Act V Scene I-II

Wave Mechanics & Sound

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What’s a Wave?

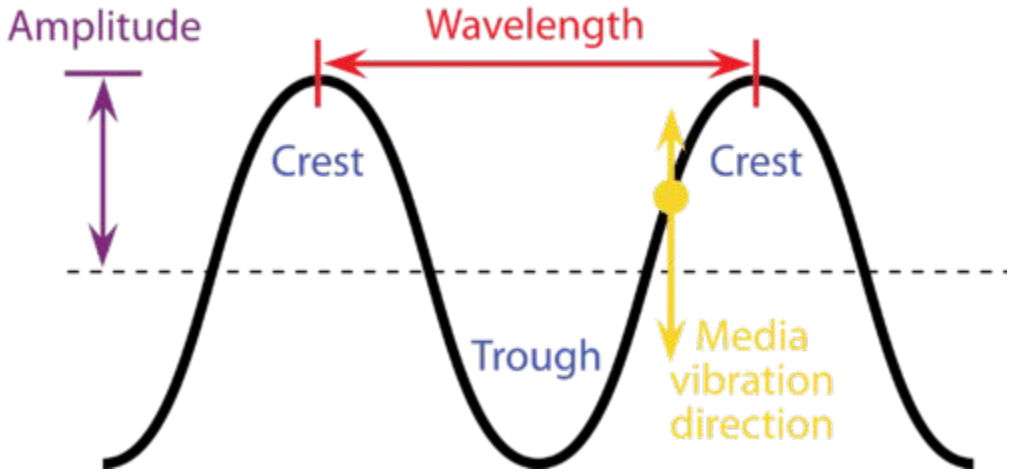
- A wave is a traveling vibration
- Carries energy from a vibration to the receiver
- Does not transfer matter

Wave Characteristics

- A **Period(T)** is the time it takes for one full cycle
  - Measured in seconds
- A **Wavelength(λ)** is the distance between adjacent troughs
  - Measured in Meters
- **Frequency(f)** is the amount of vibrations per second (or any given time)
  - Measured in Hertz
- F=1/T
  - Frequency = 1/Period
- **Velocity** is the direction and speed of a wave
  - Measured in m/s
- V=λT
  - Velocity =Wavelength*Period

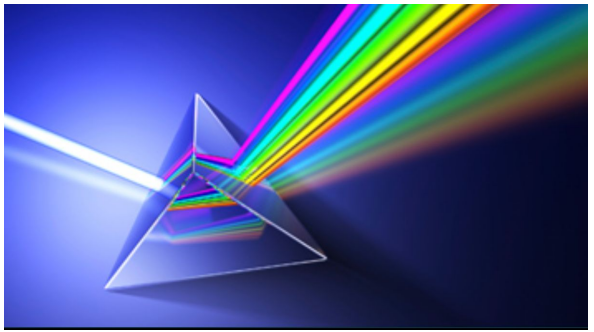
More Wave Characteristics

- A **Crest** is the high point of a wave
- A **Trough** is the low point of a wave
- **Amplitude(A)** is the distance between the crest/trough to the midpoint

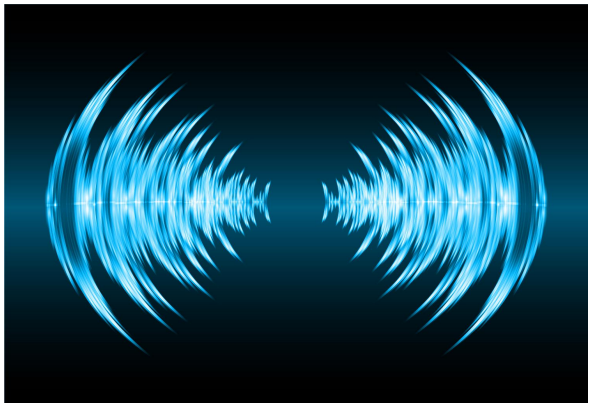


Wave Speeds

- Speed of a light wave:
  - c= 299,792 km/s (186,282 mi/s)



- Speed of a sound wave:
  - c=1235 km/hr (343 m/s)



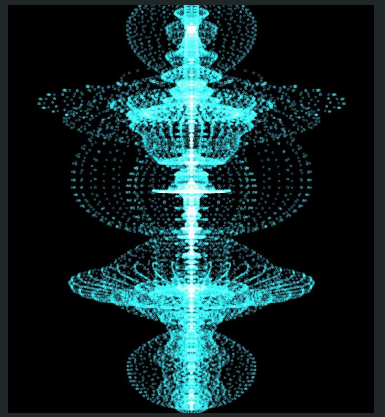
- Sound cannot travel in a vacuum

Transverse

- Motion of Medium is perpendicular to direction the wave is traveling
- Some examples are ripples in water, a whip, light, and earthquake secondary waves

Longitudinal

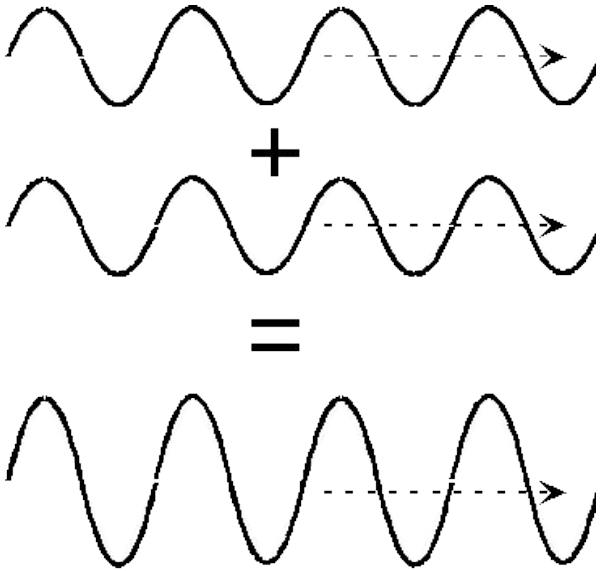
- The motion of medium moves in the same direction of the wave
- Examples are sound waves and earthquake primary waves



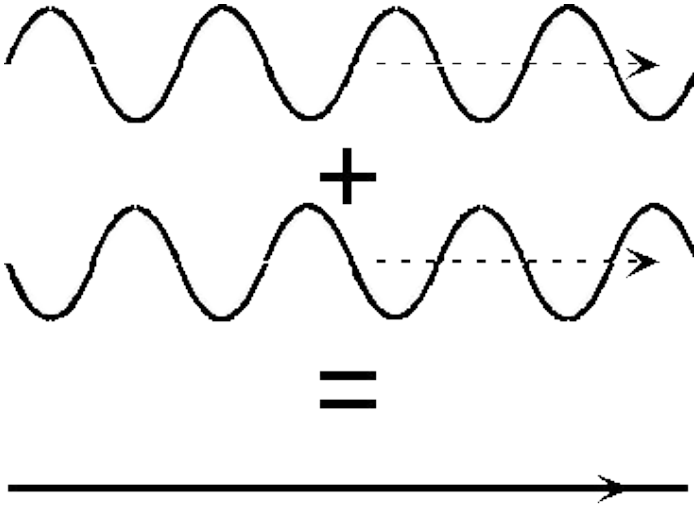
Wave Interference

- An **Interference** is when two or more waves run across each other
- When parts of a wave overlap they create an interference pattern
- This causes the effect of the wave to change
  - Either increase, decrease, or stay neutral
- When a crest interferes with another crest of another wave, the effects add up
  - This is called **Constructive Interference**
- When a trough interferes with a crest, their effects nullify/decrease
  - This is called **Destructive Interference**
- True of all waves
  - Ie. sound, light, etc.

Examples of Interference



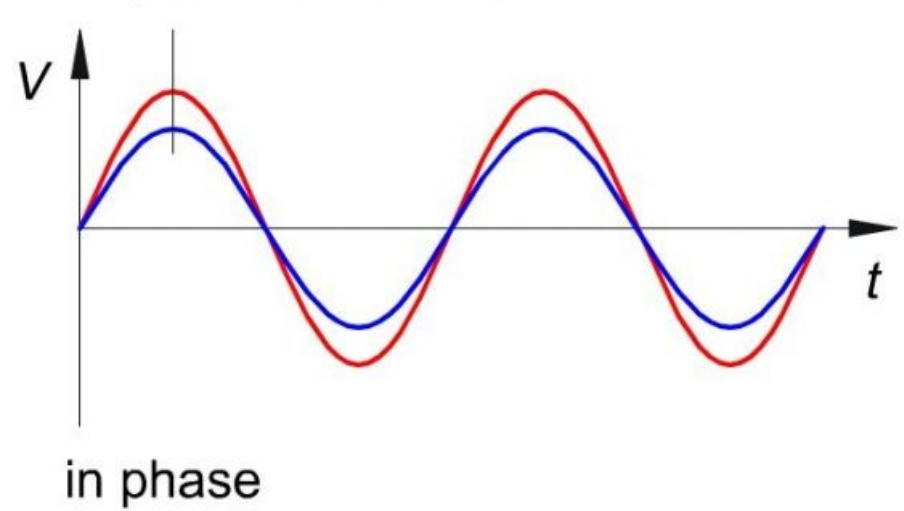
Constructive



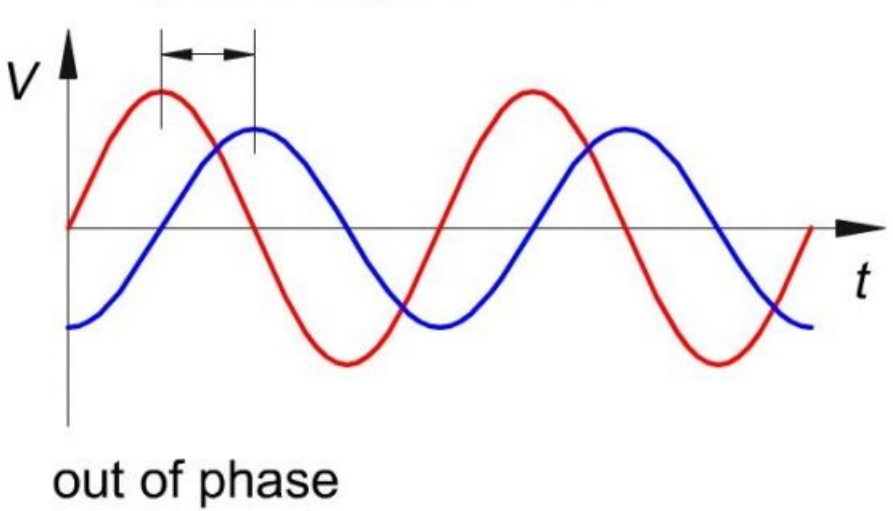
Destructive

In Phase and Out of Phase

- **Phase** - the relationship between a wave and another point, possibly another wave (Crests and troughs line up)
- Waves that are in phase are in synch and the crests and troughs line up
- Wave out of phase are out of synch and the crests and troughs don't line up



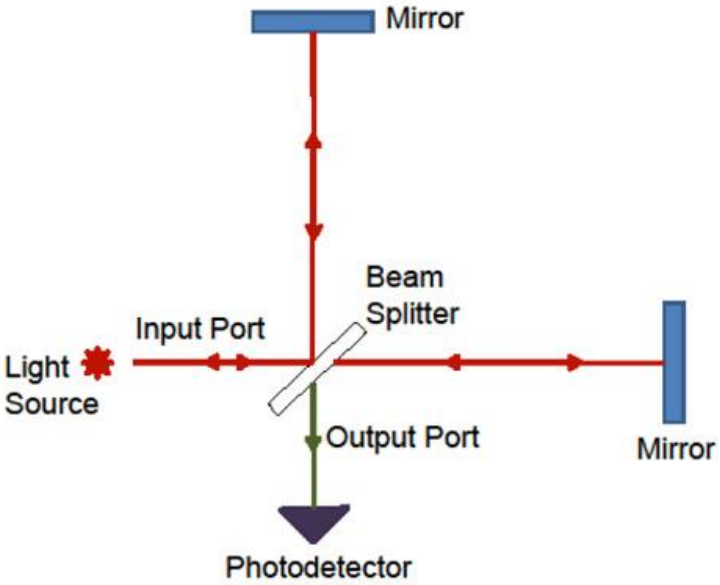
in phase



out of phase

Interferometry

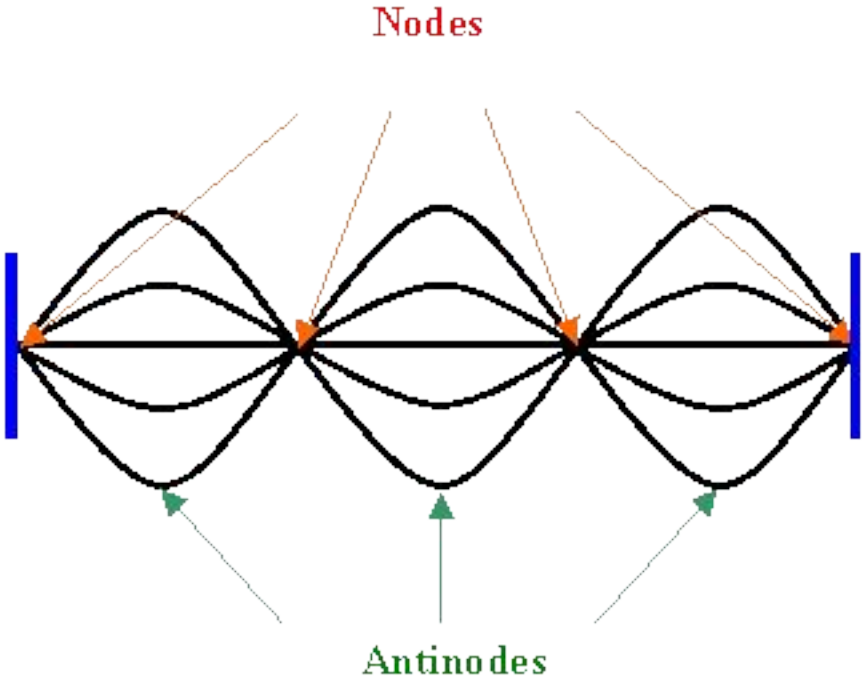
- **Interferometry** involves strategies where you can use wave interference patterns to get information about the waves (usually light)



Standing Waves

- **Standing waves** are “stationary waves with fixed points called **nodes**
- The parts on the wave with the largest amplitudes are **antinodes**
  - **Antinodes** always occur halfway in the waves
- The fixed parts of the wave are called **Nodes**
- Standing waves are the result of **interference**
- Happens when two waves of same amplitude and wavelength pass through each other on opposite sides
- Nodes are always out of phase

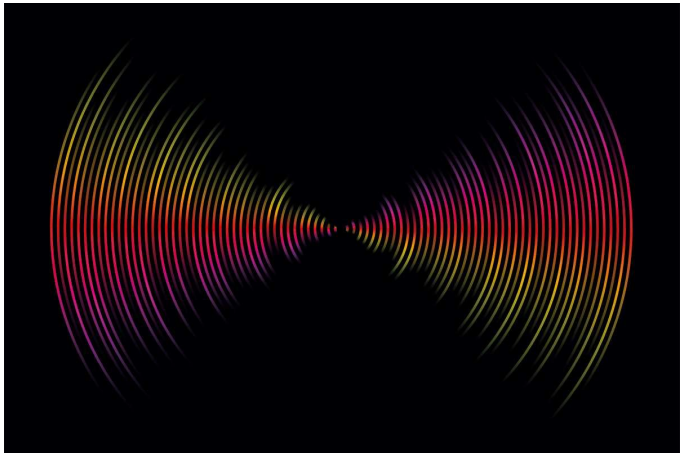
Standing Wave




Sound

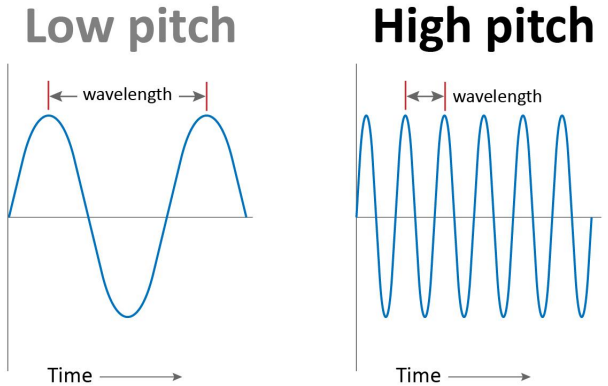
Sound

- Produced by vibrations that compress and decompress the medium around it
- Compressed areas are called **Compressions**
- Decompressed areas are called **Rarefactions**
- The frequency of a vibrating source is equal to the frequency of the sound waves



Sound Frequency

- **Pitch** is how our brains interpret frequency

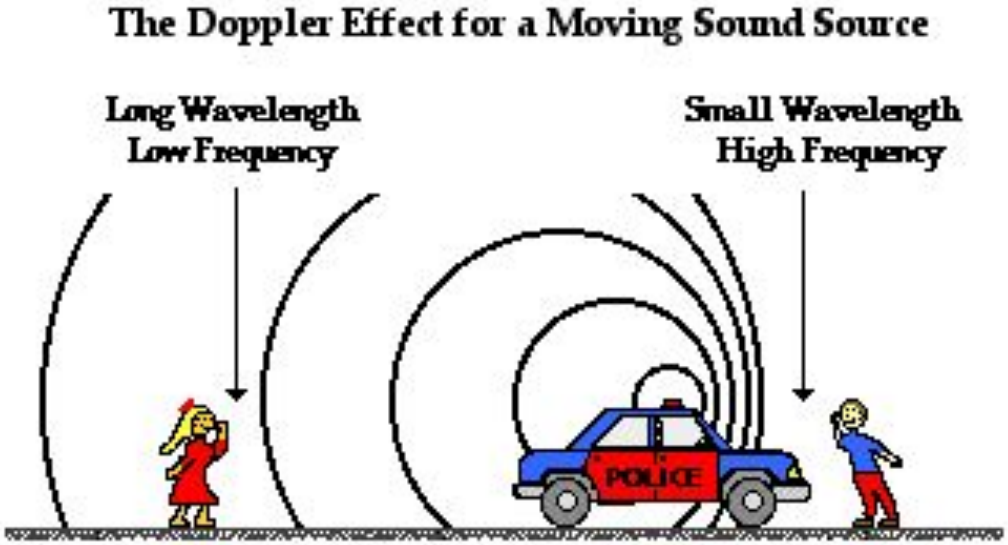


- High frequency⇒ high pitch
- Low frequency ⇒ low pitch
- A person can hear between 20-20,000 Hz

- Frequencies below 20 Hz are **Infrasonic**
- Frequencies above 20,000 Hz are called **Ultrasonic**

Doppler Effect

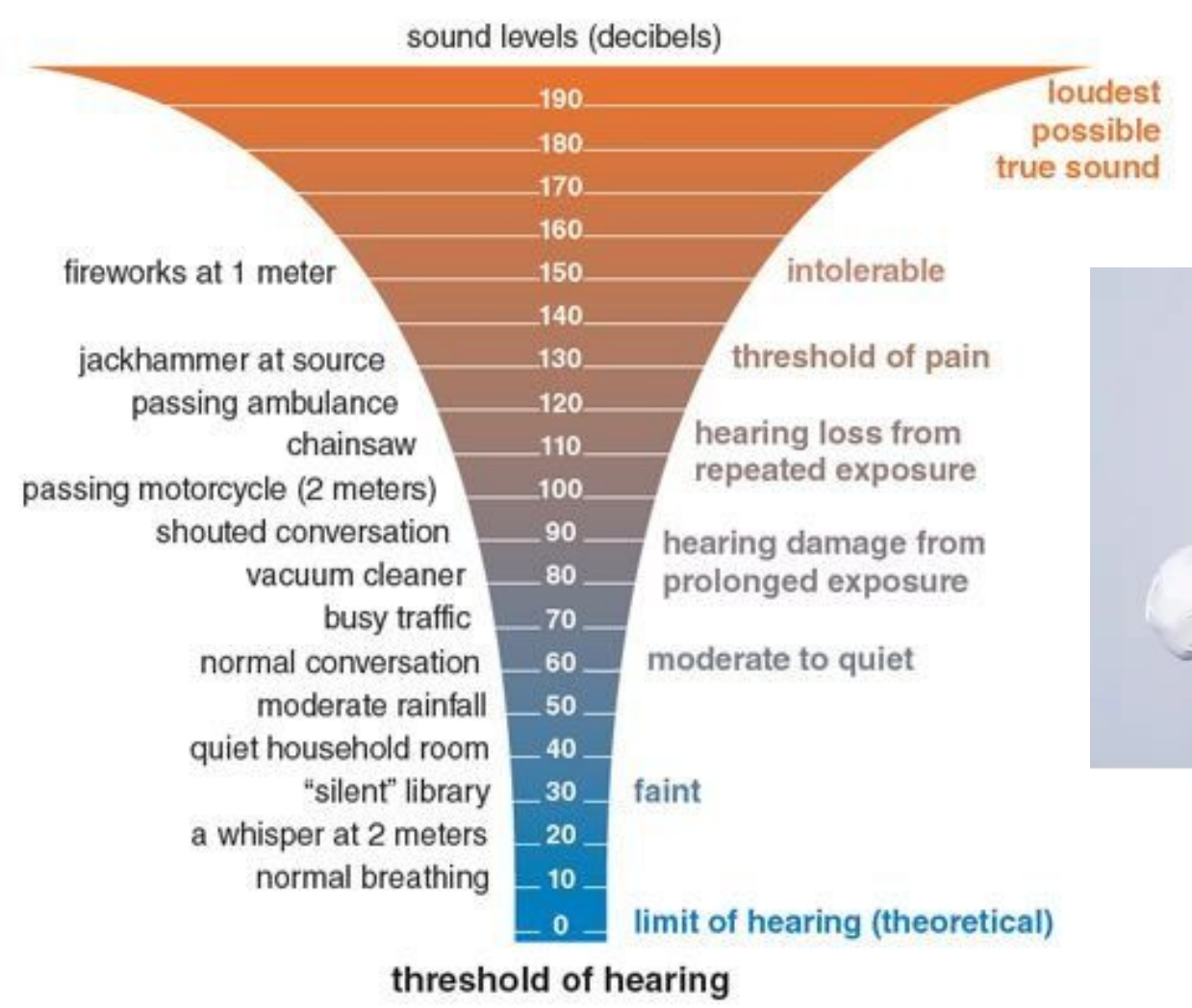
- The apparent change in frequency due to motion of the source.
- Pitch is higher when the source is moving towards you
- Pitch is lower when the source is moving away from you



Loudness

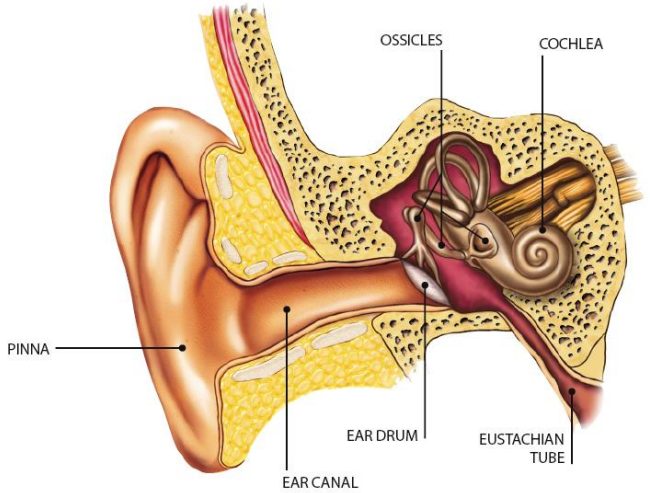
- **Loudness** is how our brains interpret **sound intensity**
  - **Intensity** = power/area
- Convert Intensity to Loudness measured in decibels (dB)= $\beta = 10 \log(I_1/I_0)$
  - I_0 is always equal to 10^-12 W/m^2
  - I_0 is the intensity of the **Threshold of Sound**
- Loudness is Logarithmic (Follows decibel scale)
- For each increase in 10 decibels, the intensity

  increased by a factor of 10 db


sound levels (decibels)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
loudest possible true sound
intolerable
threshold of pain
hearing loss from repeated exposure
hearing damage from prolonged exposure
moderate to quiet
faint
limit of hearing (theoretical)
fireworks at 1 meter
jackhammer at source
passing ambulance
chainsaw
passing motorcycle (2 meters)
shouted conversation
vacuum cleaner
busy traffic
normal conversation
moderate rainfall
quiet household room
"silent" library
a whisper at 2 meters
normal breathing
threshold of hearing

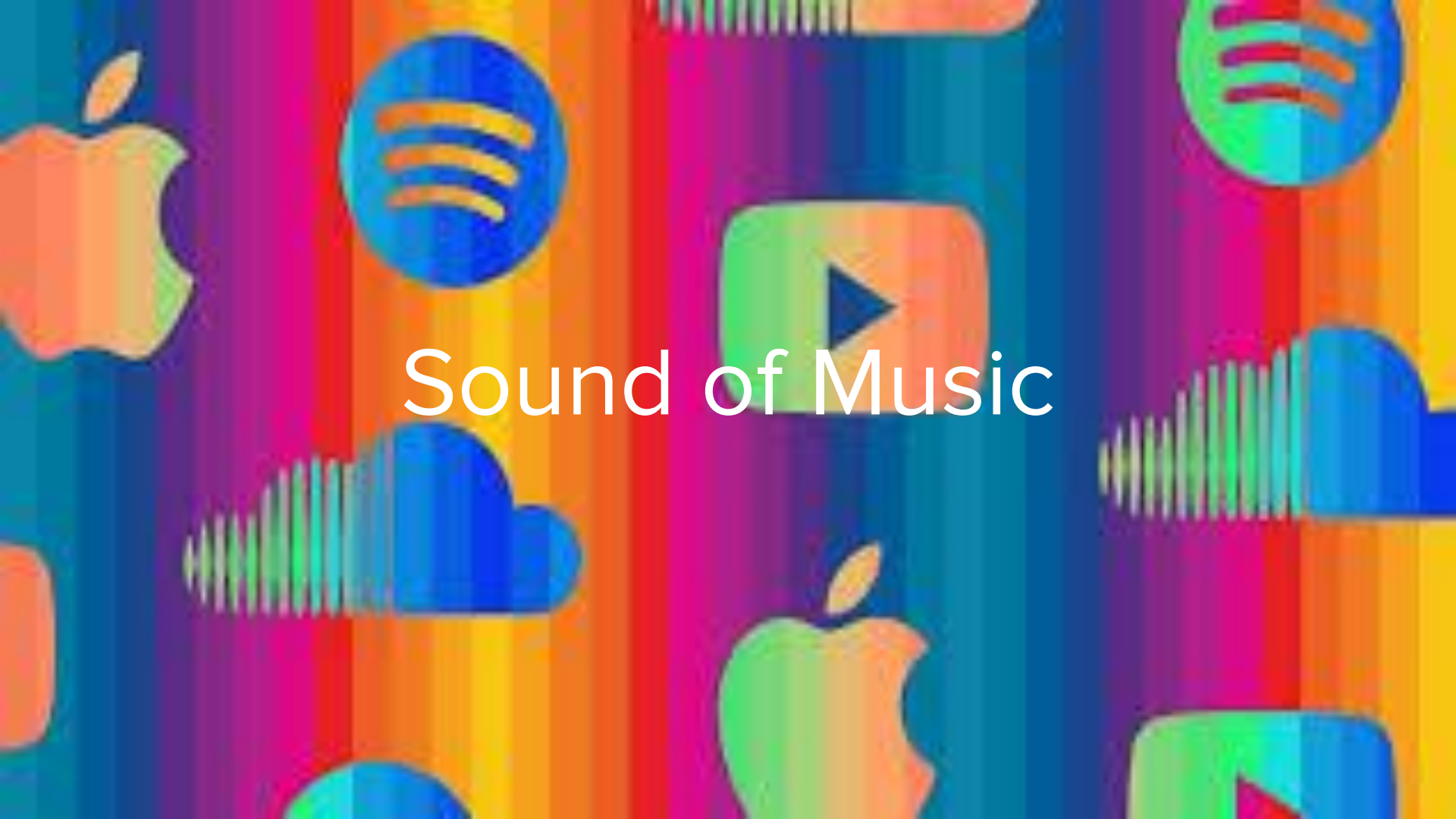
How We Hear Sound

1. Origin of the sound vibrates
2. The vibration compresses and passes through a medium
3. Vibration pushes the air inside our ear and gets detected by our eardrum



Sound Transmission

- Sound cannot travel through a vacuum
  - Need a medium to go through
- The elasticity of the medium dictates the speed of the sound
  - In air: v=343 m/s
  - In wood: v=3300-5000
  - In water: v=1428 m/s
- Higher elasticity ⇒ faster sound wave
- This is because sound waves push the medium it travels in, and materials with high elasticity have a lot of internal energy to help retain their shape
- Therefore, this leaves more energy for the wave to use for its kinetic motion

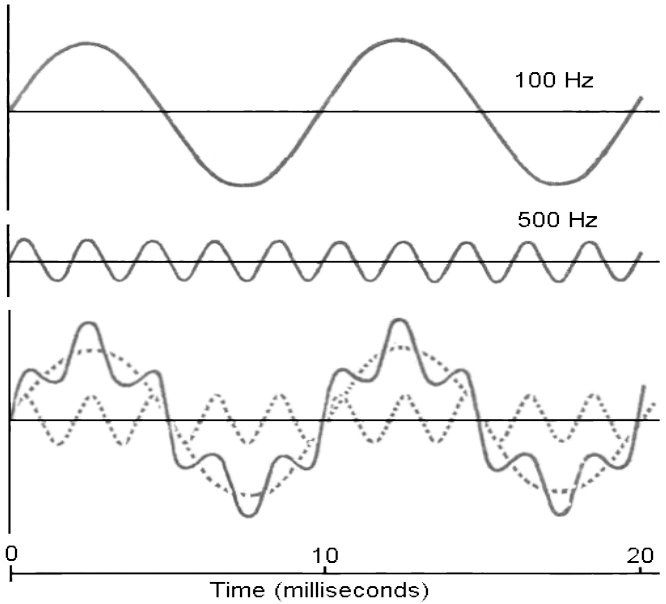

Sound of Music

Vibrations

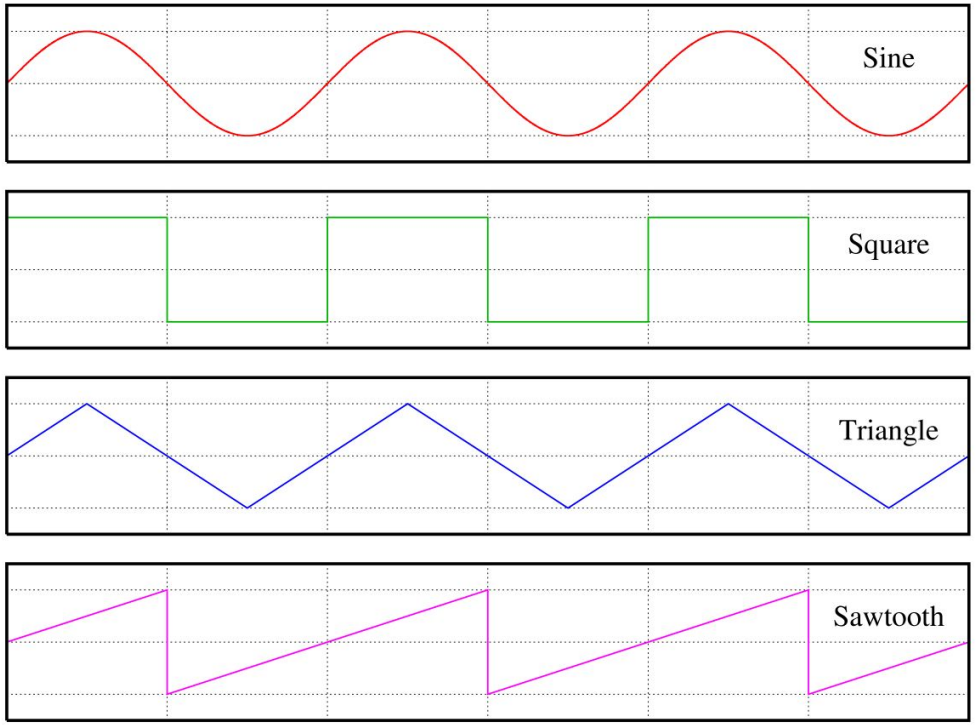
- A **Force Vibration** is when a vibration in one medium forces another vibration in another medium
- **Natural Frequency** is the frequency at which the minimum amount of energy is required to produce and keep force vibrations
  - Varied depending on the shape and elasticity of the object vibrating
- **Resonance** happens when the force vibration and the natural frequency of an object are the same
  - Creates a huge increase in sound and amplitude
- A strong force is needed to pull the material back to its starting position

Interference

- Both constructive and destructive interference are the same in music
- Interference with waves of different frequencies are different



Waveforms



Timbre is the tone quality or tone color of a sound wave

Harmonics

- A **Harmonic Series** is the sequence off all multiples of a base frequency
- Example:
  - Base frequency = 10 hz
  - 2nd harmonic = 20 hz
  - 3rd harmonic = 30 hz etc.
- Pitched musical instruments are built to simultaneously resonate at different frequencies
- Require standing waves