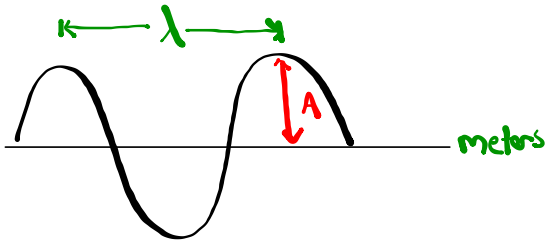
L03 - Wave Interference and Superposition

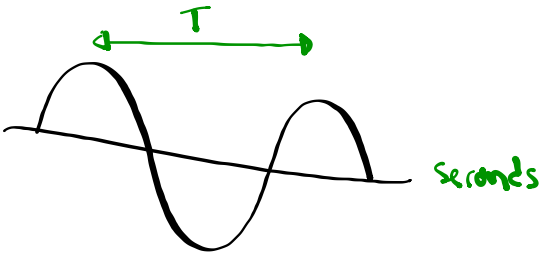
Agenda:

- Attendance
- Wave Interference
  - > Superposition Principle
  - > Constructive/Destructive Wave Interference
- Huygen's Principle
  - > Diffraction of Waves in an Auditorium
- Two-Source Wave Interference
  - > Interference SmartBoard Sound Demo
  - > Double Slit Mini-Lesson
- Standing Waves
  - > Terminology including Nodes and Antinodes
  - > Melnyk and the Aluminum Rod
  - > Visual Represetation using Slinky Activity
- Timbre in Music
  - > iPhone Guitar Video

Previously

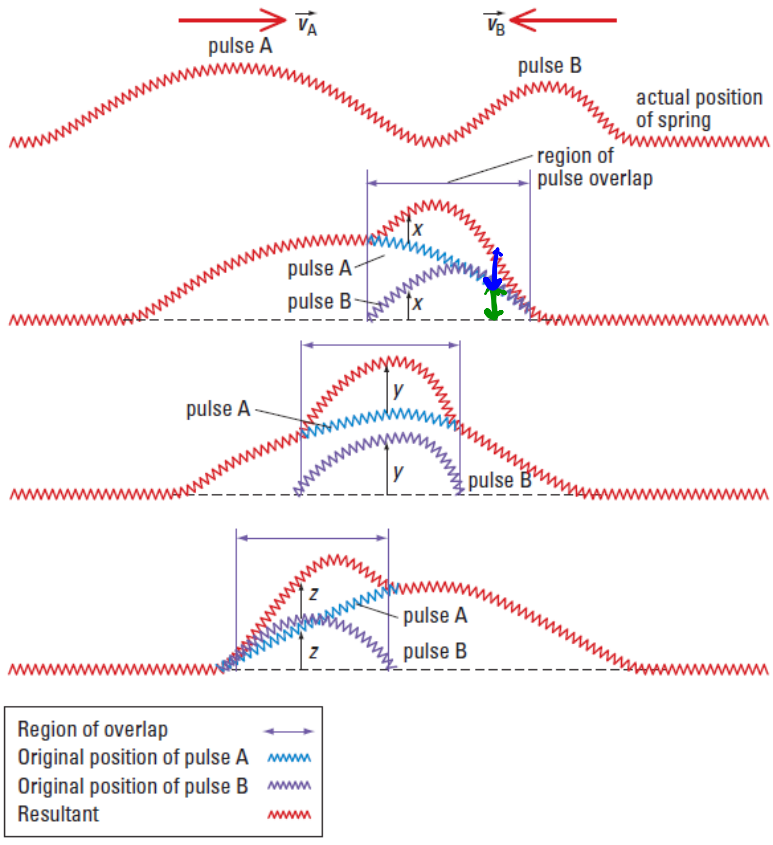
$v = f\lambda$ $f = \frac{1}{T}$ $v = \frac{d}{t}$





Wave Interference – Superposition Principle

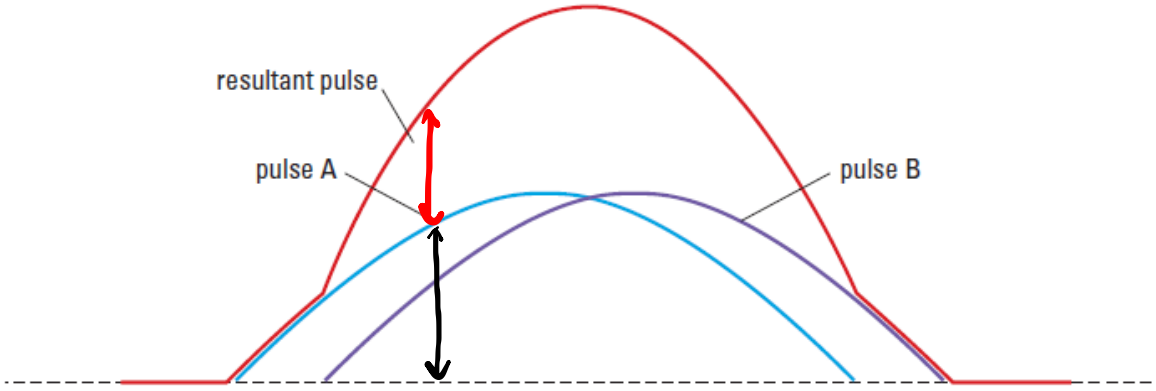
Constructive Wave Interference



principle of superposition:

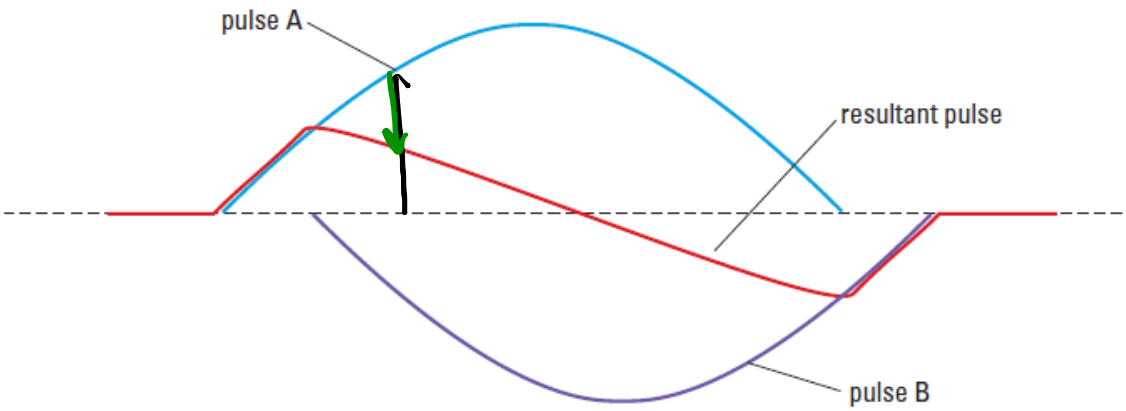
constructive interference:

Constructive Wave Interference



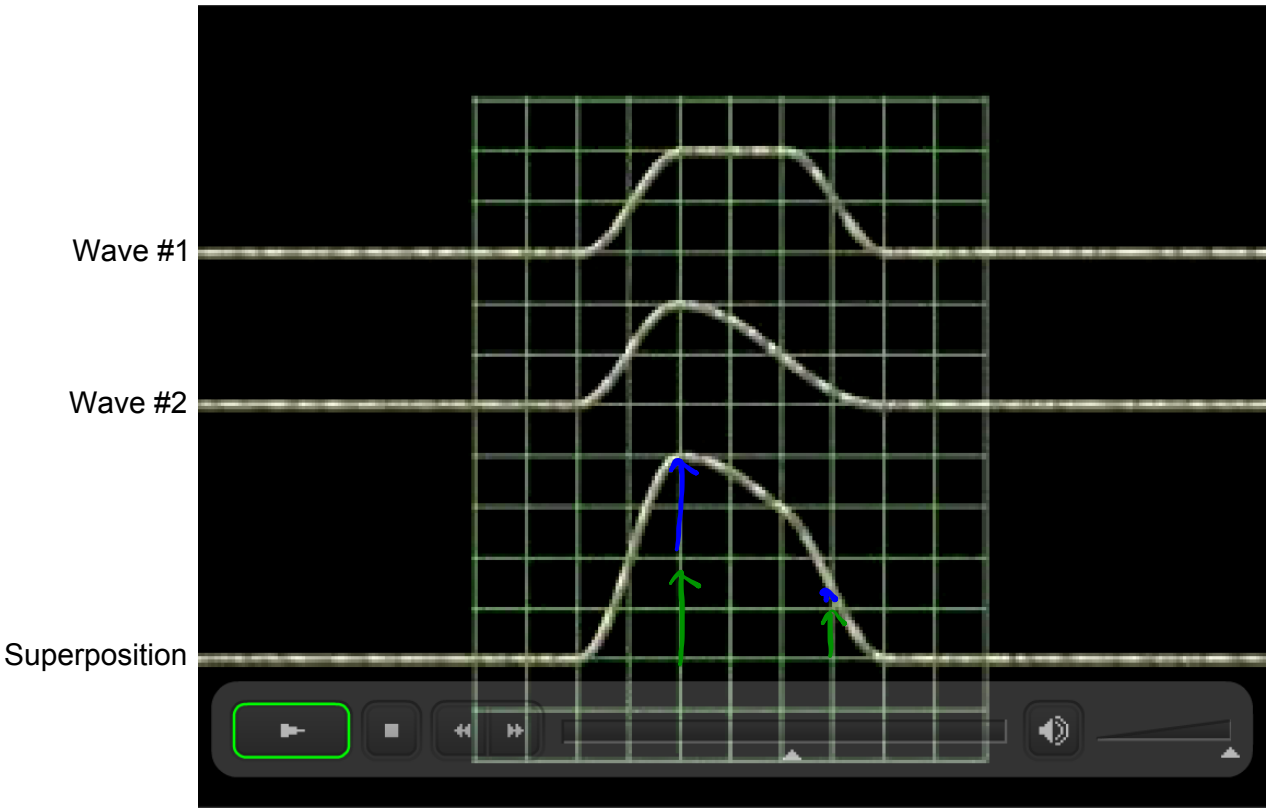
▲ **Figure 8.24** Constructive interference

Destructive Wave Interference

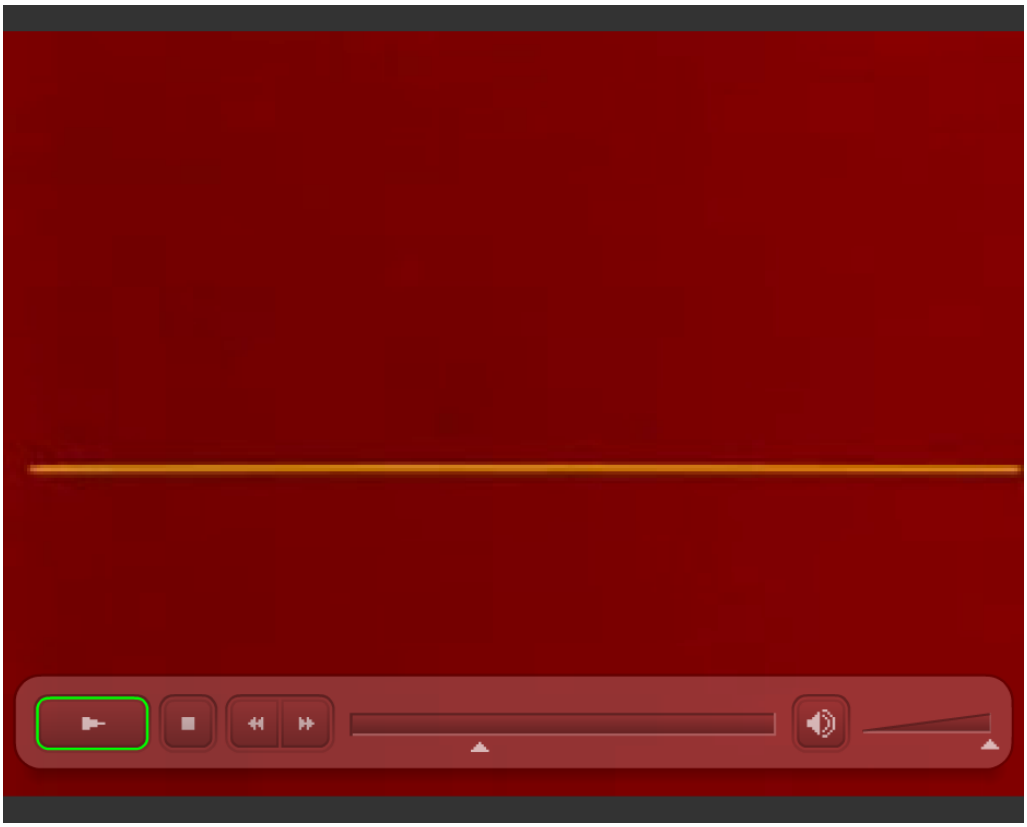


▲ **Figure 8.25** Destructive interference

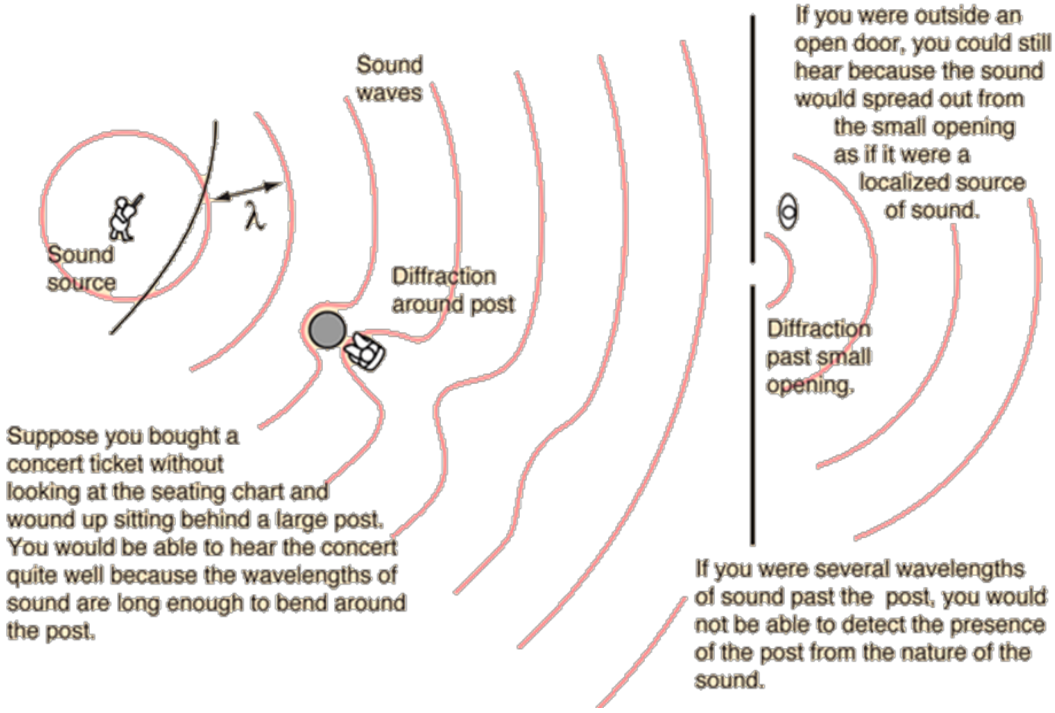
Constructive or Destructive?



Awesome Interference Simulations - In Spanish

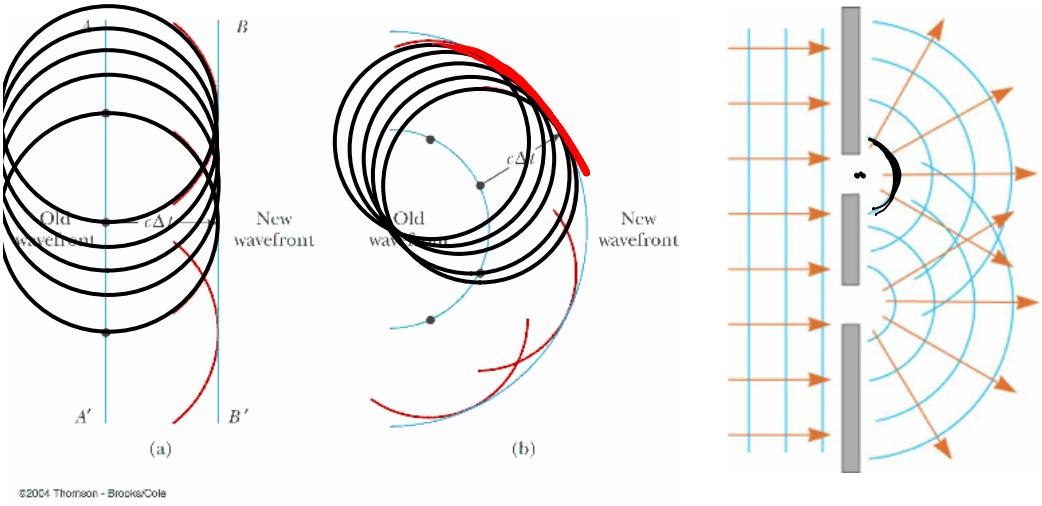


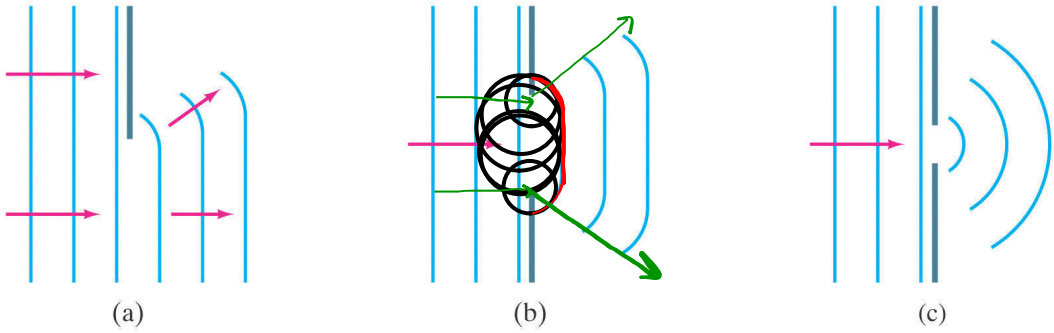
Diffraction of Waves in an Auditorium



Huygen's Principle

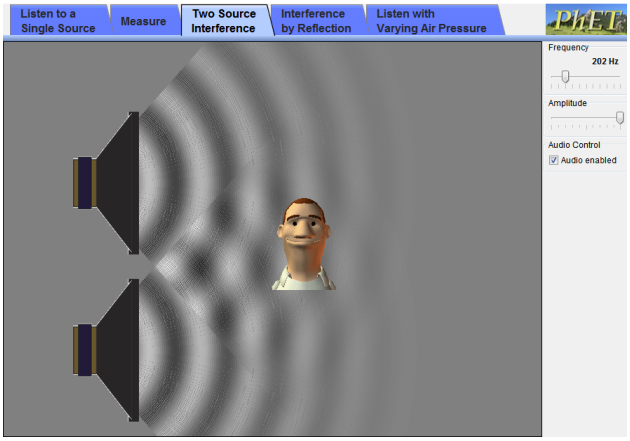
The Huygens-Fresnel principle states that every point on a wavefront is a source of wavelets. These wavelets spread out in the forward direction, at the same speed as the source wave. The new wavefront is a line tangent to all of the wavelets.





Colorado PhET Demonstrations

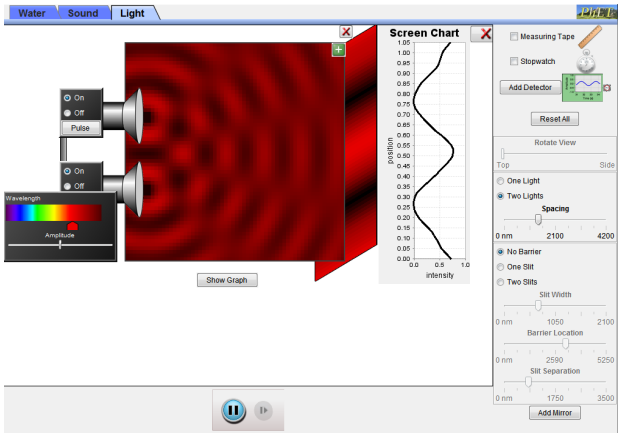
https://phet.colorado.edu/en/simulation/legacy/sound



Settings:

- Two Source Interference
- Frequency: 200 Hz
- Amplitude: Max
- Audio Enabled

https://phet.colorado.edu/en/simulation/legacy/wave-interference



Settings:

- Light
- Two Lights
- Click "Show Screen"
- Click "Intensity Graph"

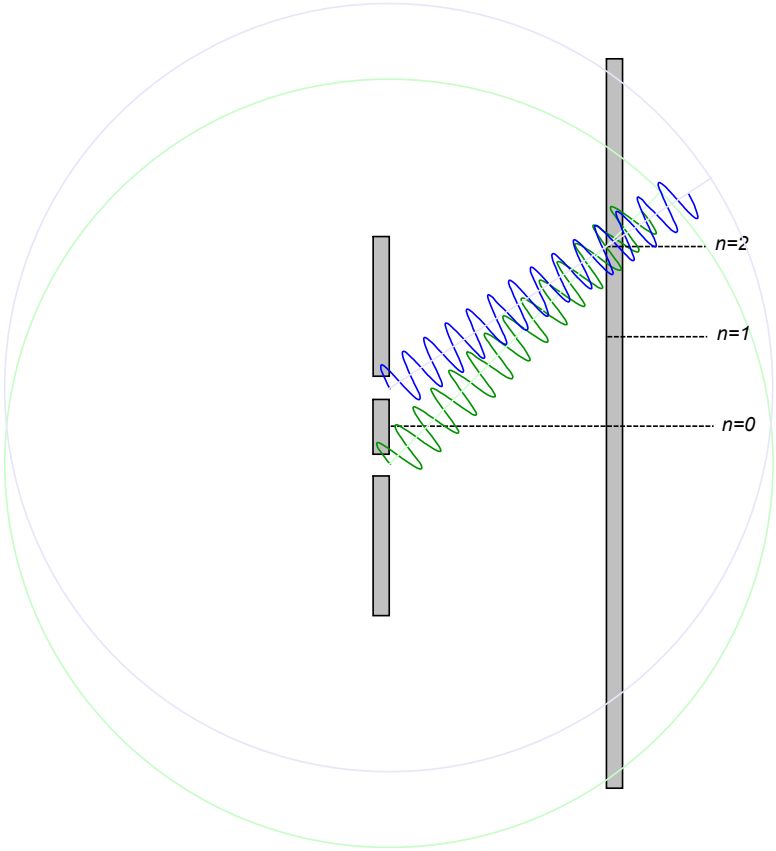
Interference SmartBoard Sound Demo

https://www.youtube.com/watch?v=TxHctJZflh8

Teacher Instructions:

- Have students line up at the back of the classroom.
- Play tone.
- One student walks from one side of the classroom to the other side SLOWLY.
- The student moving should hear the volume of the tone change at different locations.

Interactive - Diffraction of Short Wavelength

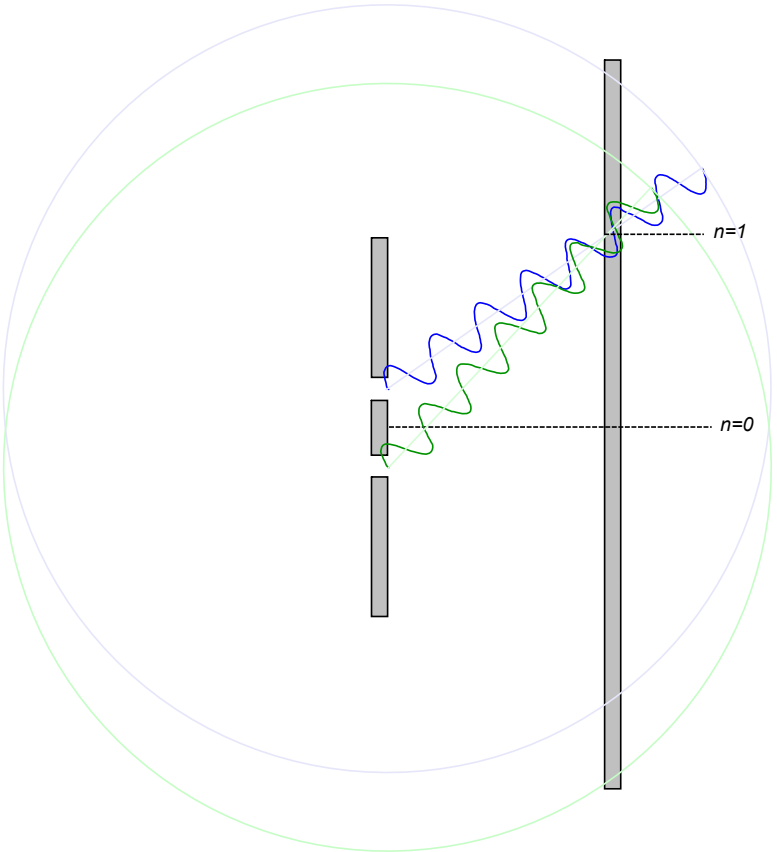


n=2 Both reach the screen just above the equilibrium position.

n=1 Both reach the screen while in a trough and constructively interfere.

Interactive - Diffraction of Long Wavelength

$v = f\lambda$

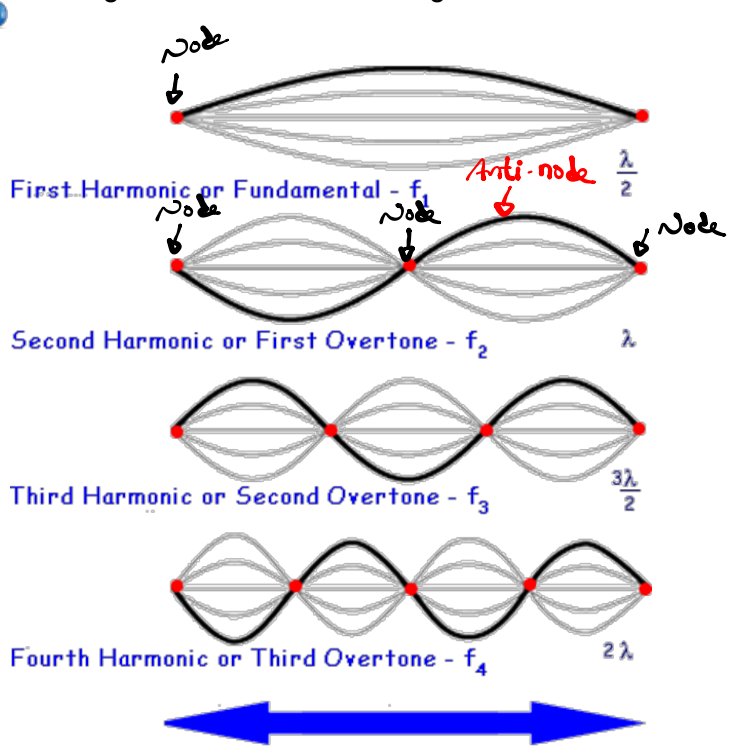


n=1 Both reach the screen while in a trough and constructively interfere.

Standing Waves

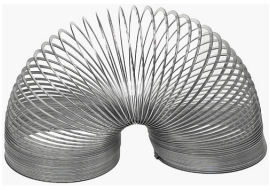
- Standing Waves
  - > Terminology including Nodes and Antinodes
  - > Melnyk and the Aluminum Rod
  - > Visual Represetation using Slinky Activity

http://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Standing-Wave-Patterns/Standing-Wave-Patterns-Interactive



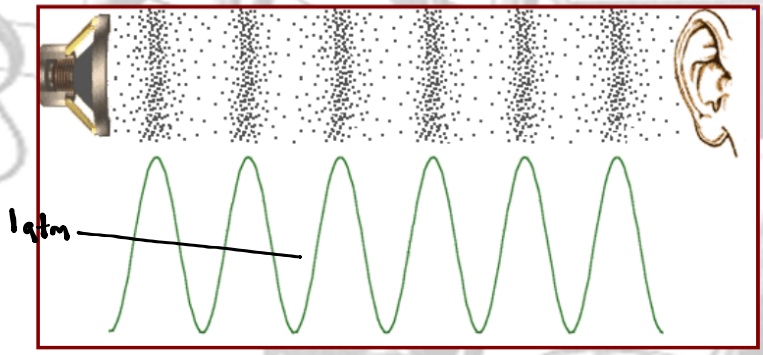
Melnyk and his Aluminum Rod

Slinky Activity



How Does Sound Travel?

In the diagram below, the black dots represent air molecules. As the loudspeaker vibrates, it causes the surrounding molecules to vibrate in a particular pattern represented by the waveform. The vibrating air then causes the listener's eardrum to vibrate in the same pattern. Viola — Sound!

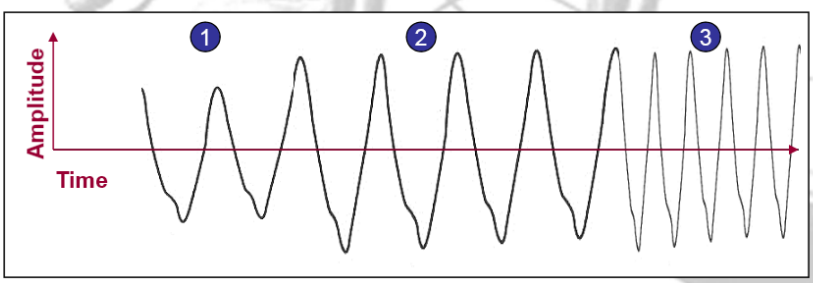


Note that air molecules do not actually travel from the loudspeaker to the ear (that would be wind). Each individual molecule only moves a small distance as it vibrates, but it causes the adjacent molecules to vibrate in a rippling effect all the way to the ear.

Major Attributes of Music

PITCH: The pitch of a musical instrument determined by the "frequency" of the sound wave, or how many times a part of the wave repeats itself per second. The A above Middle C is usually set at 440 Hz, meaning that the wave repeats itself 440 times per second.

LOUDNESS: The loudness of a musical instrument is determined by the "Amplitude" of the sound wave. The larger the amplitude, the louder the sound. The amplitude of waves add together, so two flutists will sound twice as loud as a single flutist since their combined amplitude will be twice as high as for each one!

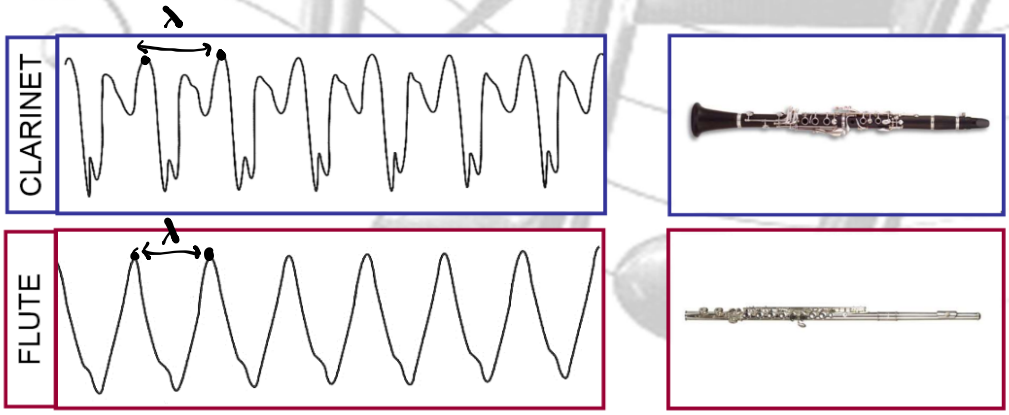


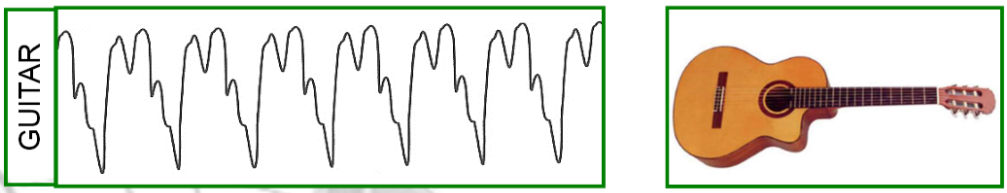
1. We start off at a moderate loudness and pitch.
2. Our loudness increases.
3. Our pitch increases.

Timbre

One of the basic elements of music is called color, or timbre (pronounced "TAM-ber"). Timbre describes all of the aspects of a musical sound that do not have anything to do with the sound's pitch, loudness, or length.

In other words, if a flute plays a note, and then a clarinet plays the same note, for the same length of time, at the same loudness, you can still easily distinguish between the two sounds, because a flute sounds different from a clarinet. This difference is in the timbre of the sounds.





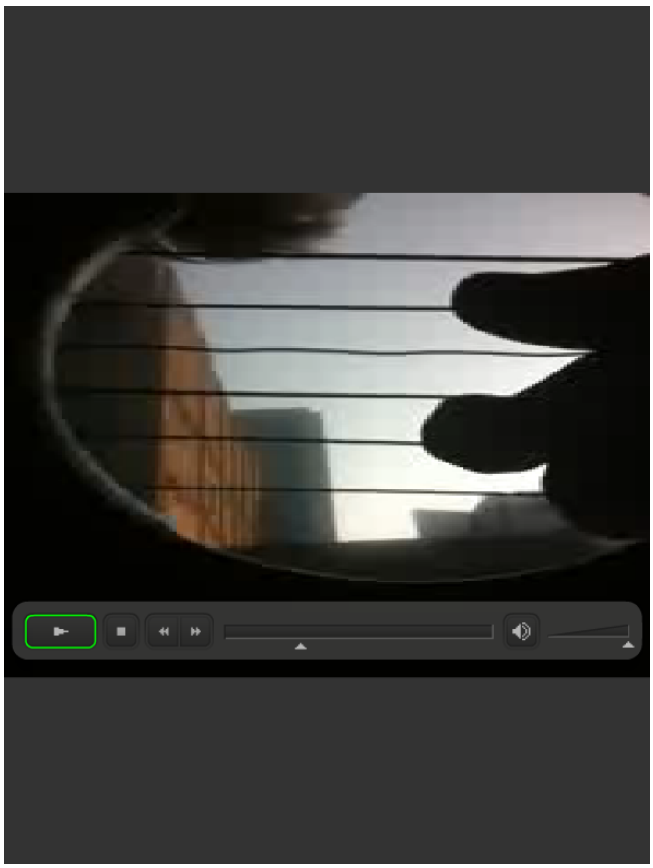
Timbre is caused by the fact that each note from a musical instrument is a complex wave containing more than one frequency.

For instruments that produce notes with a clear and specific pitch, the frequencies involved are part of a harmonic series*. For other instruments (such as drums), the sound wave may have an even greater variety of frequencies.

We hear each mixture of frequencies not as separate sounds, but as the color of the sound. Small differences in the balance of the frequencies - how many you can hear, their relationship to the fundamental pitch, and how loud they are compared to each other - create the many different musical colors.

* Harmonic Series: A series of frequencies at f, 2f, 3f, etc. So for f=440Hz, the frequencies in the harmonic series would be 440Hz, 880Hz, 1320Hz, etc.

Application of Wave Interference

http://www.mindspring.com/~j.blackstone/dist101.htm

iPhone and a Guitar