Waves

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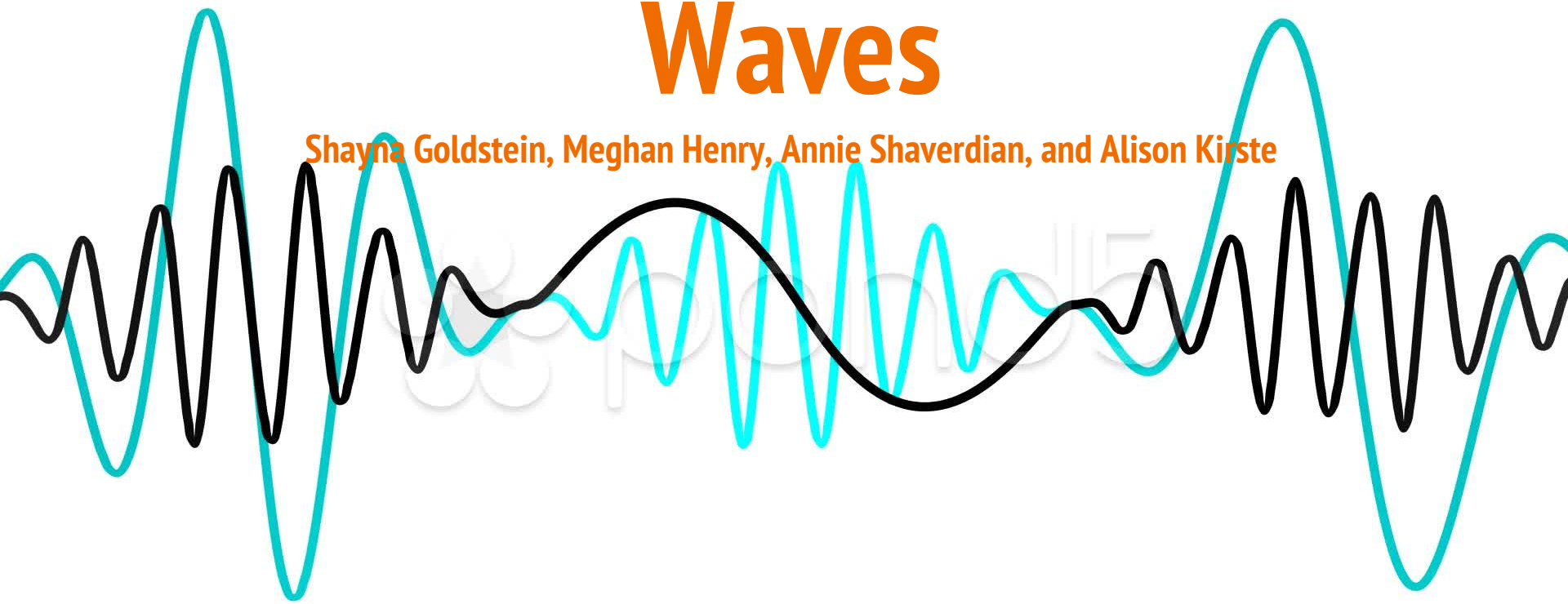


What is a Wave?

- A wiggle in time and space. The source of a wave is from vibration and a vibration is a wiggle in time.
- Vibrations carry energy but never mass

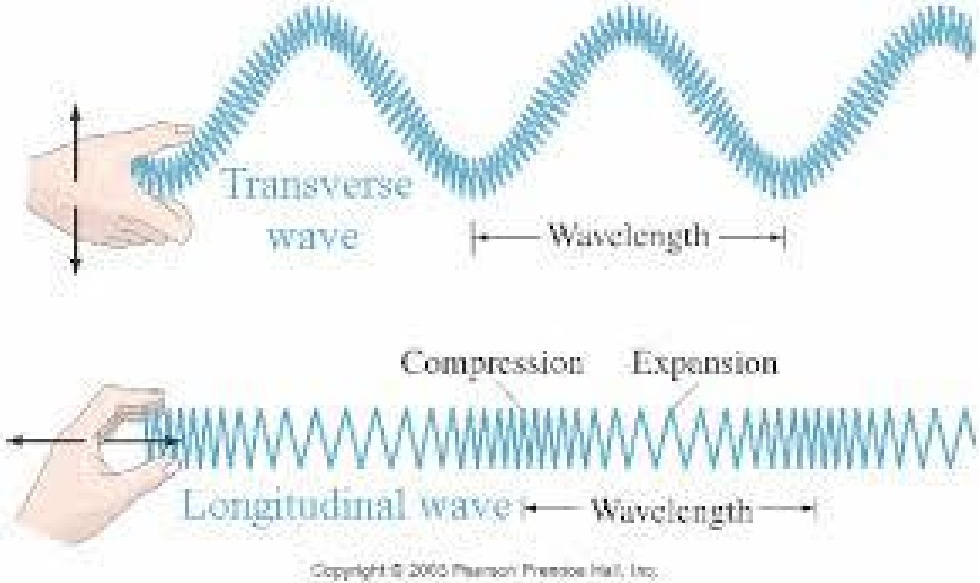
Qualities of a Wave

- Period (T) (in seconds)
  - Time it takes for one back and forth cycle
- Wavelength (λ) (in meters)
  - Distance between successive identical parts of the wave
- Frequency (f) (in hertz)
  - Number of vibrations in a given time
  - f=1/T
- Velocity (v) (in m/s)
  - Speed and direction of the wave
  - V=λf
- Crests: peaks or high points
- Troughs: valleys or low points
- Amplitude: distance from midpoints to crests (or troughs)

Types of Waves

- **Transverse waves**
  - Motion of the medium moves *perpendicular* to direction in which wave travels

- Longitudinal waves
  - Motion of medium moves in the *same direction* as in which wave travels



Interference

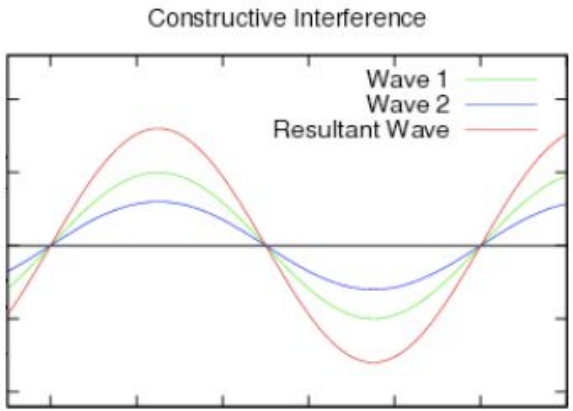
- Interference occurs when two or more waves meet
- When waves overlap they create an interference pattern
- Wave effects may be increased decreased or neutralized

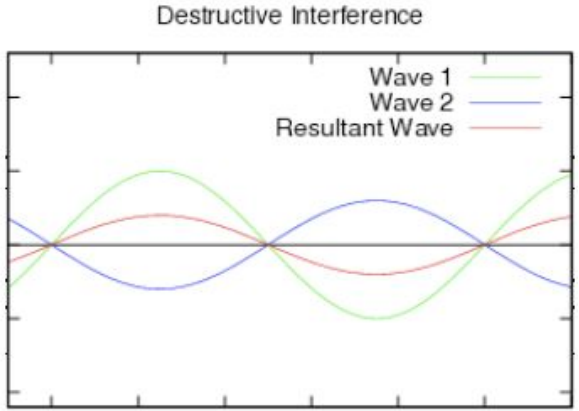
Standing Waves

- Standing waves are stationary waves
- There are points on the wave that are fixed or stationary
  - Fixed points are called nodes
  - Unfixed points are called antinodes
    - (which happen halfway between nodes)
- Standing waves are the result of interference
  - 2 waves of the same amplitude and wavelength moving in opposite directions
  - Nodes are stable regions of destructive interference

Constructive/Destructive Interference

- Constructive interference: when when the crest of one wave overlaps with the crest of another, as a result their individual effects add up
- Destructive interference: when the crest of one wave meets the trough of another, their individual effects decrease





Sound Waves

- Produced by vibrations that compress and decompresses the air around the vibrating object.
- The compresses areas are of higher pressure called **compressions**.
- Decompressed areas are of lower pressure called **rarefractions**.

Frequency of Sound

- Pitch is an interpretation of sound.

High Frequency ⟹ High pitch

Low Frequency ⟹ Low Pitch

- Sound frequencies below 20 Hertz are called **infrasonic**
- Sound frequencies above 20,000 Hertz are called **ultrasonic**

The Doppler Effect

- The apparent change in frequency due to the motion of the source or receiver
- The pitch sound is higher when the source is moving towards you

Loudness

- It is the brain's interpretation of sound intensity

$\beta = 10 \log (I_1 / I_0)$

I_0= 10^-12 W/m^2 This is the threshold of hearing measured in decibels (dB)

- For each increase to 10 dB, intensity increases by a factor of 10, thus human hearing is logarithmic

Sound

-it is produced by vibrations that compress and decompress to form areas of high pressure (compressions) and areas of low pressure (rarefactions)

-the frequency of the vibrating force almost always equals the frequency of sound waves

-speed of sound (in dry air at 20 degrees C)

v=343.59 m/s or 768.59 mph

-speed of sound in a vacuum is 0 m/s

- Sound is a longitudinal wave

Sound Waves

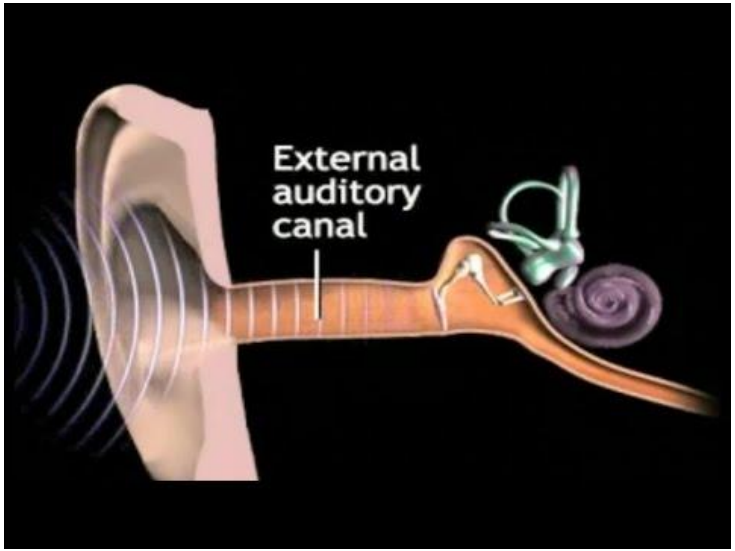
-sound needs a medium to travel through

-the speed of sound depends on the elasticity (measure of how well an object retains its shape) of the medium

-elasticity: solids>liquids>gasses

Transmission of Sound Waves

1. Vibration of the source
2. Compression waves thru the media
3. Vibration of our eardrums
4. Electrical pulses are pushed to the brain



Transmission of Waves

- Materials with high elasticity have greater internal energy to retain their shape.
- When the wave pushes the material, the material pulls itself back

Speed of sound in air:

v= 343 m/s

In water:

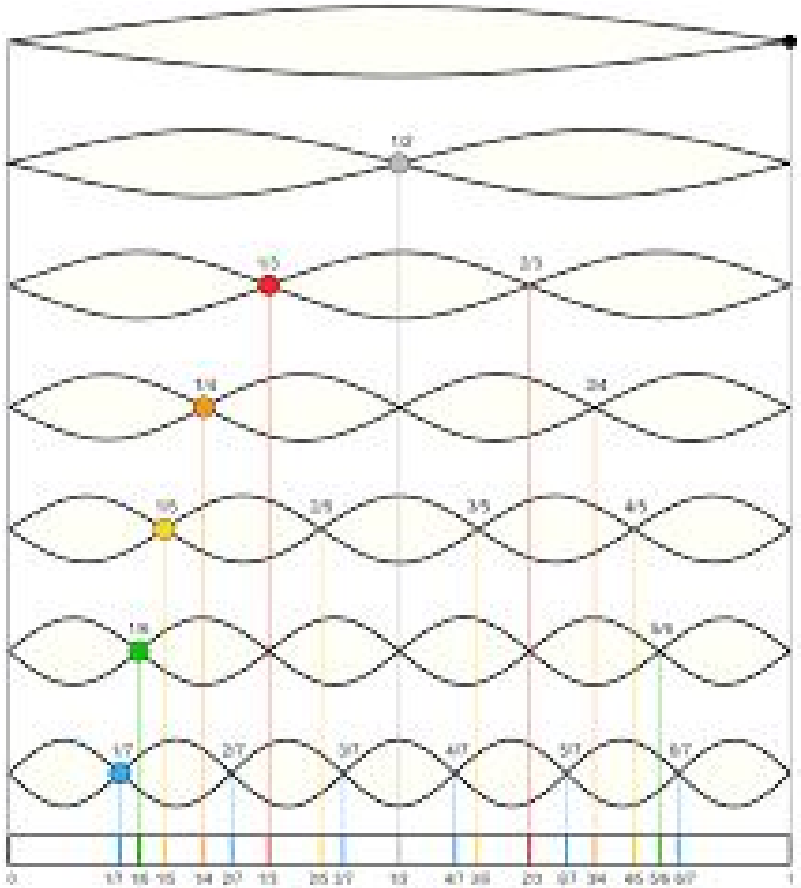
v= 1,482 m/s

In steel:

v= 5,960 m/s

Harmonic Series

- Sequence of all multiples of a base frequency
  - 1st frequency, 1st harmonic: 110
  - 2nd frequency, 2nd harmonic: 220
- Pitched instruments are built to resonate at several frequencies simultaneously
- All you need are standing waves where endpoints are nodes

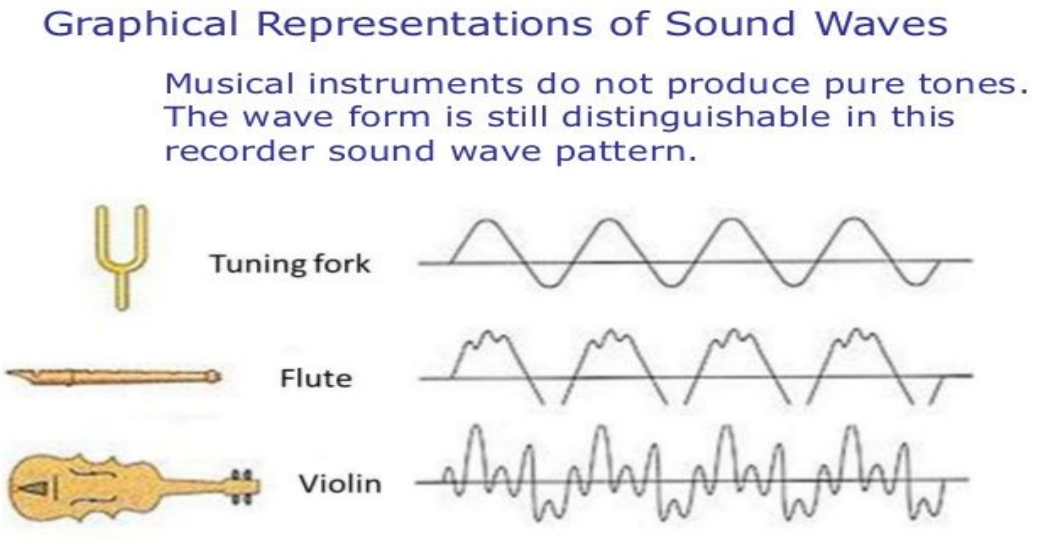


Resonance

- When the frequency of a forced vibration on an object matched the object's natural frequency a dramatic increase in amplitude occurs
- This only occurs in elastic materials because there needs to be a strong enough force to pull the material back to its starting position and enough energy to keep it vibrating.

Timbre

- It is the tone quality of the tone color
- Is it our biological interpretation of wave form



Misconceptions

- Some people think sound can travel through a vacuum but it actually cannot because it needs a medium to travel through so it can vibrate to produce sound
- Frequency is the reciprocal of period not the opposite of a period
- Intensity is logarithmic which means that for each increase in 10dB, the intensity increases with a factor of 10, this follows the decibel scale

Practice Problem

Find the wavelength of a 680-Hz tone in air, where the wave speed is 340 m/s

Now You Try

What is the frequency of a sound wave that has a wavelength of 3 m?