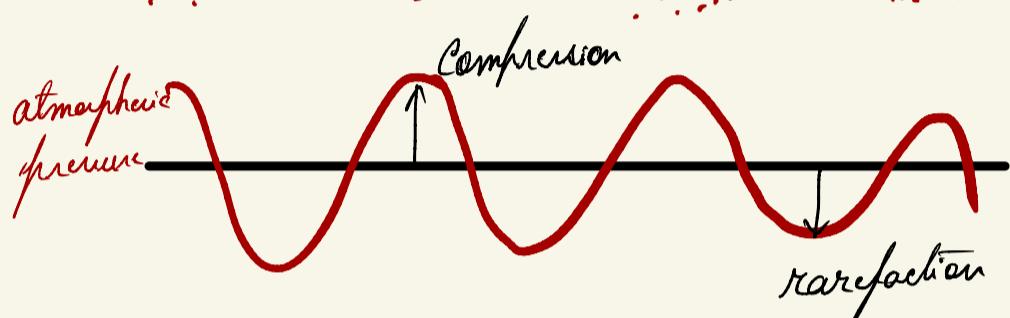
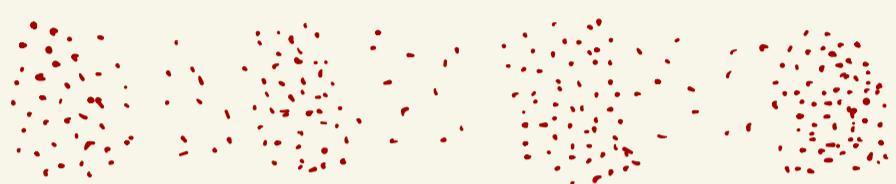


Sound

- ① Produced by vibration of an object.
- ② Vibrations cause air molecules to oscillate
- ③ Change in air pressure creates a wave.

Mechanical wave

1. Oscillation that travels through space.
2. Energy travels from one pt. to another
3. The medium is deformed.



Waveform

Frequency Intensity Timbre.

Waveform

Periodic

Simple
(Single Sinewaves)



Complex
(Multiple Sinewaves)

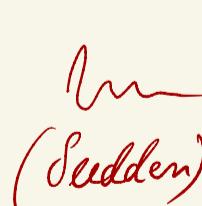


Aperiodic

Continuous
(Noise)



Transient
(Pulse)



(Sudden)

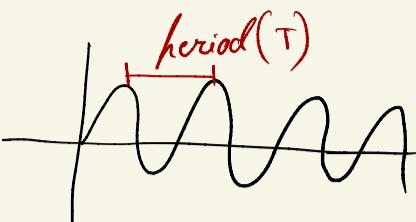
① Sine wave

time phase

$$y(t) = A \sin(2\pi f t + \phi)$$

amplitude

frequency



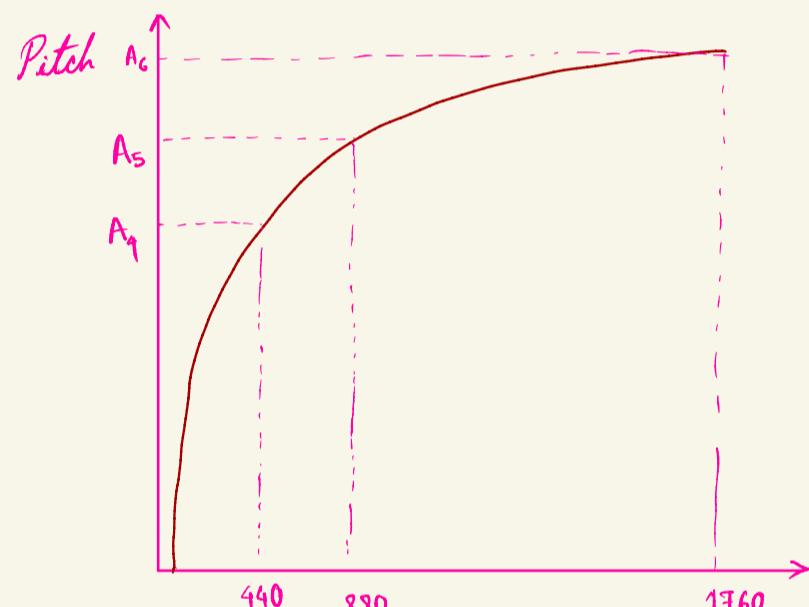
$$f = 1/T \text{ in Hz}$$

(No. of cycles per second)

Pitch

① Logarithmic perception

② 2 frequencies are perceived similarly if they differ by a power of 2.



$$F(p) = 2^{\frac{p-69}{12}} \cdot 440, \text{ where } p = \text{midi number.}$$

Cents

* octave divided in 1200 cents

* 100 cents in a semitone.

* Noticeable pitch diff 10-25 cents.

Sound Power

1. Rate at which energy is transferred.
2. Energy per unit of time emitted by a sound source in all directions.
3. Measured in watt (W).

Sound Intensity

1. Sound power per unit area.

2. Measured in W/m^2 .

Thunder \rightarrow 1 Watt

Light bulb \rightarrow 100 W

Threshold of hearing

$$I_{\text{TOH}} = 10^{-12} \text{ W/m}^2 \quad 10 \text{ W/m}^2$$

Intensity level

→ logarithmic scale

→ measured in decibels (dB)

→ Ratio between two intensities

→ Use an intensity of ref (I_{TOH})

$$\text{dB}(I) = 20 \log_{10} \left(\frac{I}{I_{\text{TOH}}} \right) \quad I = I_{\text{TOH}}$$

• Every ~ 3 dB, intensity doubles

$$I_{\text{TOH}} \cdot 10^{\frac{3}{10}} = I \Rightarrow I = 10^{-12} \cdot 10^{0.3}$$

Loudness

→ Subjective perception of sound intensity

→ Depends on duration / frequency of a sound.

→ Depends on age.

→ Measured in phon

Timbre

- Color of sound
- Diff between two sounds with same intensity, frequency, duration.

What are the features of timbre?

* Timbre is multi-dimensional

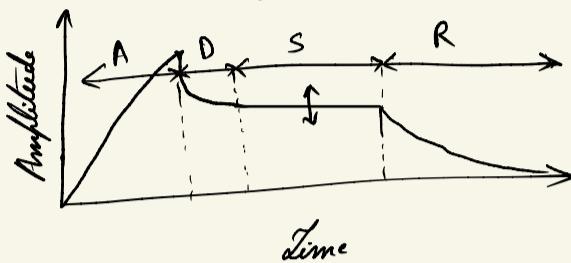
* Sound envelope

* Harmonic content

* Amplitude / frequency modulation

Sound envelope

- Attack - Decay - Sustain - Release model



Complex sound

- Superposition of sounds.

- A partial is a sinusoid used to describe a sound.
- The lowest partial is called fundamental frequency.

$$f_1 = 440 \text{ Hz } (A_4)$$

$$f_2 = 2 \cdot 440 \text{ Hz } (A_5)$$

- A harmonic partial is a frequency that's a multiple of the fundamental frequency.

- Inharmonicity indicates a deviation from a harmonic partial

Frequency modulation

1. AKA vibrato

2. Periodic variation in frequency.

3. In music, used for expressive purposes.

Amplitude modulation

1. AKA tremolo.

2. Periodic variation in amplitude