Fundamentals of Sound and Music

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 Christopher Ariza. 21M.380 Music and Technology: Recording Techniques and Audio Production. Spring 2012. Massachusetts Institute of Technology: MIT OpenCourseWare, <u>https://ocw.mit.edu</u>. 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



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 Low lower the frequency, thus the lower the perceived sound.
 - \circ 20 Hz cycle = 17 m
 - \circ 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: Attack, Decay, Sustain and Release.



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.



180° Out of Phase Wayes cancel each other





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.

If you were outside an open door, you could still hear because the sound would spread out from the small opening as if it were a localized source of sound.

Diffraction past small opening.

If you were several wavelengths of sound past the post, you would not be able to detect the presence of the post from the nature of the sound. 19

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 <u>http://www.audacityteam.org/download/</u>
- Cubase LE <u>https://new.steinberg.net/cubase/le/</u>
- Pro Tools First http://www.avid.com/pro-tools-first
- Cakewalk by BandLab <u>https://www.bandlab.com/products/cakewalk</u>
- LMMS <u>https://lmms.io/</u>
 - 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