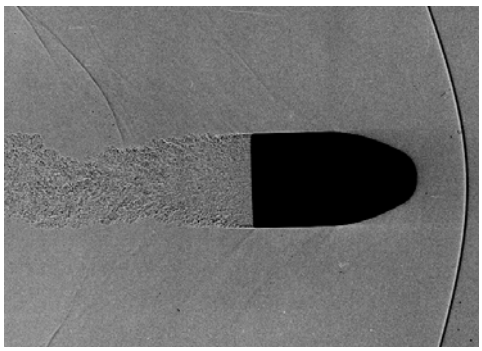
- **Relative motion creates a change in frequency**
- **When the object creating the sound and the observer are moving farther apart the pitch (frequency) is lower**
- **When the object creating the sound and the observer are moving closer together the pitch (frequency) is higher**

Stationary Object

Moving Object

Change in Frequency (Pitch)

Moving at the Speed of Sound



Sonic Boom

- When the object creating a sound moves faster than the sound waves it's creating
  - the compressions constructively interfere and create a "wall" of sound
  - heard as a "boom" when the sound passes an observer.

Moving Faster than Speed of Sound