Multimedia Systems

II. Introduction to Sound

2.1. Audio Signal Fundamentals

António Sá Pinto

FEUP

Physics of sound

Sound is produced by a vibrating source around which the carrying media (e.g. air) is caused to move. From the vibrating source, a sound wave radiates omnidirectionally away from itself, and the sound energy is transferred to the carrying media through compressions and rarefactions (similar to waves moving on the surface of the sea).
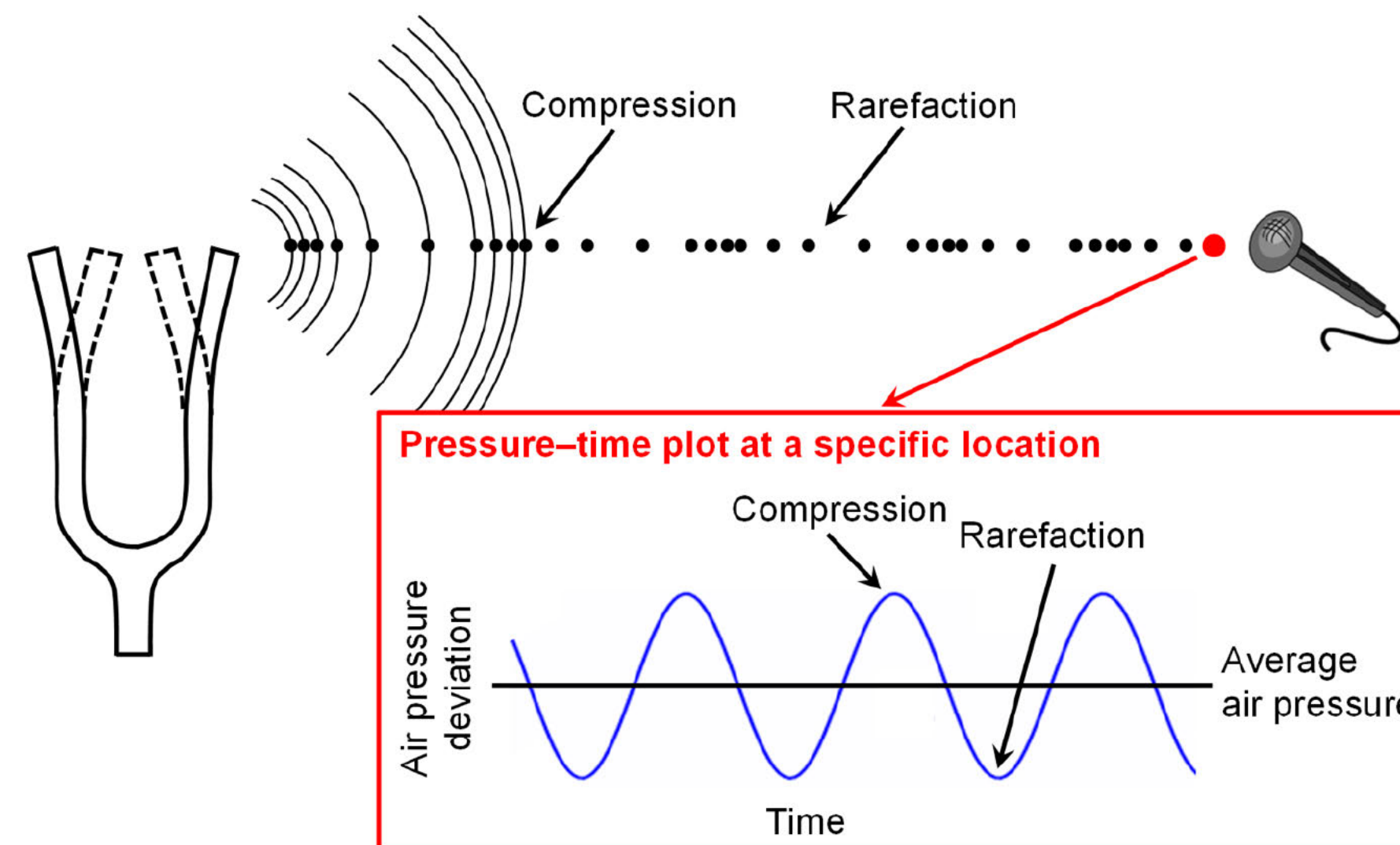
from: (Müller) Fundamentals of Music Processing, *Springer 2015*

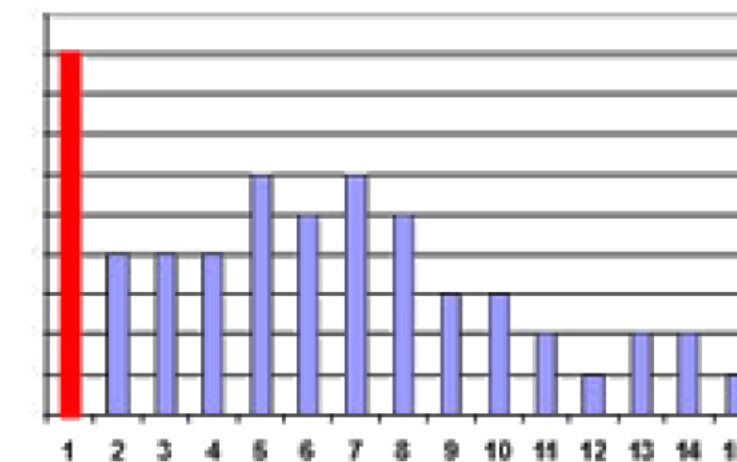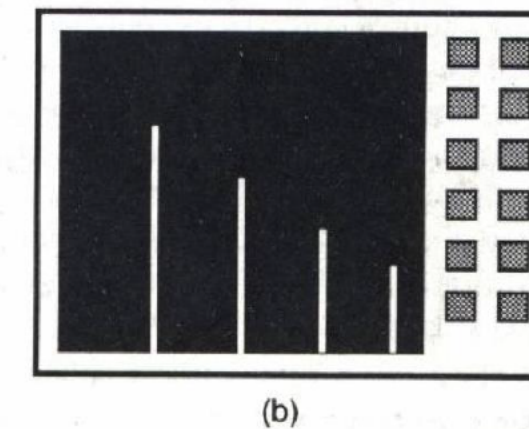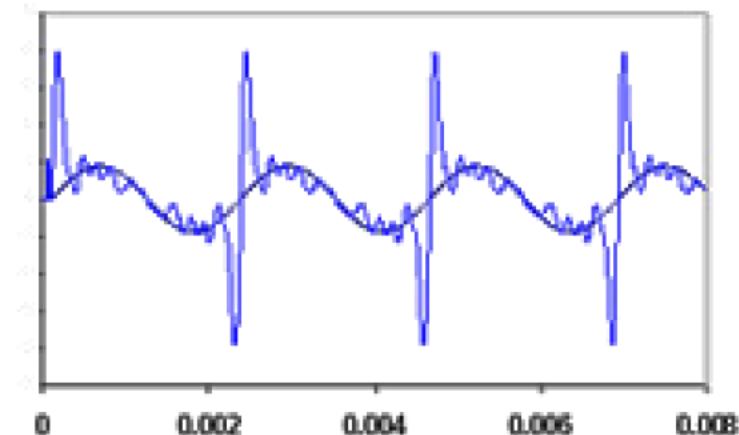# Displaying a Sound Wave
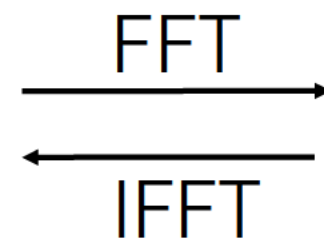
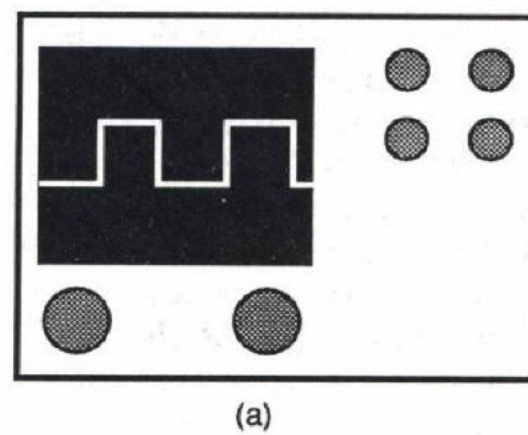**Time domain** $\xrightarrow{\text{FFT}}$ $\xleftarrow{\text{IFFT}}$ **Frequency domain**

a) Waveform

b) Spectrum

Old days: using oscilloscope

Old days: using spectrum analyser

Basic characteristics of sound waves (1)

- **Period**: is the time it takes to complete one cycle. The standard unit of a wave period is seconds.

- **Frequency:** the rate at which the vibrating source oscillates, quoted in hertz (Hz) or cycles per second (cps), measured as the number of cycles of a wave that occur in one second. *The human ear is able to perceive sounds with frequencies between approximately 20 Hz and 20 kHz (known as audio frequency range).*

- **Amplitude:** the amount of compression and rarefaction of the carrying media resulting from the motion of the vibrating source, *related to the loudness of the sound when perceived by human ears.*

Frequency = 1/Time Period
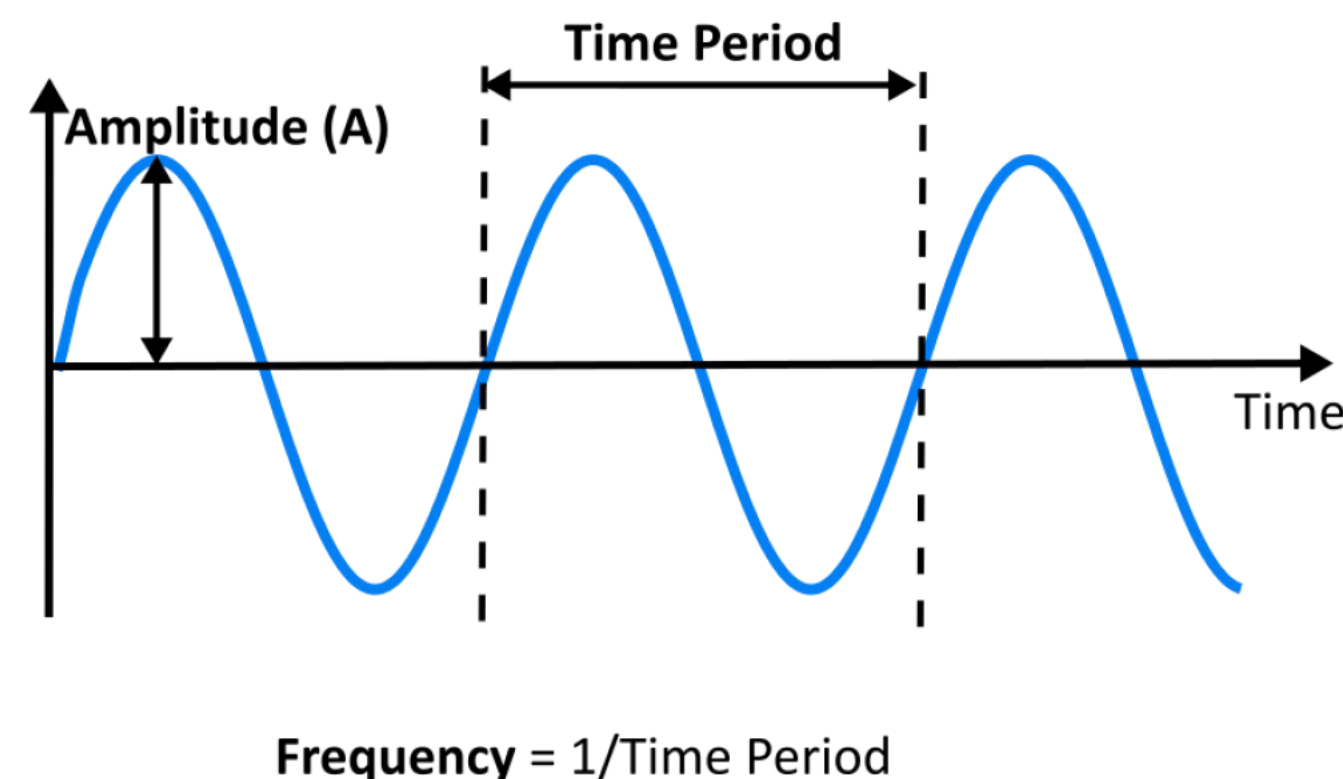
Basic characteristics of sound waves (2)

- **Wavelength:** the distance between two adjacent peaks of compression or rarefaction as the wave travels through the carrying media.

- **Velocity:** the speed of the sound energy transfer. The velocity of sound in air is about 314 meters per second. The velocity of sound depends on the carrying media and also its density.
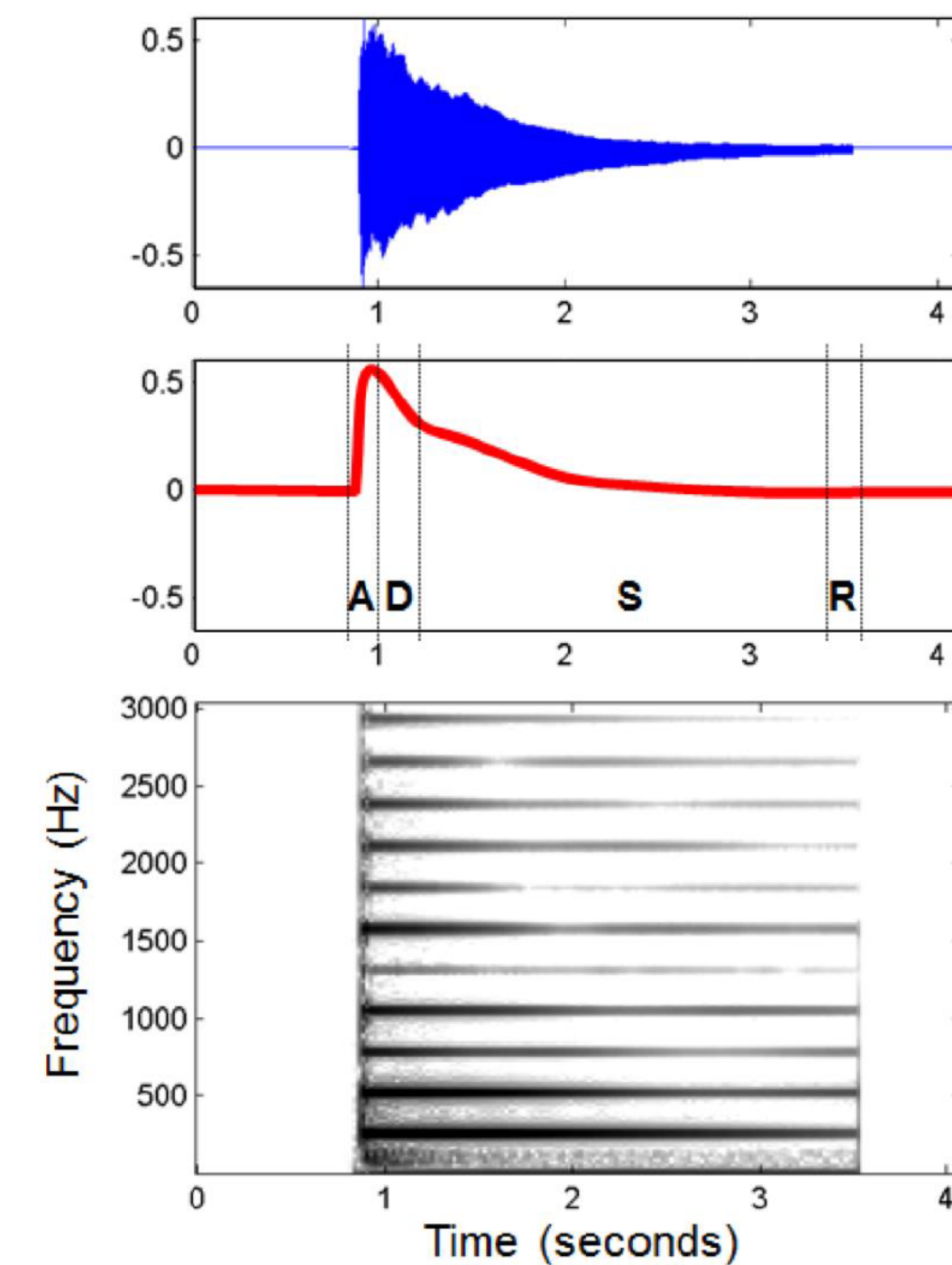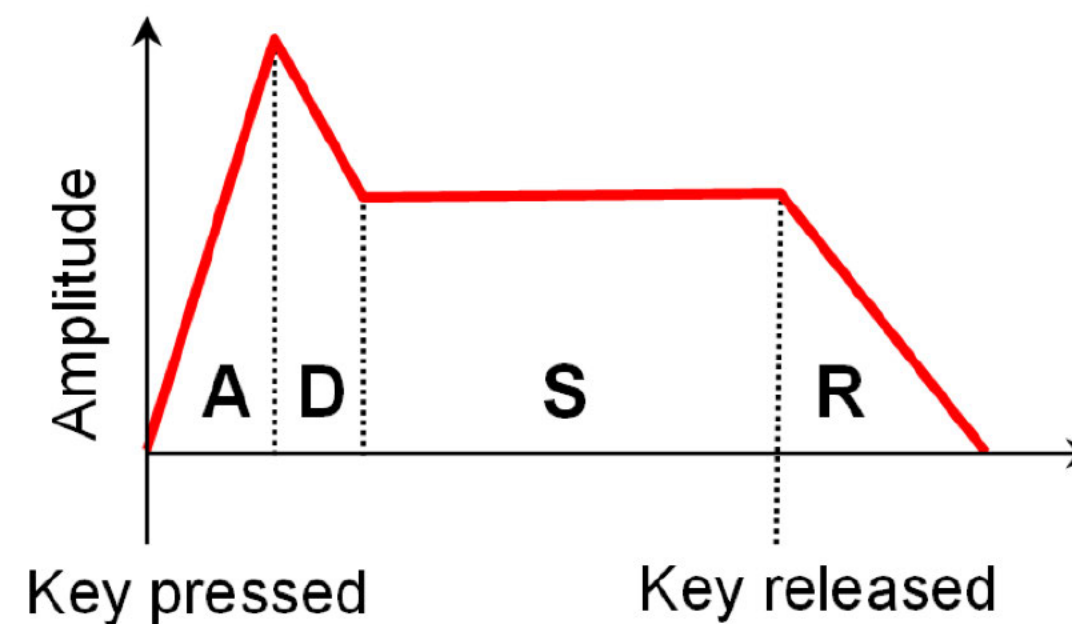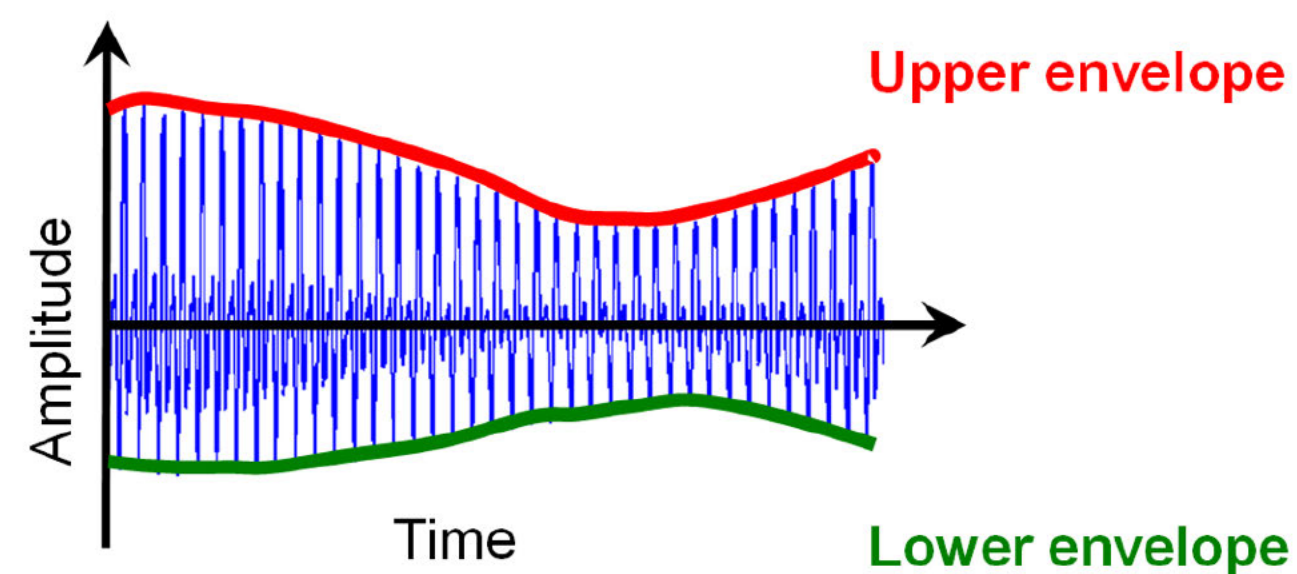
$$v = \tfrac{\lambda}{T}$$

v : speed $(m.s^{-1})$
λ : wavelength (m)
T : period (s)

$$v = f\lambda$$

v : speed $(m.s^{-1})$
λ : wavelength (m)
f : frequency $(Hz$ or $s^{-1})$

Basic characteristics of sound waves (3)

- **Envelope:** the shape of sound wave evolution. Usually, it includes four main parts: the attack, the initial decay, the sustain (i.e. internal dynamic), and the final decay (i.e. release).
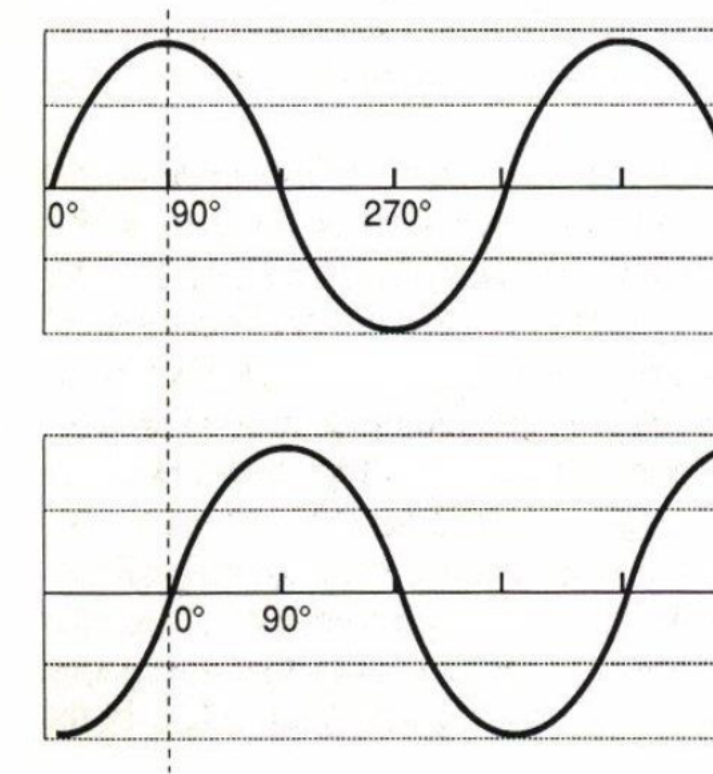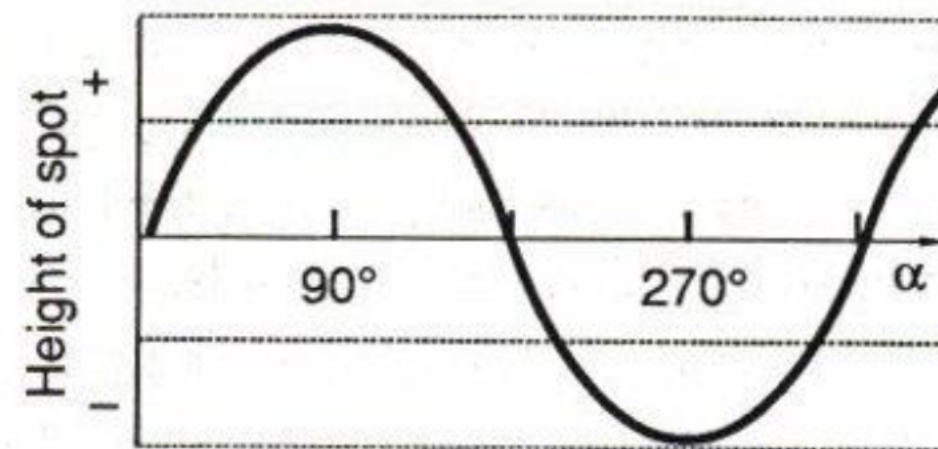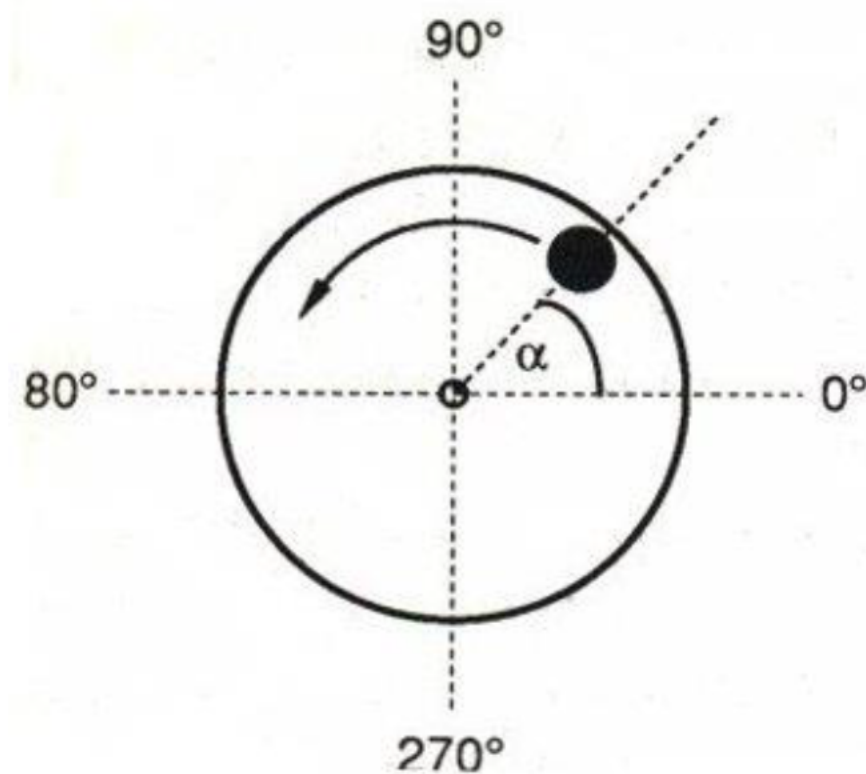

from: (Müller) Fundamentals of Music Processing, *Springer 2015*

Basic characteristics of sound waves (4)

- **Phase**: the time course of a signal relative to a reference arriving to a receiver (i.e. ear).

For the phase relationship between two waves of the same frequency, if each cycle is considered as corresponding to 360 degree, then the phase difference between the two waves can be determined by comparing the 0 degree point on one wave with the 0 degree point on the other. In the second example, the top signal is 90 degree out of phase with the below signal.

End.