# Fundamentals of Sound and Music

Nimal Skandhakumar

Faculty of Technology
University of Sri Jayewardenepura

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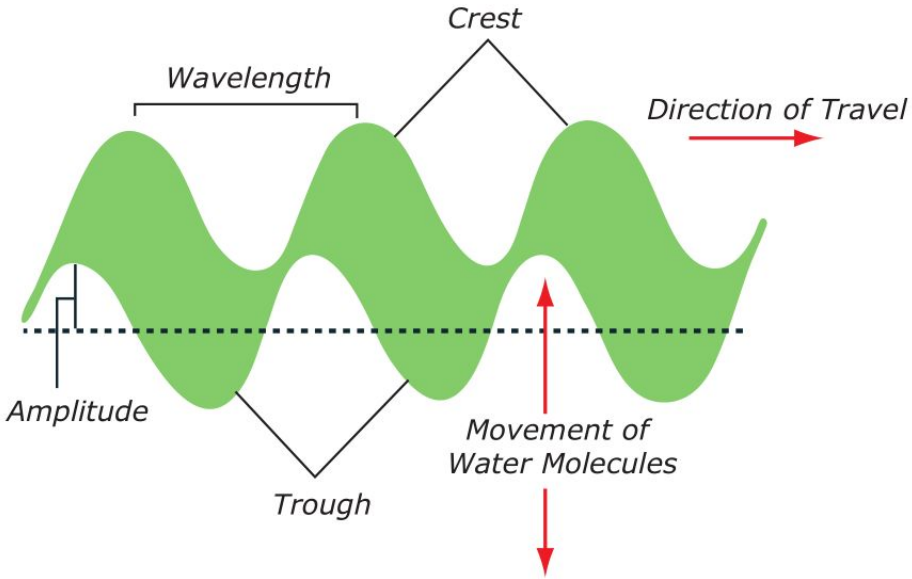
# Partially based on:

- Christopher Ariza. 21M.380 Music and Technology: Recording Techniques and Audio Production. Spring 2012. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.

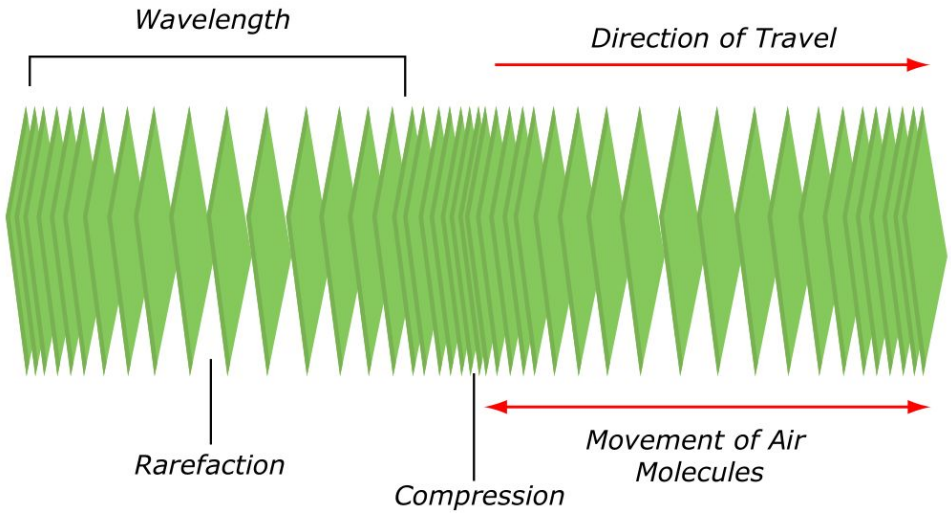
# Sound Wave

- Sound is the result of vibrations of air molecules caused by the motion of an object
- A sound wave is made when a series of vibrations move through the air (or other medium)
- The overall shape of crest and trough over time is called a waveform



# Sound Wave

- Each compression is represented by a peak or crest
- Each rarefaction is shown by the trough
- The spot where the wave is in neutral position is called zero crossing



# Properties of Sound Waves

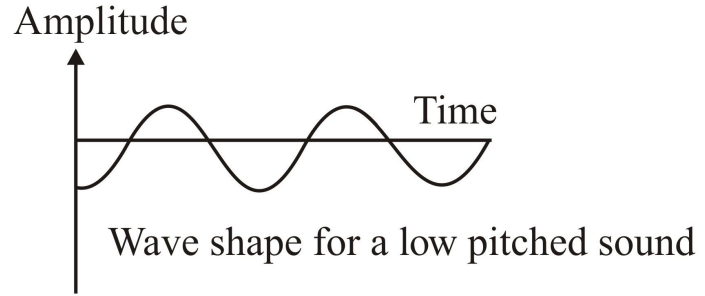
1. Speed
2. Frequency
3. Wavelength
4. Amplitude
5. Loudness
6. Envelope
7. Phase
8. Harmonics
9. Timbre

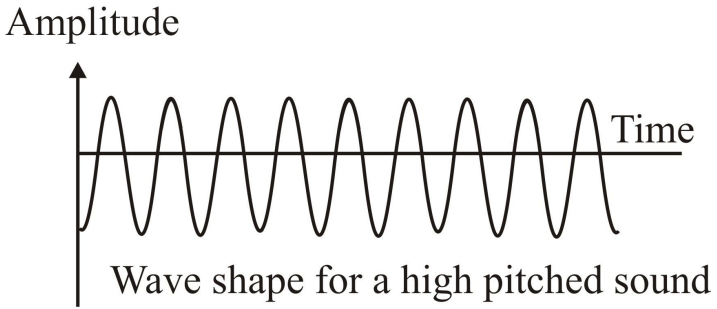
# Speed

- How much distance a sound wave travels in a given amount of time.
- Approximately 344 meters/second, in air at room temperature of 20°C.
- Varies with the temperature of air, such that sound travels slower at higher altitudes or on cold days.

# Frequency

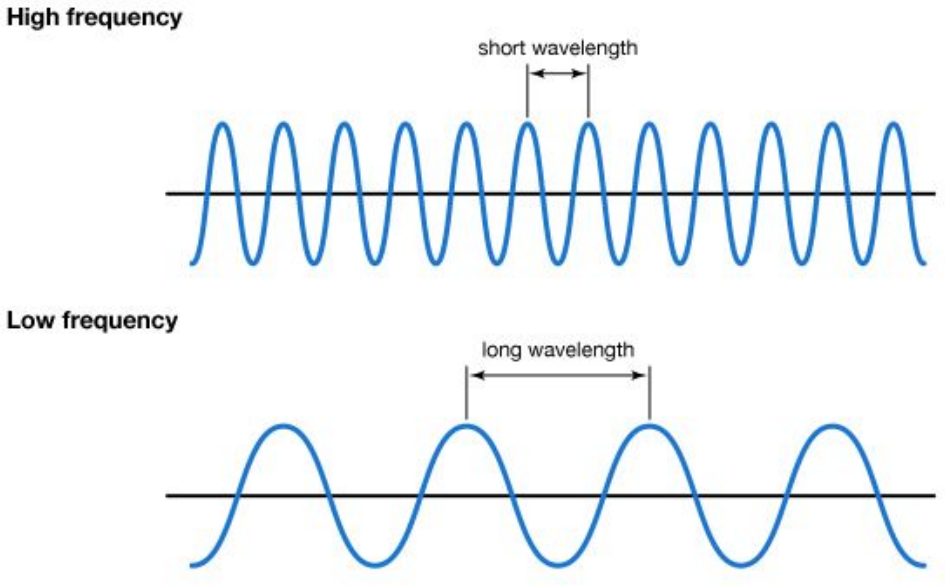
- How often it oscillates: its frequency, in Hertz (Hz), which means cycles per second
- The closer together the peaks of a wave are, the higher its frequency
- Pitch relates to how the ear interprets frequency



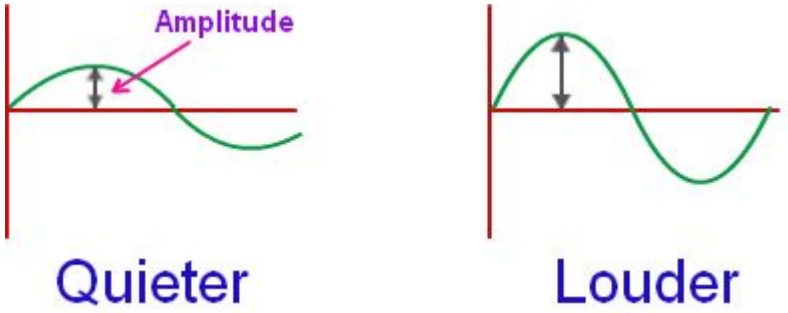
# Wavelength

- Distance between crests: wavelength, in metres
- Wavelength is the physical distance of a complete cycle
- The longer the wavelength, the lower the frequency, thus the lower the perceived sound.
  - 20 Hz cycle = 17 m
  - 20 kHz cycle = 2 cm



# Amplitude

- How large are the oscillations: its amplitude
- Technically described as dB SPL
  - dB = decibel
  - SPL = Sound Pressure Level
- Increased SPL = Increased volume

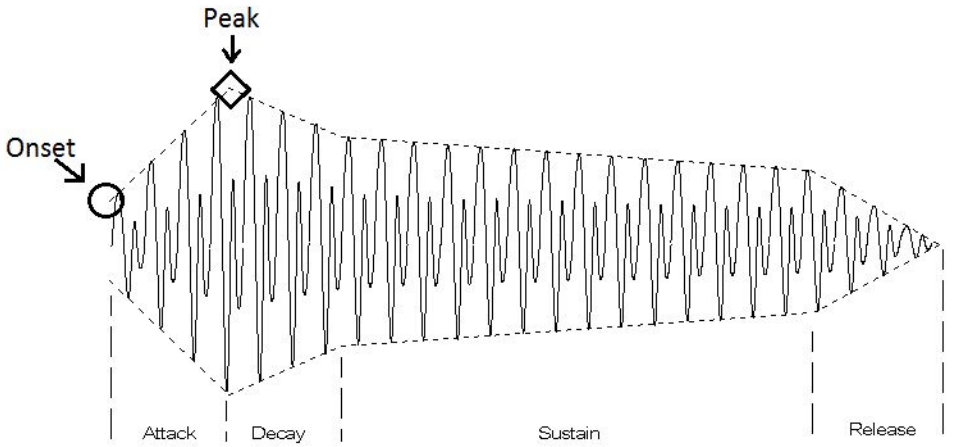


# Loudness

- Amplitude is the measurement of the strength or weakness of air pressure produced by a sound signal
  - The loudness of a sound is not the same as the amplitude of a sound
- Loudness is the subjective perception of how loud or soft a sound is
- Loudness is the psychological measurement of the magnitude of a sound, which includes everything from its frequency, pressure, harmonics, surface properties within the sound space and duration

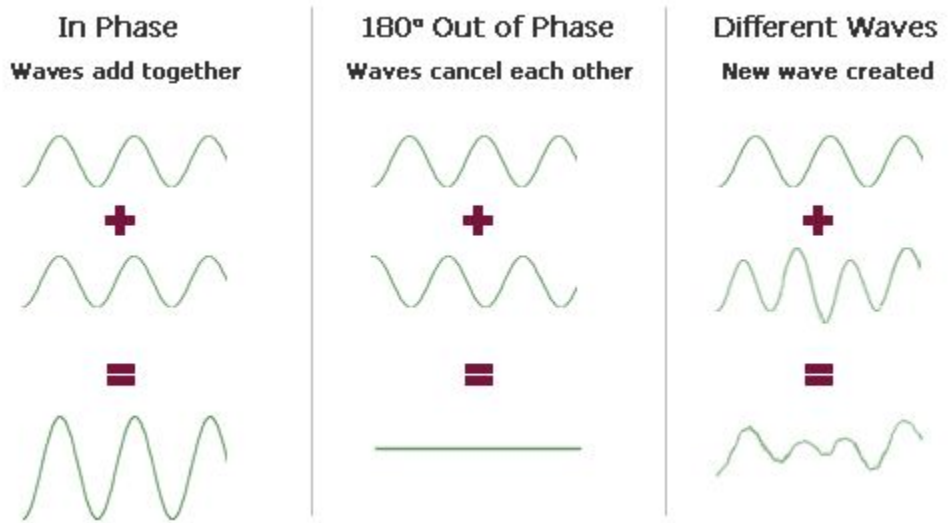
# Envelope

- The envelope of a sound is the defining characteristic of the shape of a sound
- All sounds possess a change in amplitude as time increases
- The features included in an envelope are: **A**ttack, **D**ecay, **S**ustain and **R**elease.



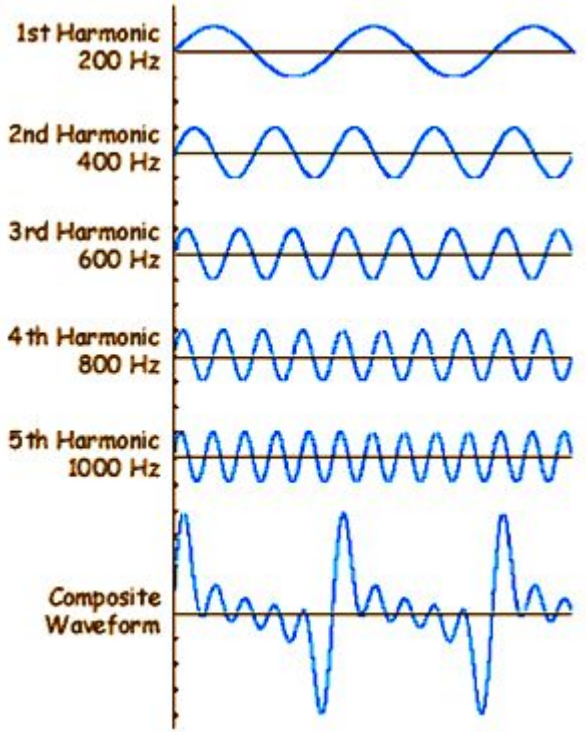
# Phase

- Phase is the time difference between two waveforms in relation to a corresponding point in the wave cycle
- When a simple waveform moves through one complete cycle, it is said to have traveled through 360° or one full phase.



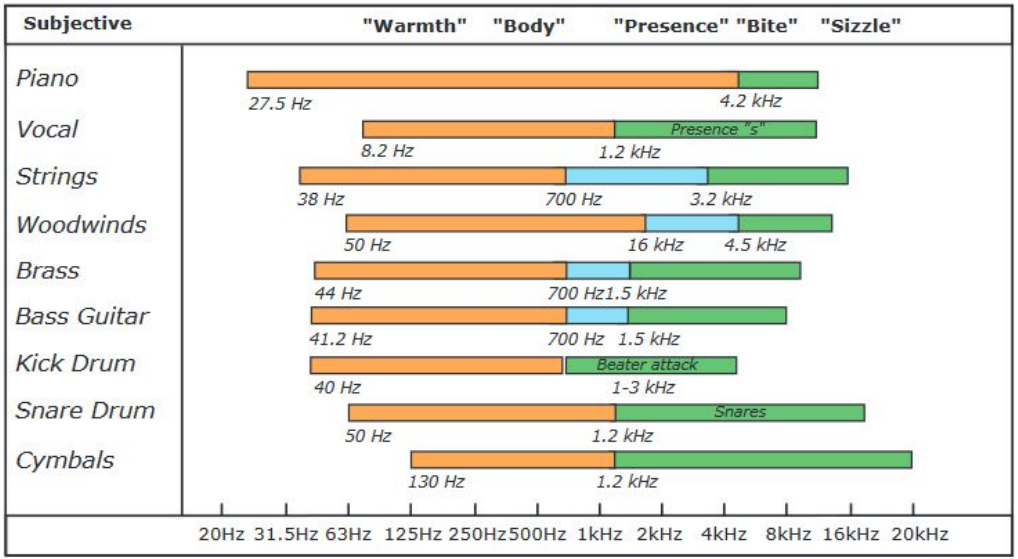
# Harmonics

- Harmonics are a series of related frequencies that make up a sound
- All sounds we hear are a combination of sine waves at different frequencies and amplitudes

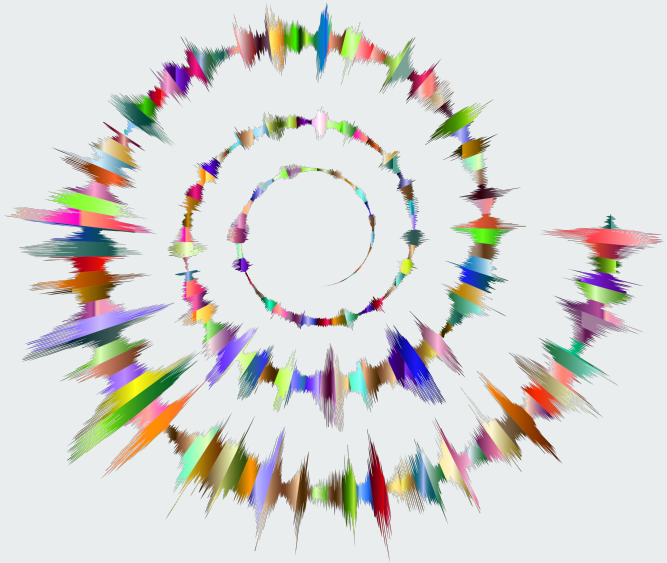


# Timbre

- All sounds in nature are more complex than a sine wave
- Our ears are designed to distinguish sounds based on timbre



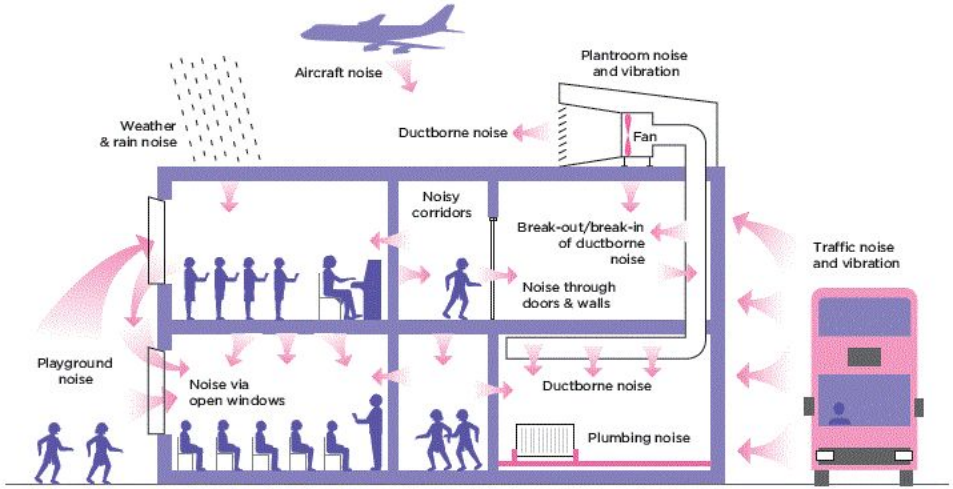
# Types of Sound Transmission



1. Isolation
2. Reflection
3. Refraction
4. Diffraction
5. Absorption
6. Interference

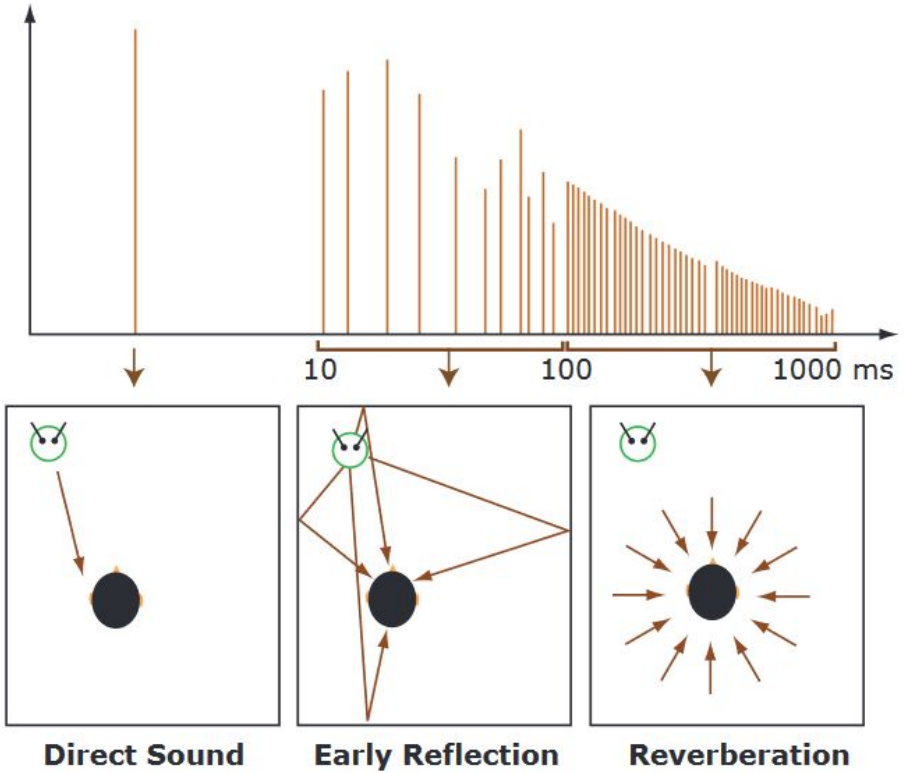
# Isolation

- Isolation is cutting down of sound from leaking into or out of a room.
- Must stop both air-borne and structure-borne sounds.
- The simplest way to cut down sound is to put a solid wall in its way - the more solid, the better the isolation you'll get.



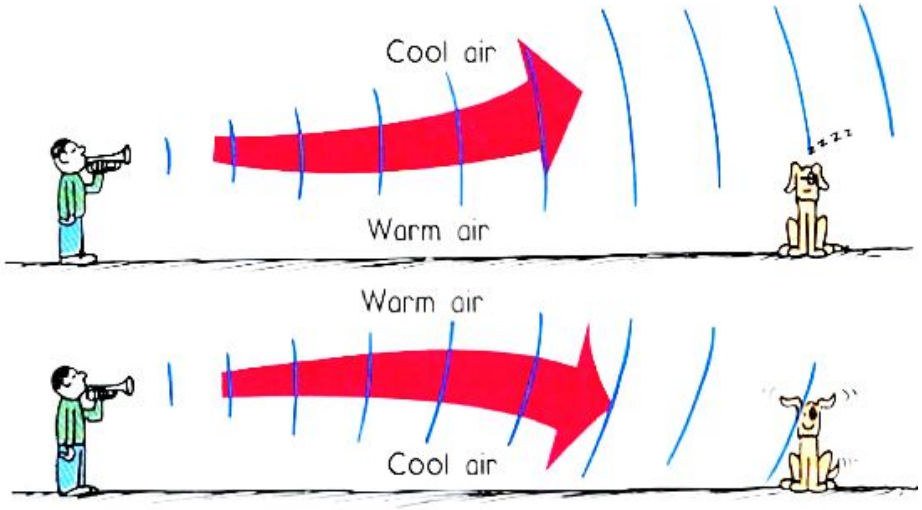
# Reflection

- Sound reflects (bounces), diffuses, and absorbs off of surfaces
- Three steps: direct sound, early reflections (echos), reverberations
- Reverberations are echos that are so close together (less than 30 msec apart) that they form a continuous sound



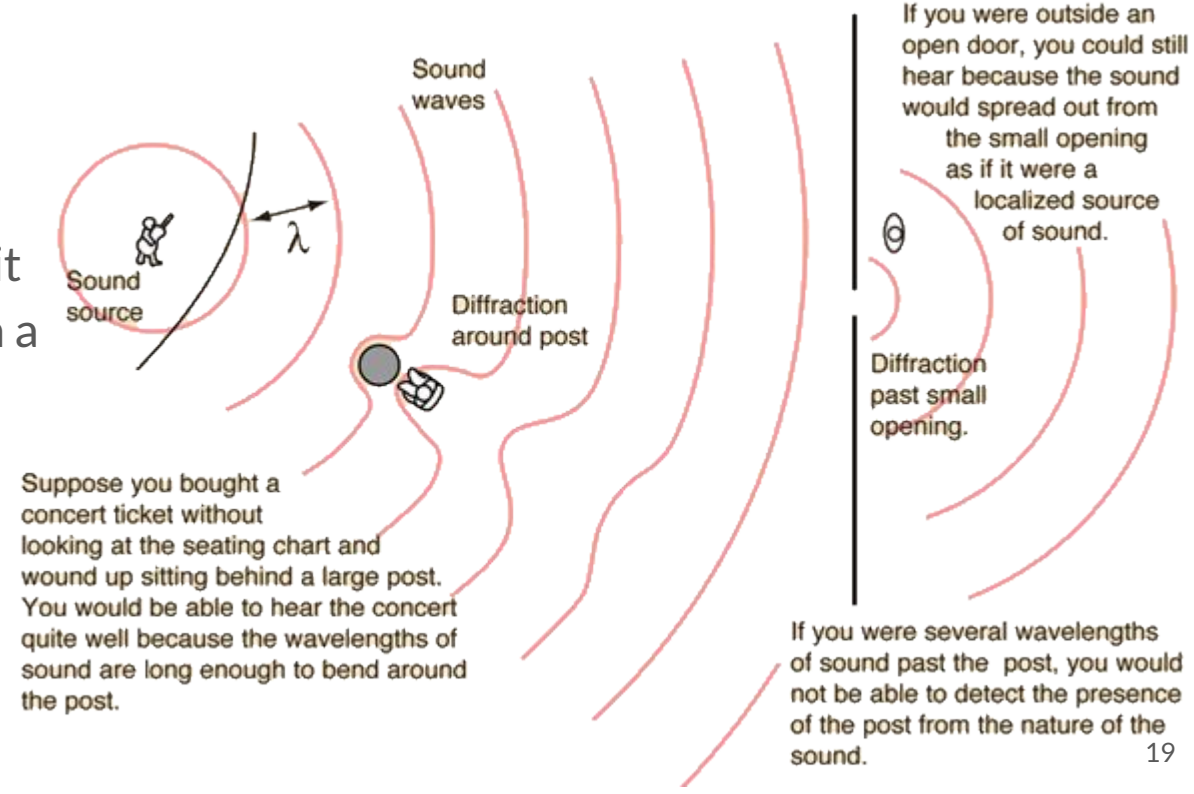
# Refraction

- A sound wave refracts when it passes from one medium to another.
- When a sound signal passes from a thinner medium to a thicker or denser one, it refracts away from the surface of the denser medium.



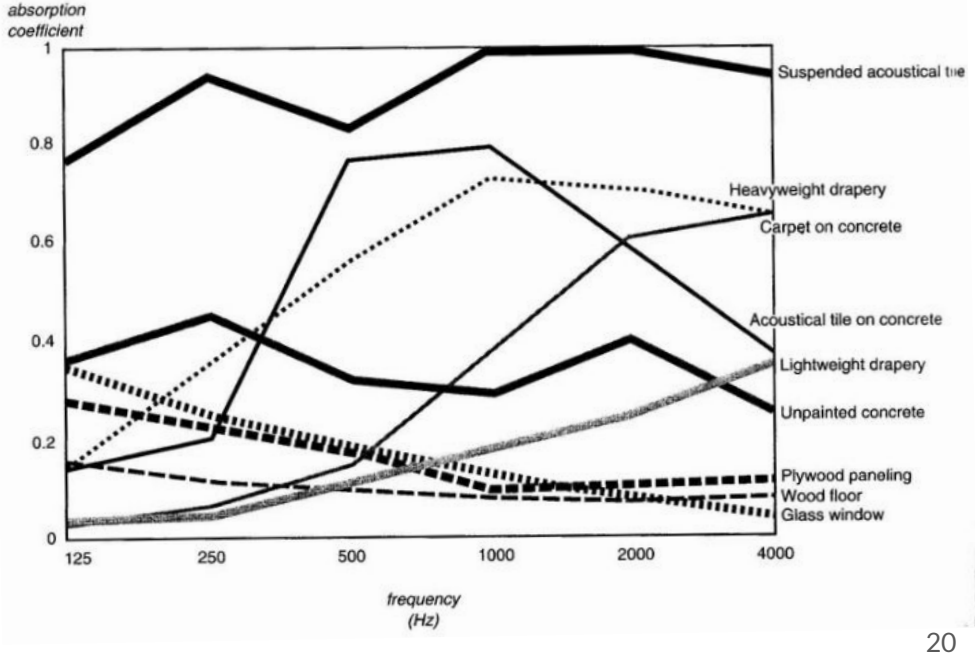
# Diffraction

- Diffraction is the bending of a wave as it either passes through a barrier or passes through an opening.



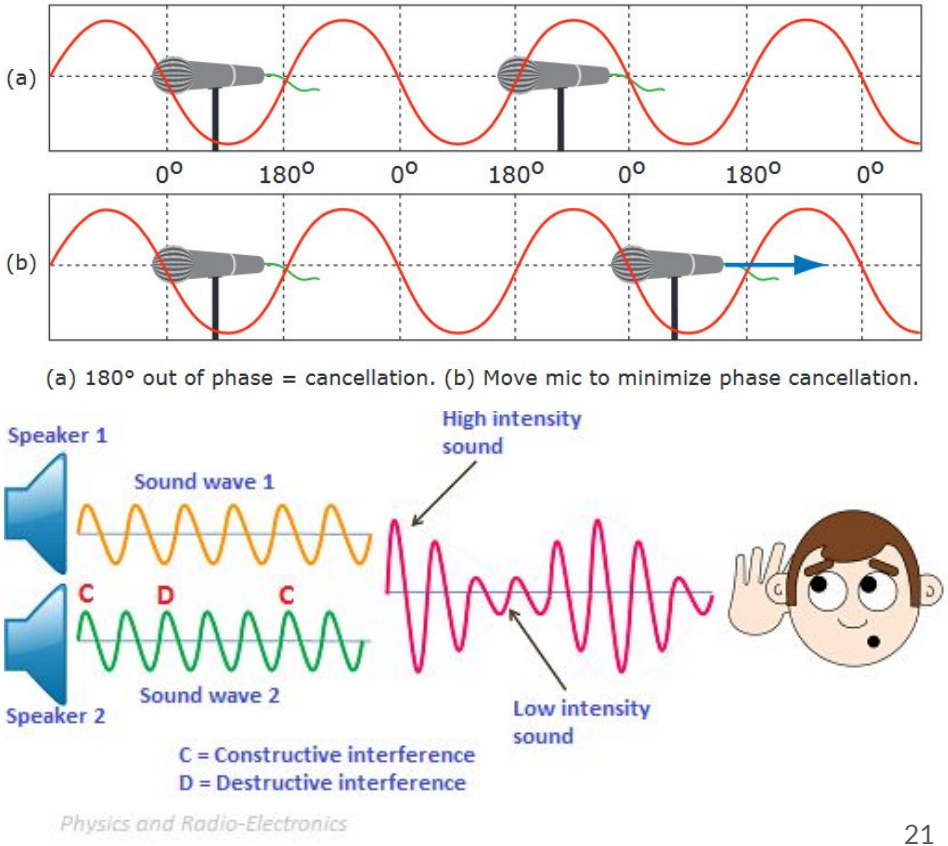
# Absorption

- Absorption consumes the energy of sound
- Sound does not absorb equally for all frequencies



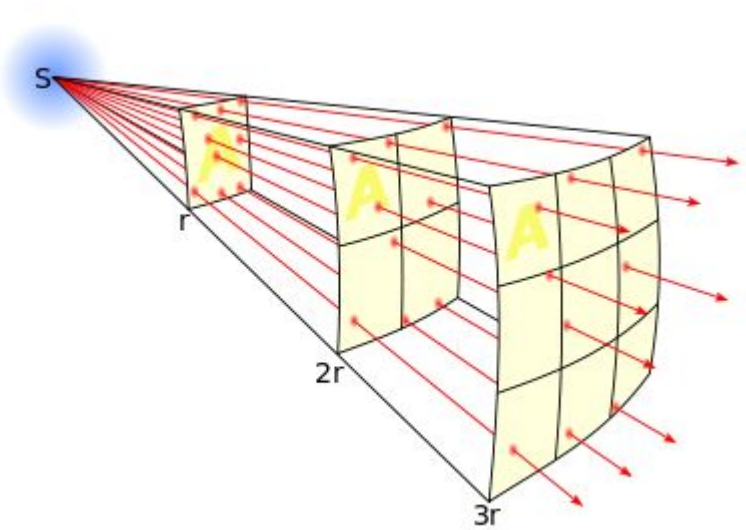
# Interference

- Interference is the addition of two or more waves resulting in a new wave pattern.
- Combining two signals 180 degrees out of phase causes signal cancellation
- Combining two signals slightly out of phase causes a timbrel change, called comb filtering

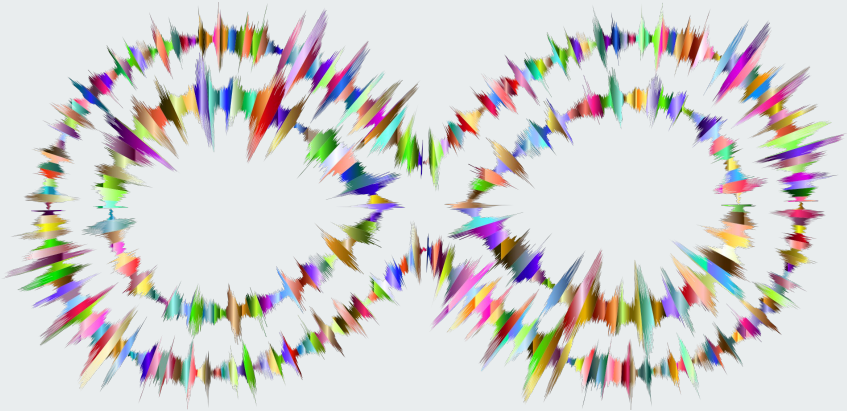


# Inverse Square Law

- Inverse Square Law states that the sound intensity (outward) is inversely proportional to the square of the distance from the point source.
- Doubling the distance from a source reduce the amplitude by 6 dB (real-world measures differ).



# Fundamentals of Music



- Some aspects of physics of sounds are specific to the art of music.

# Basic Concepts

- **Musical note:** a sound produced by a musical instrument (or the human voice) with the intention of creating music.
- **Melody:** a sequence of individual musical notes played one after the other. This makes a song recognizable.
- **Harmony:** two or more musical notes being played at the same time. Usually, the harmony's job is to accompany the main melody.
- **Rhythm:** how the musical notes (melody and harmony) are laid out through time. It's about how long a note is and how long it takes for the next note to be played.

# Digital Audio Workstation (DAW)

An electronic device or application software used for recording, editing and producing audio files

# Digital Audio Workstation (DAW)

- A DAW provides an immediate way to record and create audio.
- You can record and manipulate acoustic and electric sounds and instruments by using digital audio aspects of a DAW.
- You can also record and manipulate MIDI information.
- The music literacies used with DAWs are not specific to or reliant on staff notation.

# Which DAW?

- Audacity http://www.audacityteam.org/download/
- Cubase LE https://new.steinberg.net/cubase/le/
- Pro Tools First http://www.avid.com/pro-tools-first
- Cakewalk by BandLab https://www.bandlab.com/products/cakewalk
- LMMS https://lmms.io/
    - *https://ehomerecordingstudio.com/best-daw-software/*

# Self-learning Homework

- Choose a DAW software
- Familiarise with basic functionalities
- Try out something…

# Class Project Groups

- Based on project type interest
- For class projects
- Final project is individual
- Group size???

# Learning by Doing