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A new time and intensity trade-off function for localisation of natural sound sources

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# Acoustics

## Lecture 1

### Introduction to Sound and Acoustics

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University of Huddersfield

# Lecture 1 contents

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

# What is Sound?

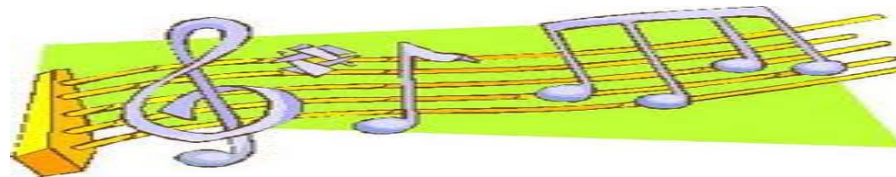
# Definitions of sound

- “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]

# What is Acoustics?

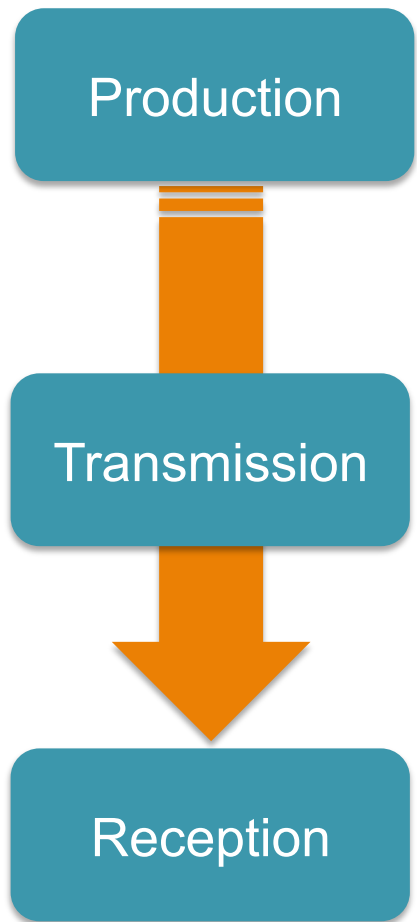
# Acoustics overviews

- Acoustics is the science about sound.
  - deals with the production, transmission and reception of sound.





# Acoustics overview

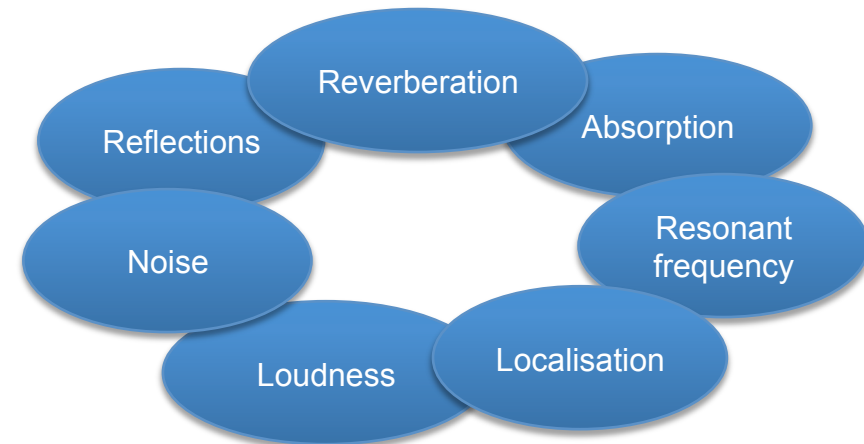


- Sound source: Voice, Musical inst., Loudspeaker
- Vibration and generation of sound waves
- Musical acoustics, Electroacoustics, Vibration research
  
- Conveying medium: Air, Solid, Liquid, etc.
- Wave propagation, Control of acoustic parameters
- Architectural acoustics, Underwater Acoustics
  
- 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?



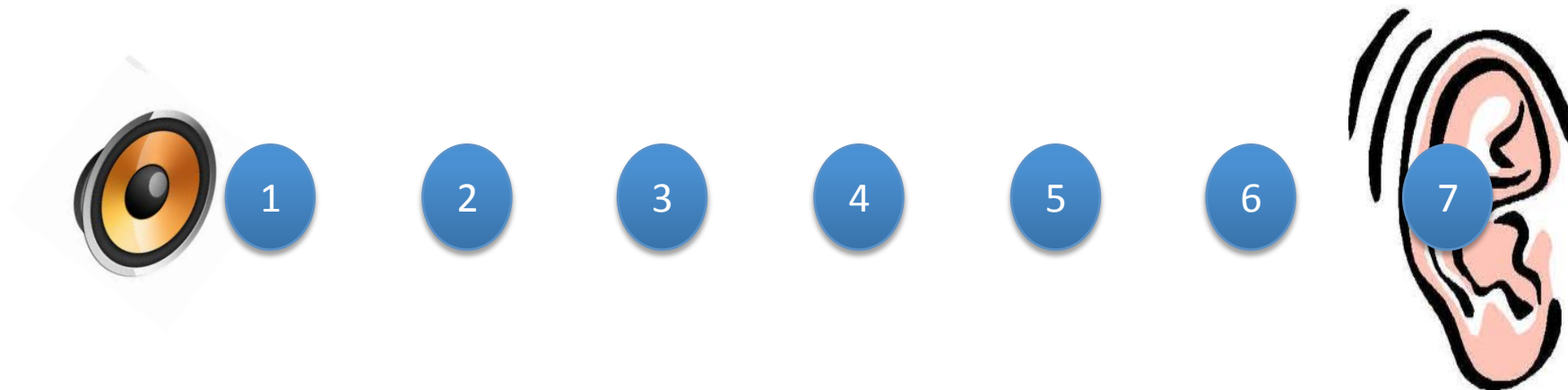
- We can ‘control’ sounds effectively and efficiently by understanding how they are produced, how they behave in different environments, and how we perceive them.

# 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.



# Sound wave

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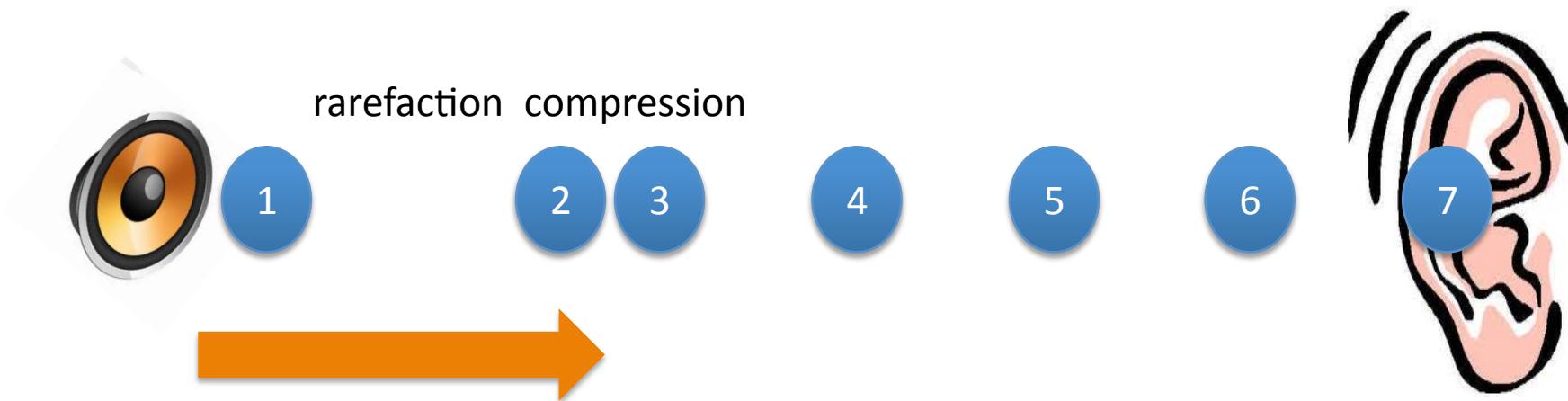
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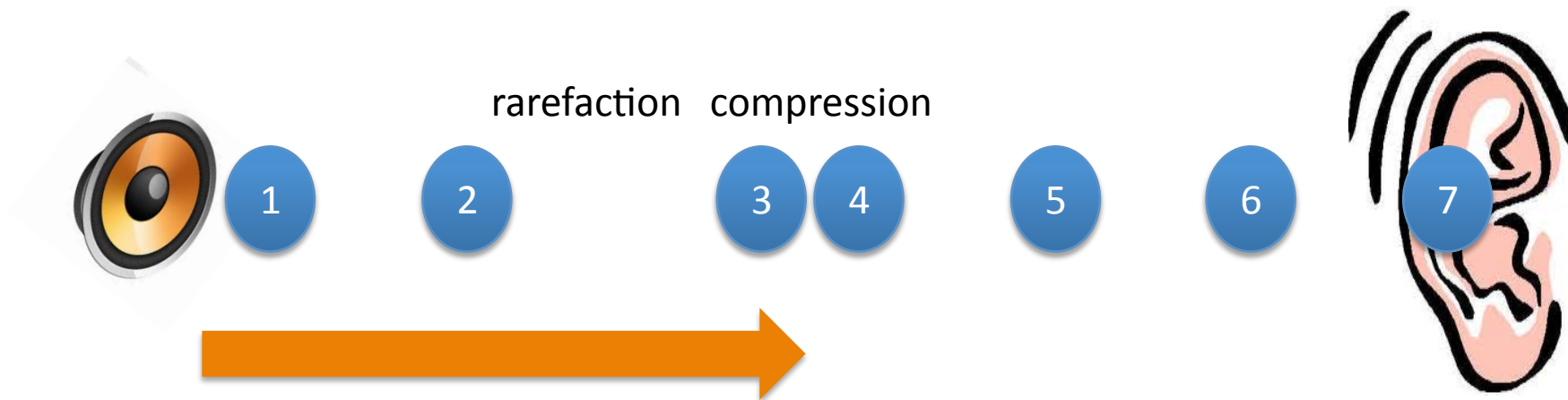
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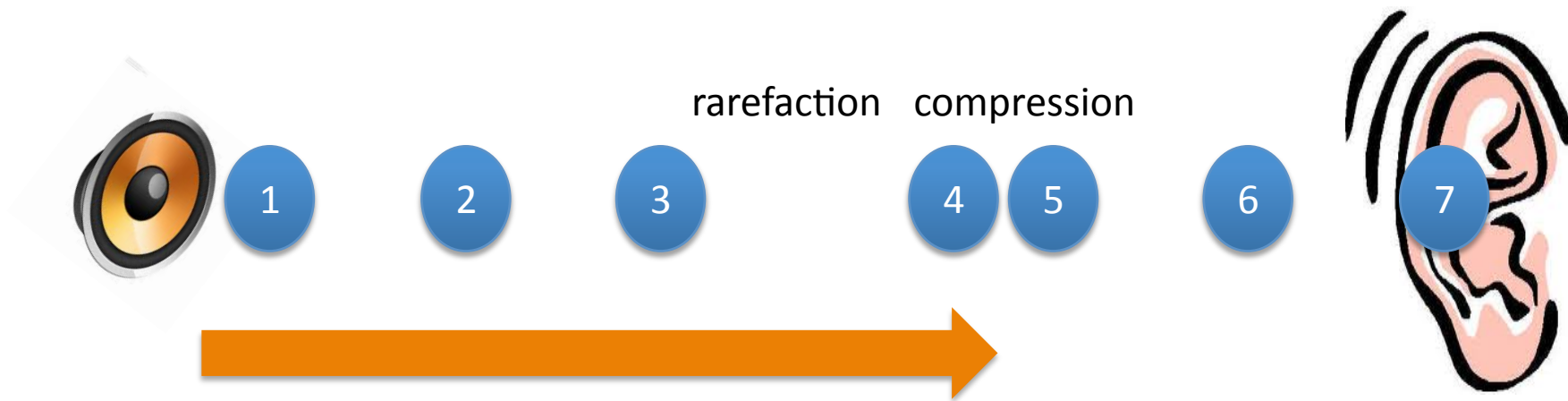
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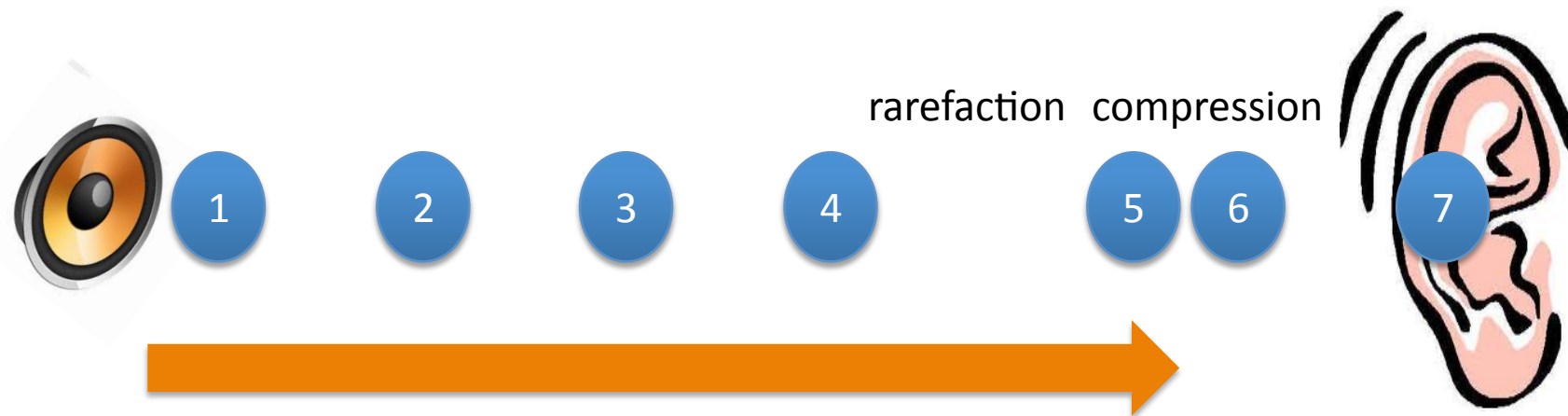




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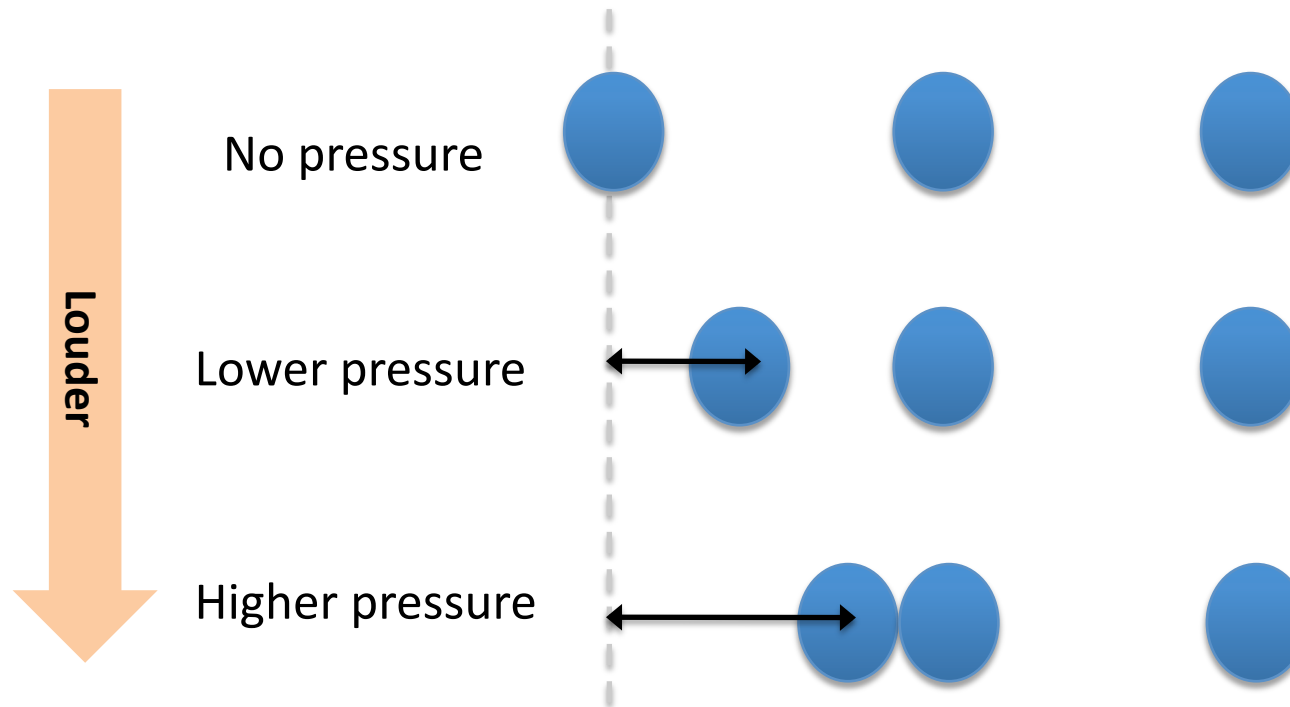
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# Sound wave

- Sound is a pressure wave.

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

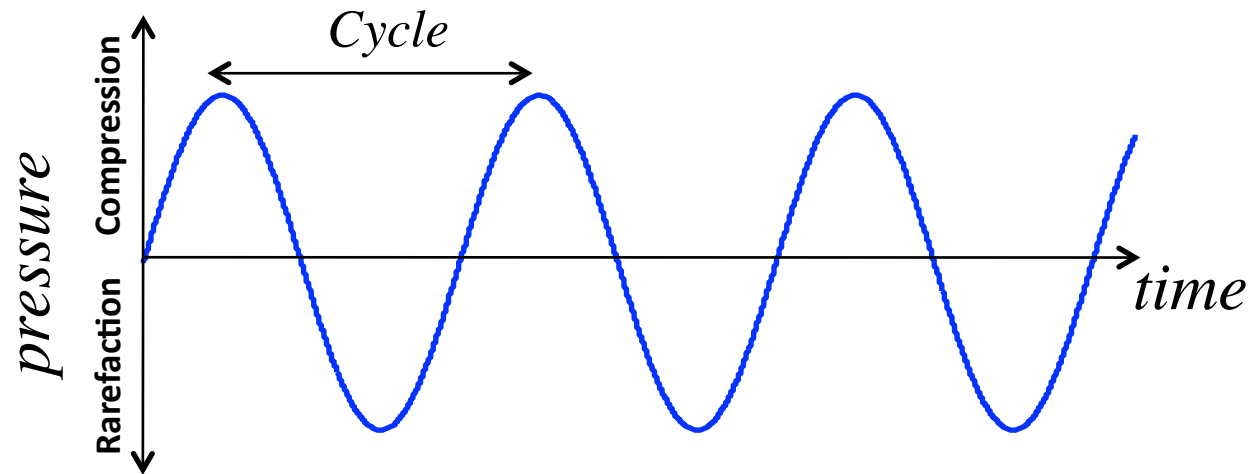


# Sound wave

- Sound is a pressure wave.  
The degree of particle displacement represents the degree of pressure variation. → determines the perceived loudness.
- Particle displacement: 0.5nm ~ 5mm
- Pressure variation: 20  $\mu$ Pa ~ 100Pa

# Properties of sound wave

# Properties of a sound wave



- **Period (T)**            Time to complete one cycle (s)
- **Wavelength (Lambda  $\lambda$ )**    Length of one complete cycle (m)
- **Amplitude (A)**        Maximum particle displacement from rest position (Pa or N/m<sup>2</sup>)
- **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, 3<sup>rd</sup> Edition [Howard and Angus]
- Science of sound, 3<sup>rd</sup> Edition [Rossing]