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Acoustics

Lecture 1
Introduction to Sound and Acoustics

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Lecture 1 contents

- Definition of sound
- Acoustics overview
- Sound propagation
- Properties of a sound wave

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What is Sound?

Definitions of sound

- "Sound is vibration transmitted through a solid, liquid, or gas; particularly, sound means those vibrations composed of frequencies capable of being detected by ears" [Wikipedia]

- "Sensation caused in the ear by the vibration of the surrounding air or other medium" [Oxford English Dictionary]

- "Mechanical radiant *energy that is transmitted* by longitudinal pressure waves in a material medium (as air) and is *the objective cause of hearing*" [Merriam-Webster Dictionary]

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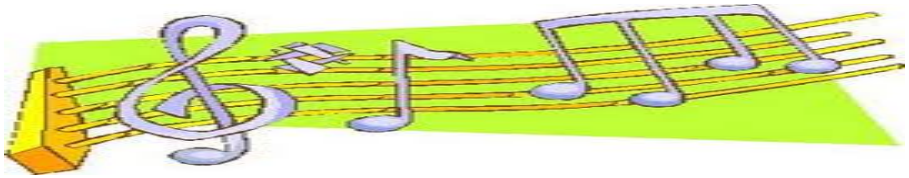
What is Acoustics?

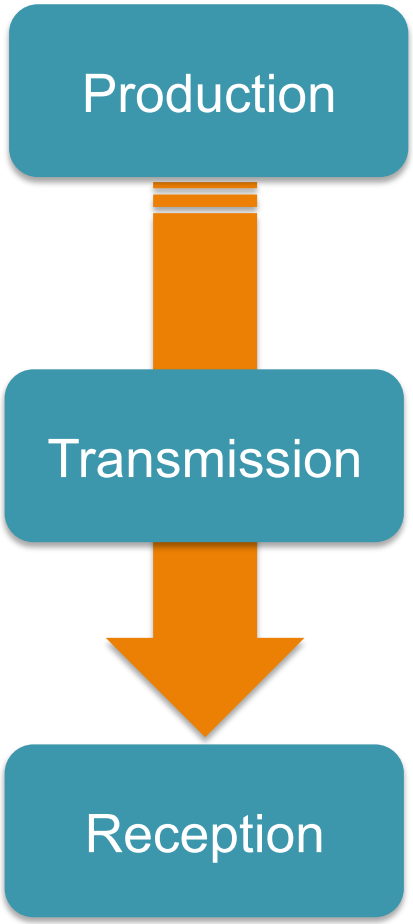
Acoustics overviews

- Acoustics is the science about sound.

  - deals with the production, transmission and reception of sound.



Acoustics overview



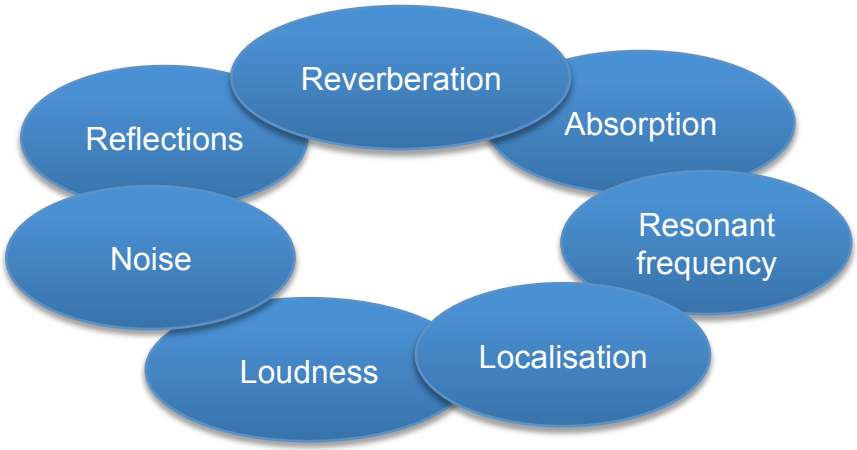
- Sound source: Voice, Musical inst., Loudspeaker
- Vibration and generation of sound waves
- Musical acoustics, Electroacoustics, Vibration research

- Conveying medium: Air, Solid, Liquid, etc.
- Wave propagation, Control of acoustic parameters
- Architectural acoustics, Underwater Acoustics

- Receptor: Ear
- Detection and perception of sound
- Hearing aid research, Psychoacoustics

Why study acoustics?

- What is the goal for audio system or software engineers?
- Obstacles?



- We can ‘control’ sounds effectively and efficiently by understanding how they are produced, how they behave in different environments, and how we perceive them.

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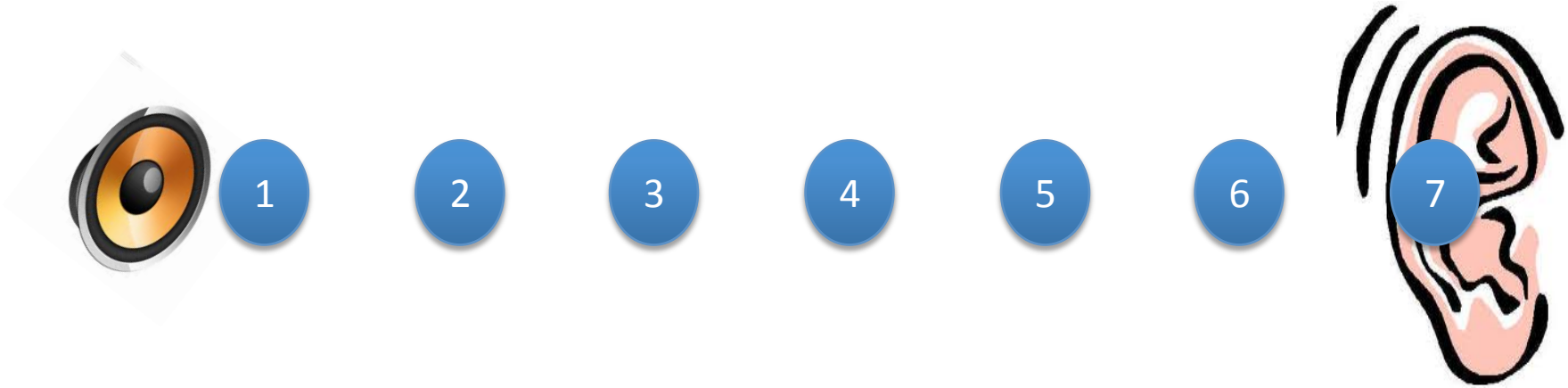
Sound propagation

Sound wave

- Sound is a longitudinal wave.

  A vibrating source causes a series of compression and rarefaction of the air particles and the resulting wave propagates longitudinally.



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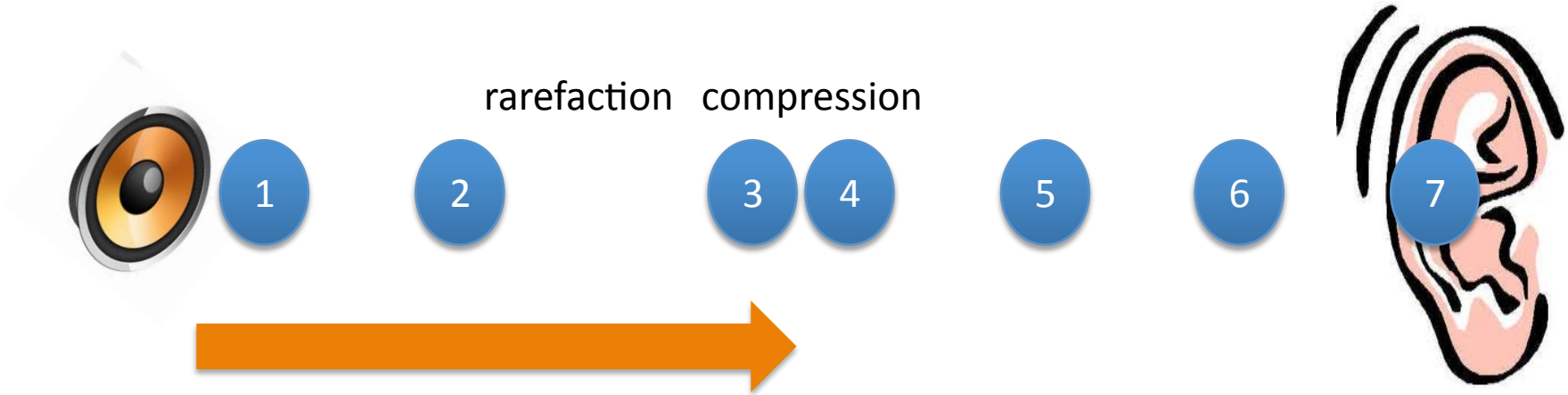

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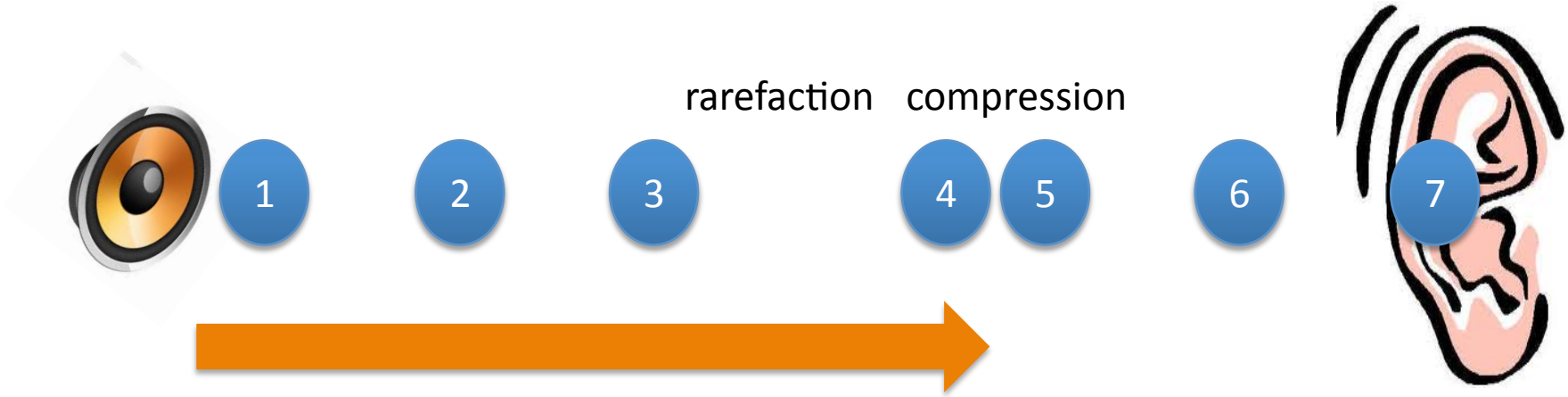

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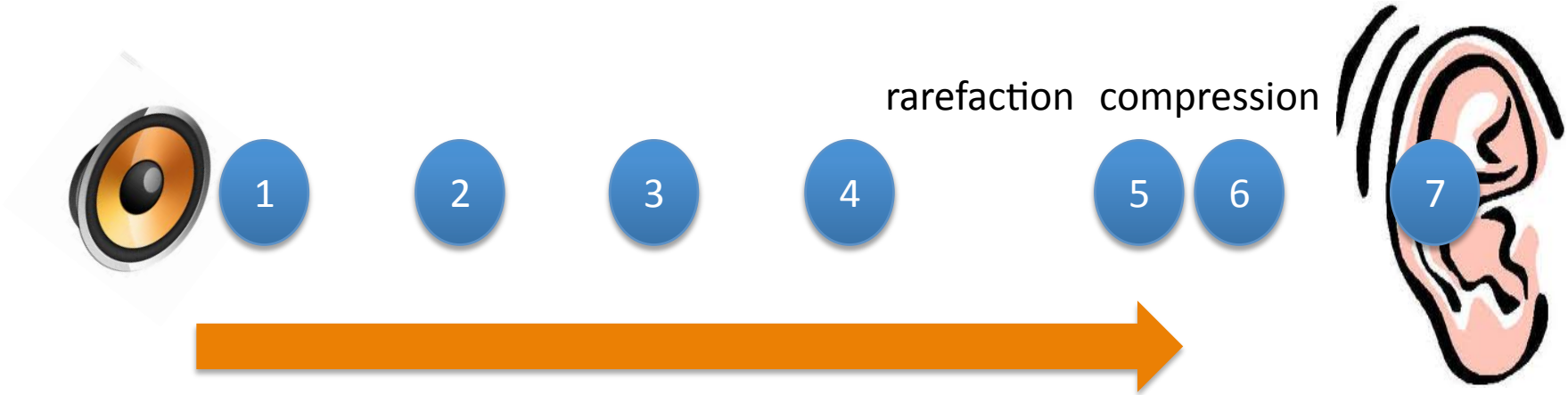

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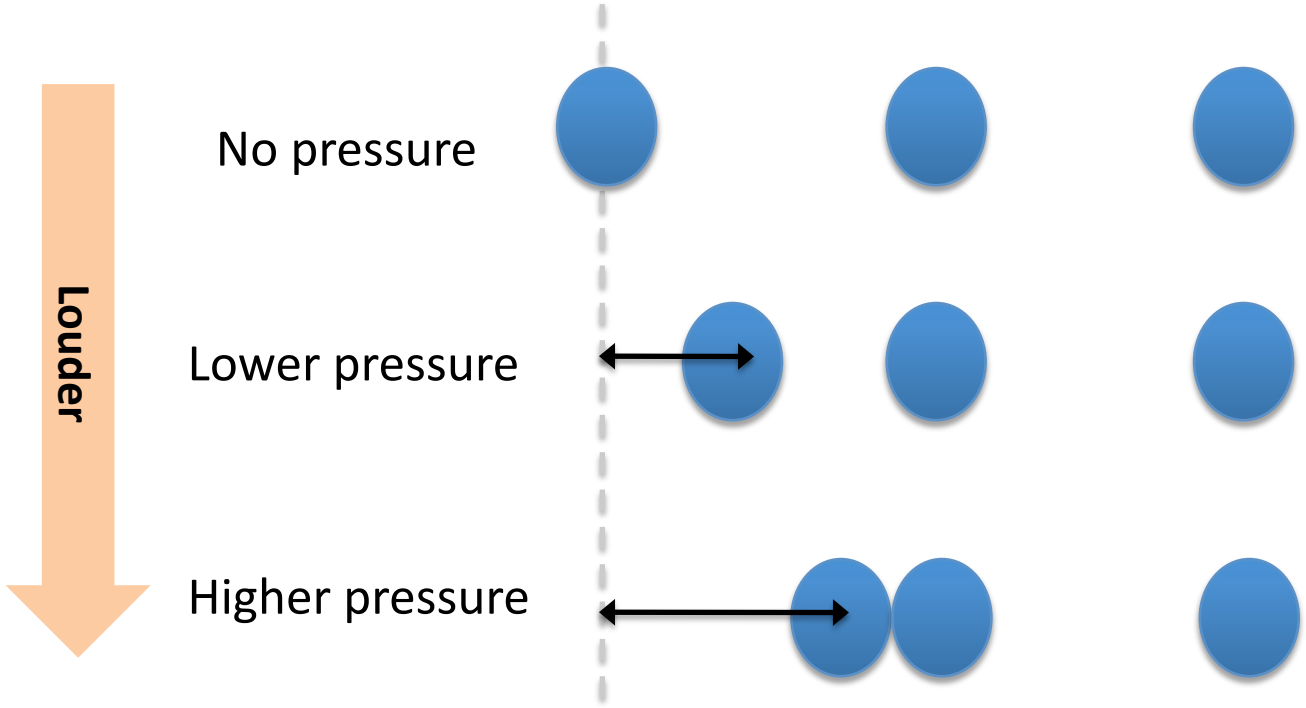
Sound wave

- Sound is a pressure wave.

  The degree of particle displacement represents the degree of pressure variation. → determines the perceived loudness.



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- Particle displacement: 0.5nm ~ 5mm

- Pressure variation: 20 μPa ~ 100Pa

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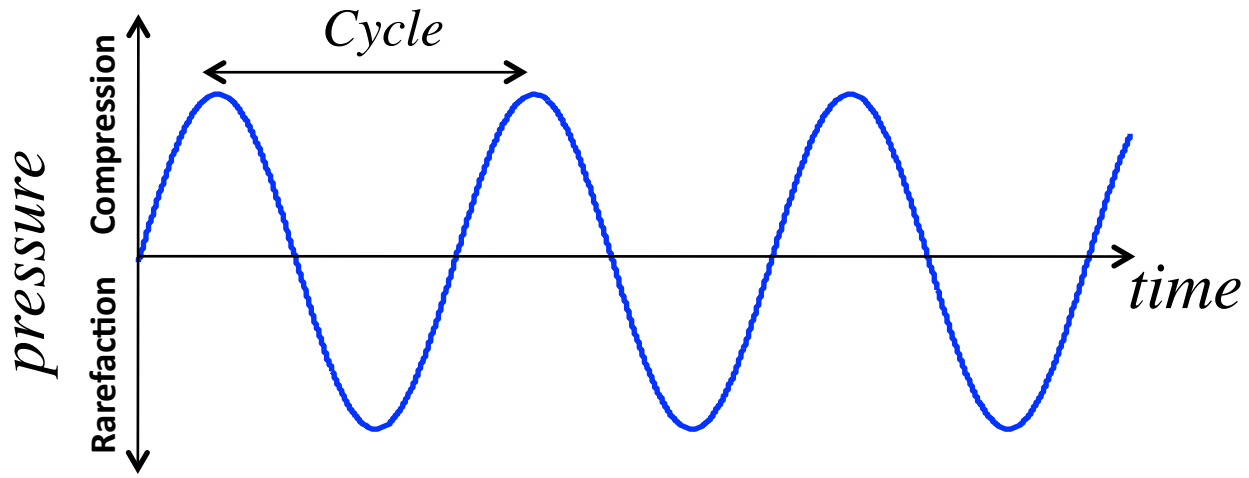
Properties of sound wave

Properties of a sound wave



- **Period (T)** Time to complete one cycle (s)
- **Wavelength (Lambda λ)** Length of one complete cycle (m)
- **Amplitude (A)** Maximum particle displacement from rest position (Pa or N/m2)
- **Frequency (f)** Number of cycle per second (Hz)

Properties of a sound wave

- Speed of sound (c) in air
  - Usually taken as 340m/s.
  - Dependent on temperature.
  - Becomes faster in lower temperatures.
    (0˚C : 332m/s, 20˚C: 344m/s)

- Speeds of sound for different materials

Material	Speed of sound (m/s)
Water	1517
Concrete	3536
Aluminium	5037
Steel	5189

Properties of a sound wave

- Speed of sound = Wavelength x Frequency

$$c = \lambda * f$$

- What is the range of wavelength in air that human ears can detect?

Properties of a sound wave

- What's the frequency of sound with a wavelength of 34cm in air?

- How far does the sound travel in air for 1ms?

Further reading

- Acoustics and psychoacoustics, 3rd Edition [Howard and Angus]
- Science of sound, 3rd Edition [Rossing]