Fourier analysis of signals & physics of sound

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Salamanca, Spain
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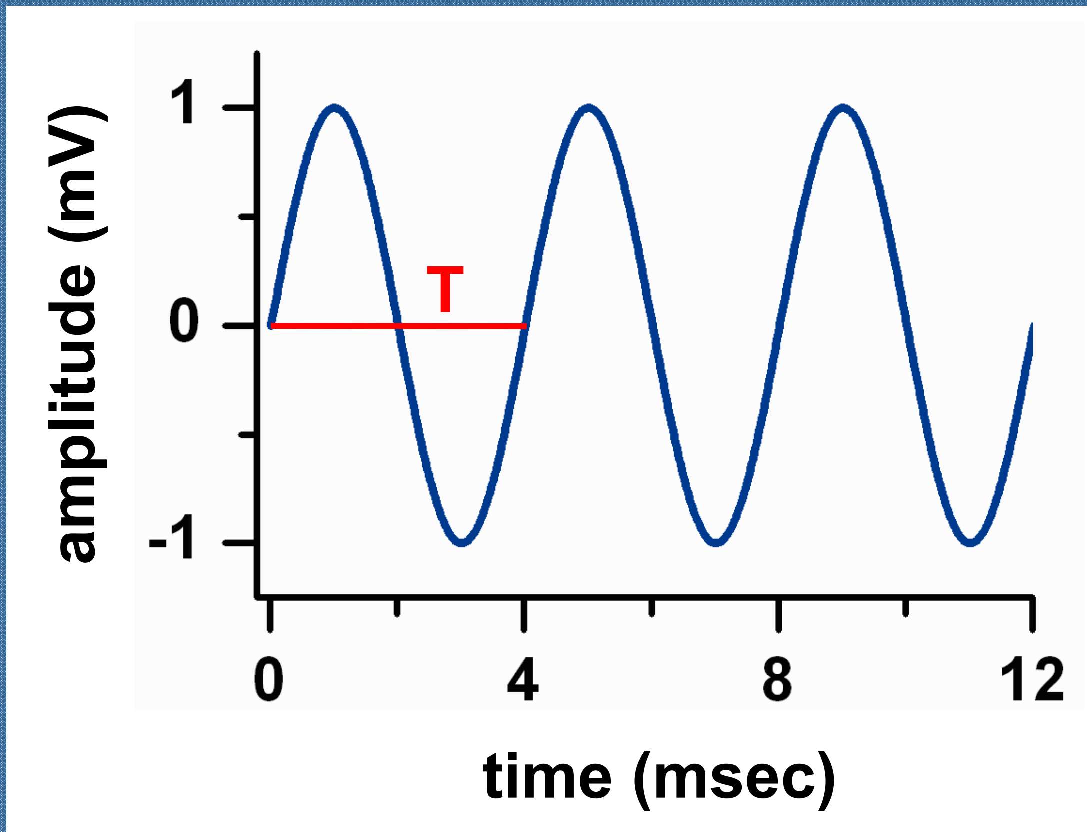
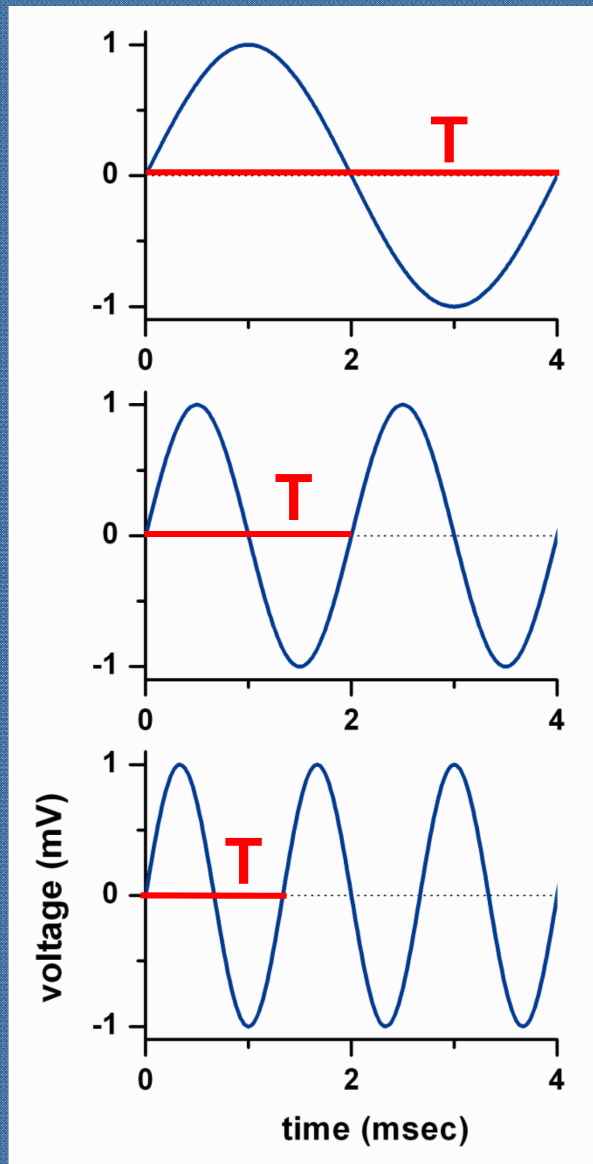
pure tone; frequency = 250 Hz



period, T = 1 / frequency

pure tones

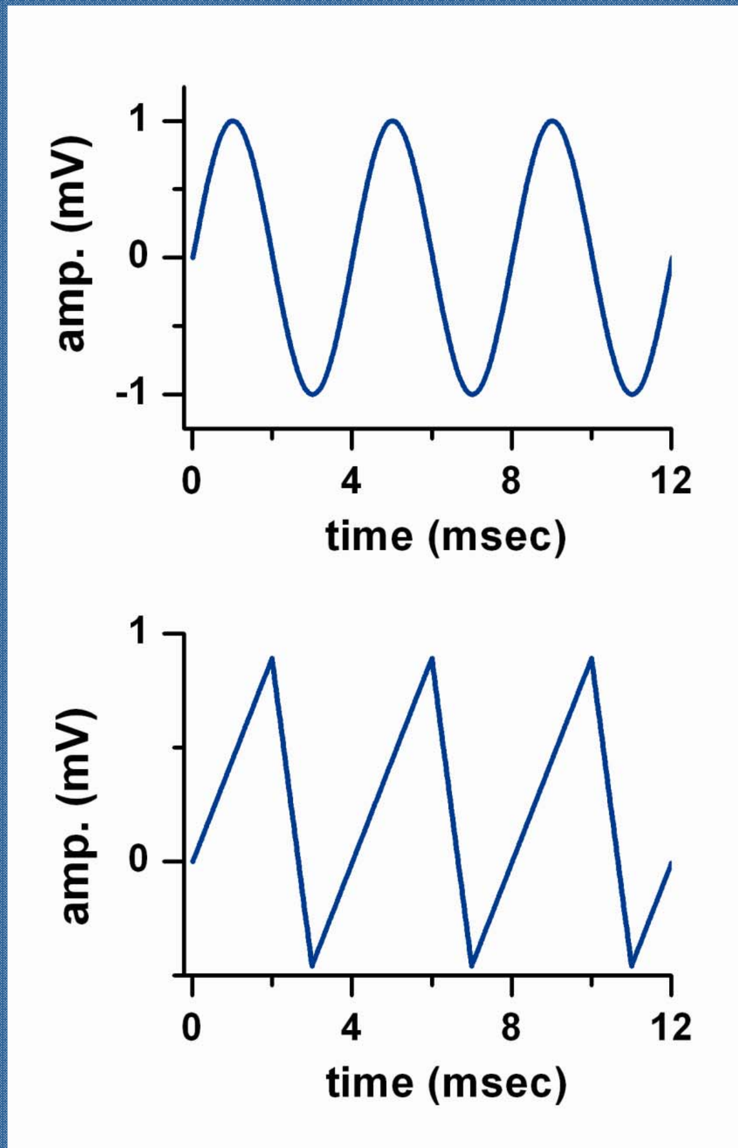
period (T) = 1 / frequency



250 Hz

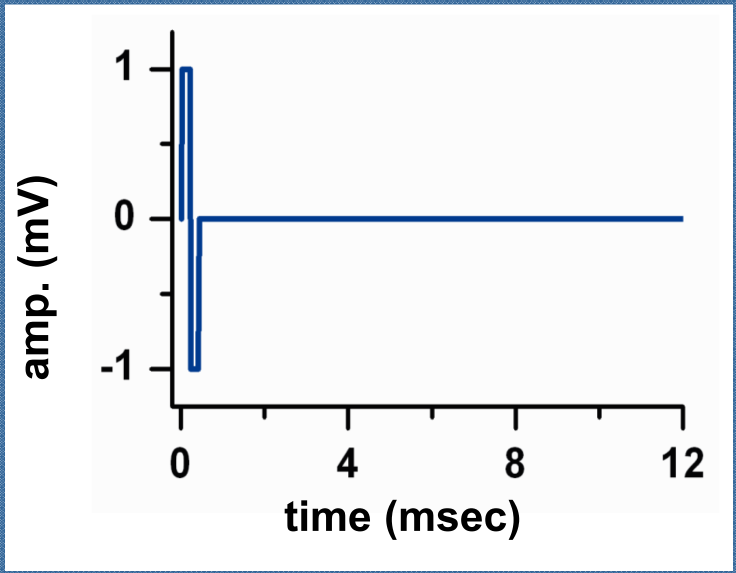
500 Hz

750 Hz

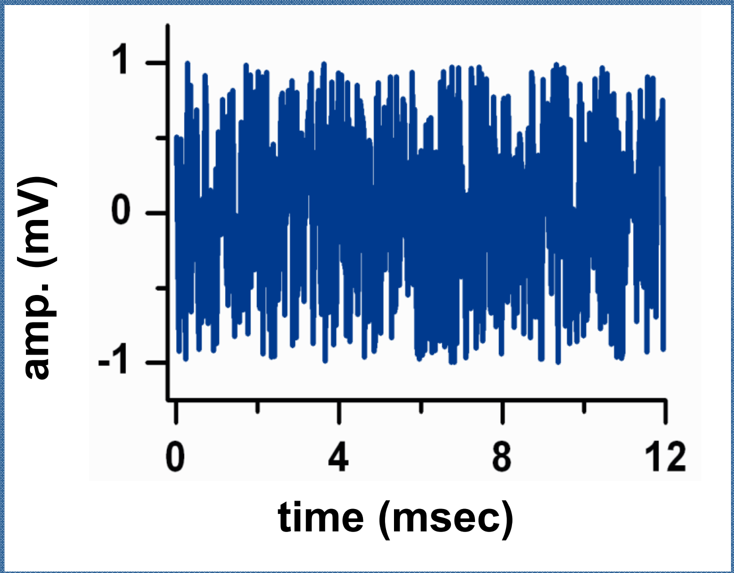


pure tone

triangular wave



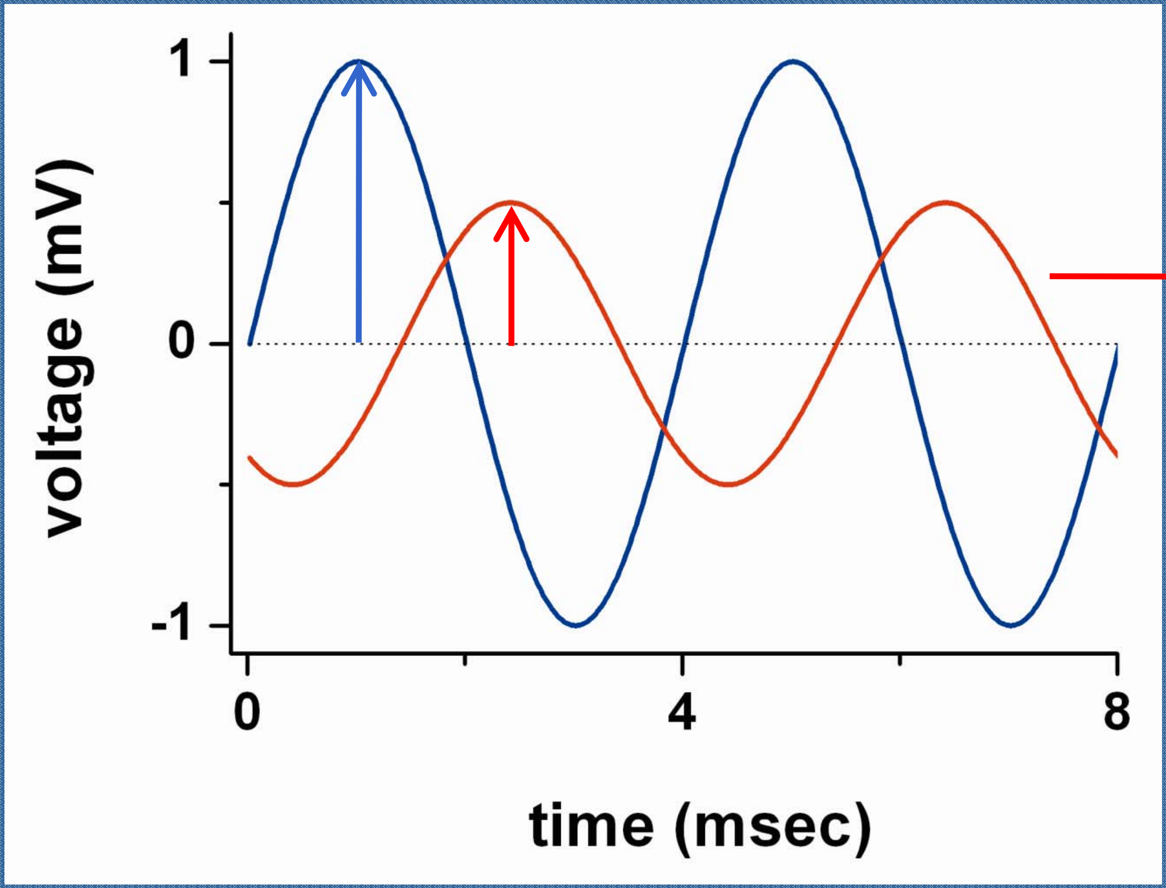
click



noise

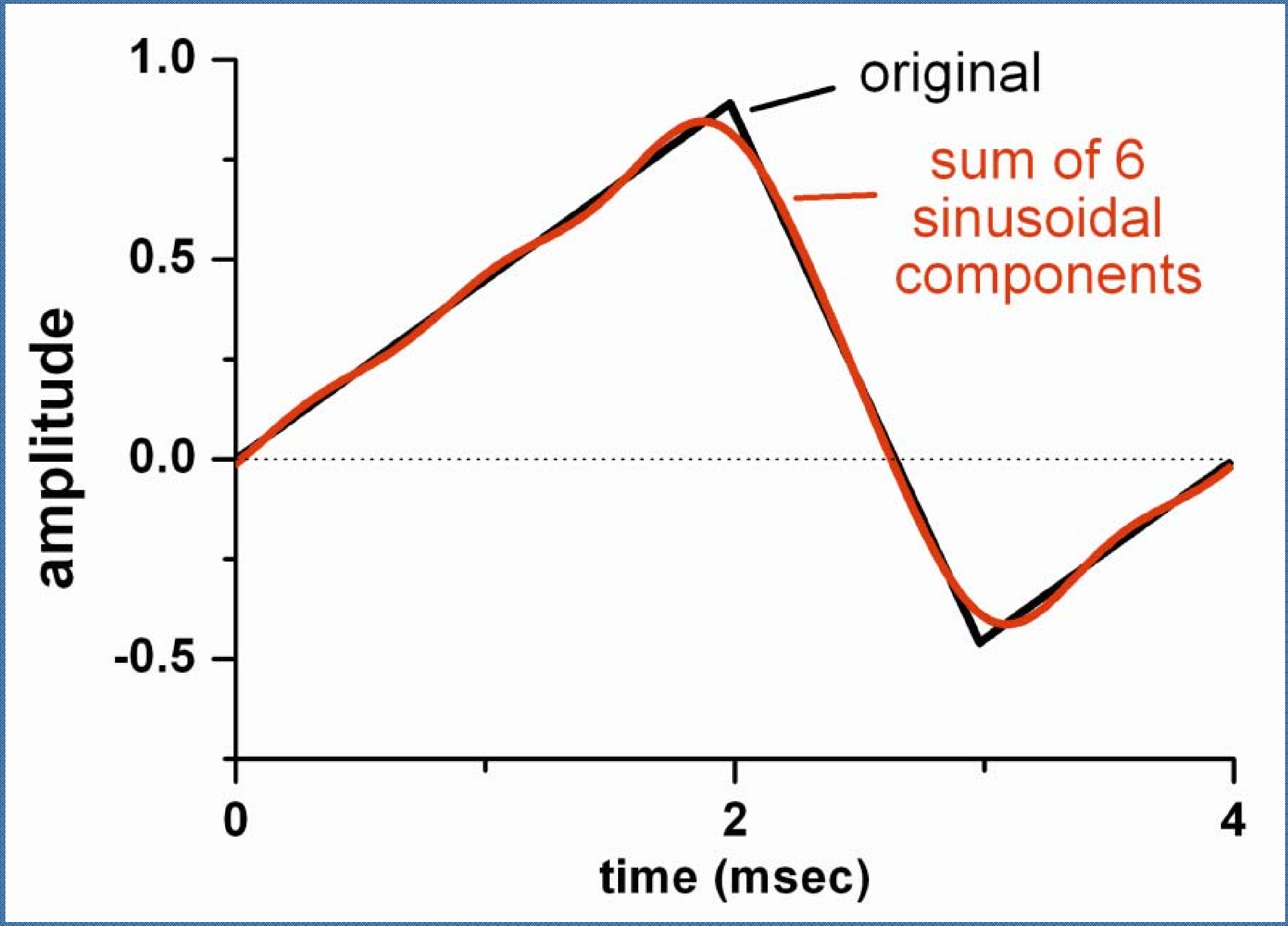
sinusoid: $y(t) = A * \cos(2*\pi*f*t + \theta)$

f: frequency; A: amplitude; θ: phase

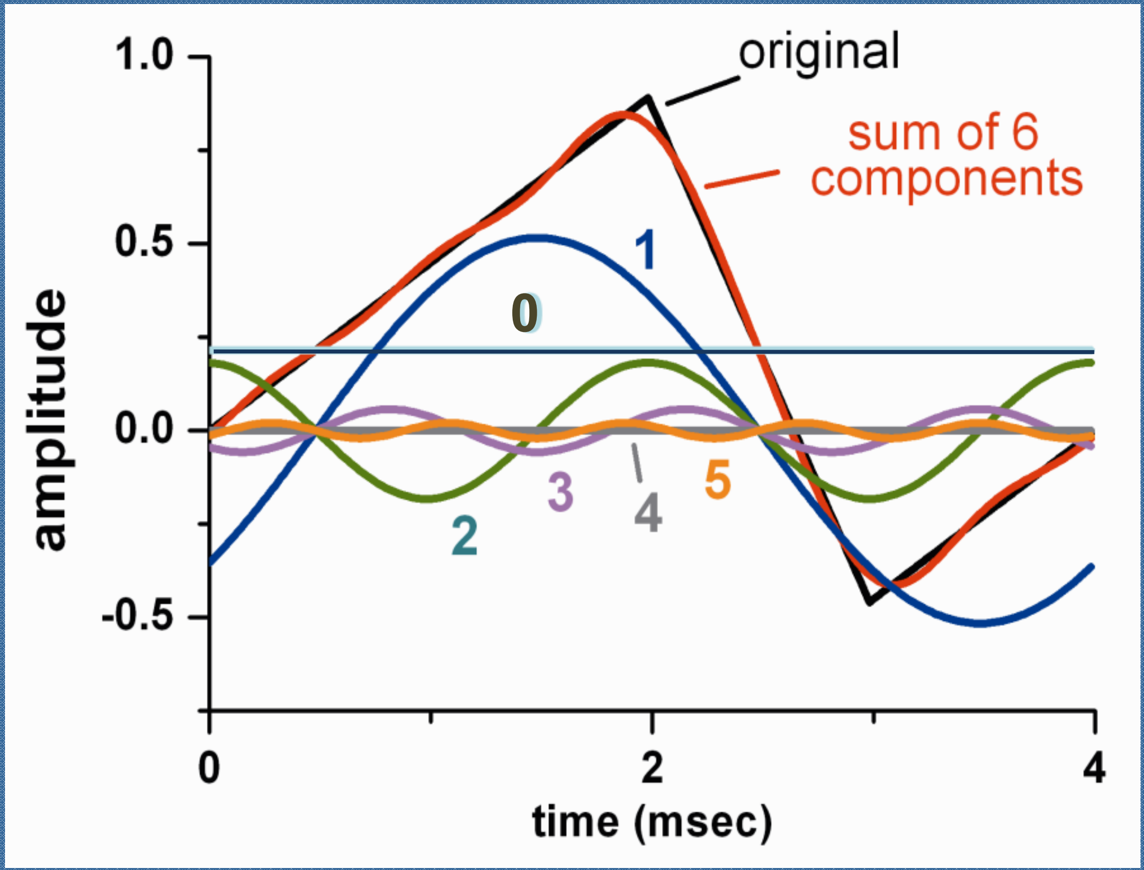


amplitude: smaller;
phase: delayed

time-domain signals
(waveforms)



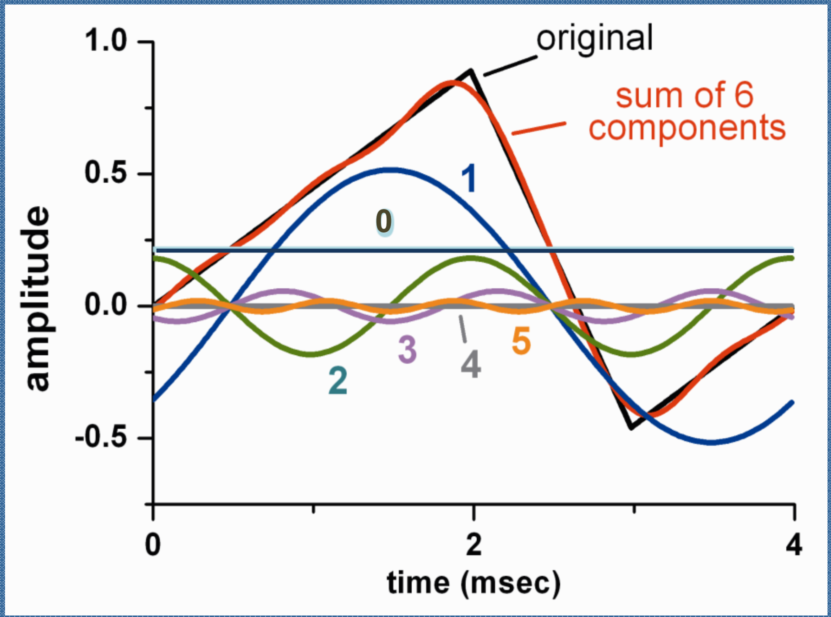
Fourier analysis

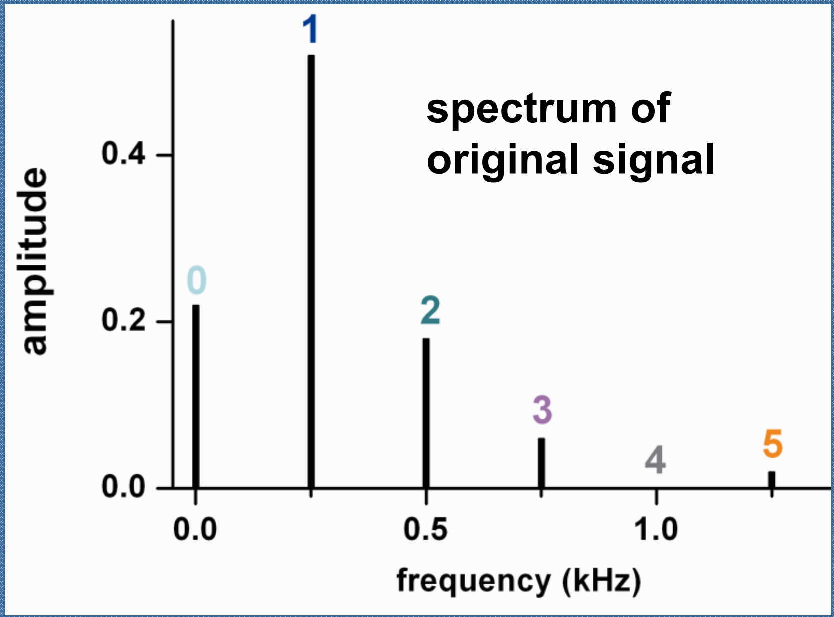


original
synthesized
1st harmonic
2nd harmonic
3rd harmonic
5th harmonic

Fourier transform

time-domain signal ⟷ frequency-domain signal





key slide of this lecture

1st harmonic

3rd harmonic

2nd harmonic

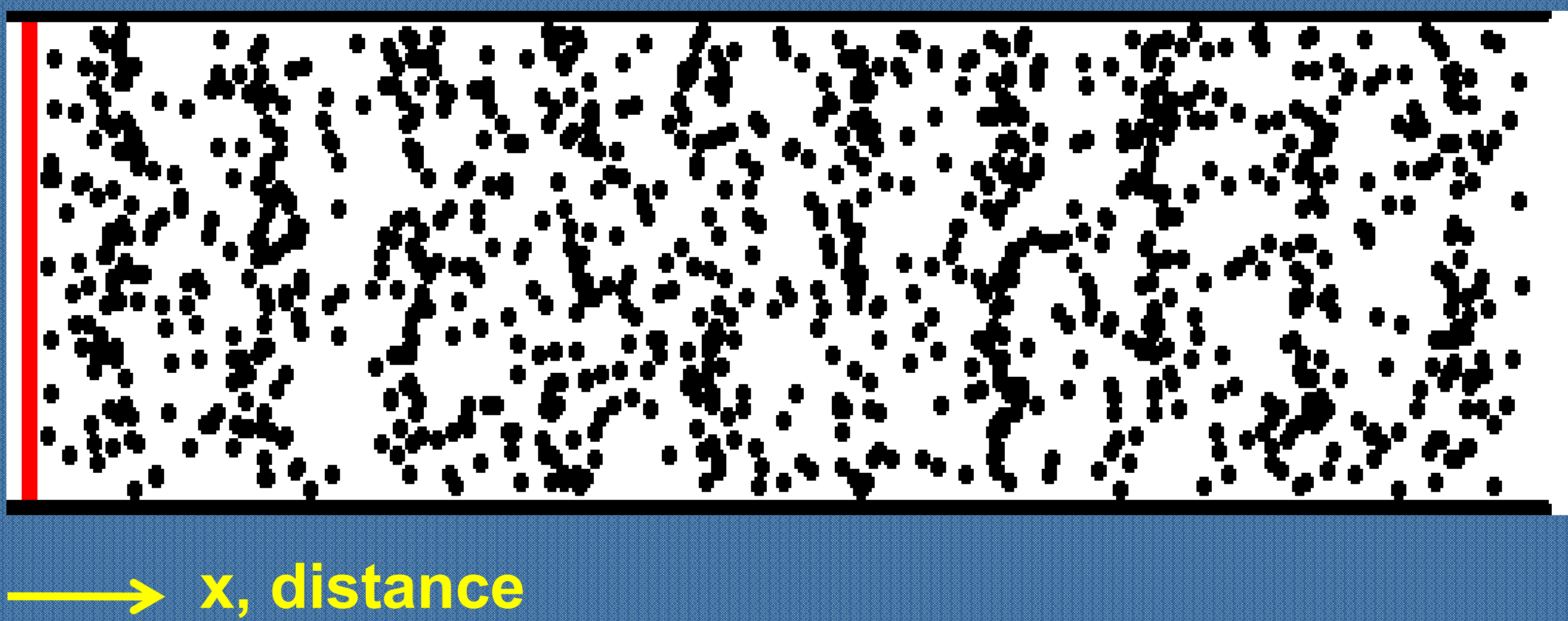
5th harmonic

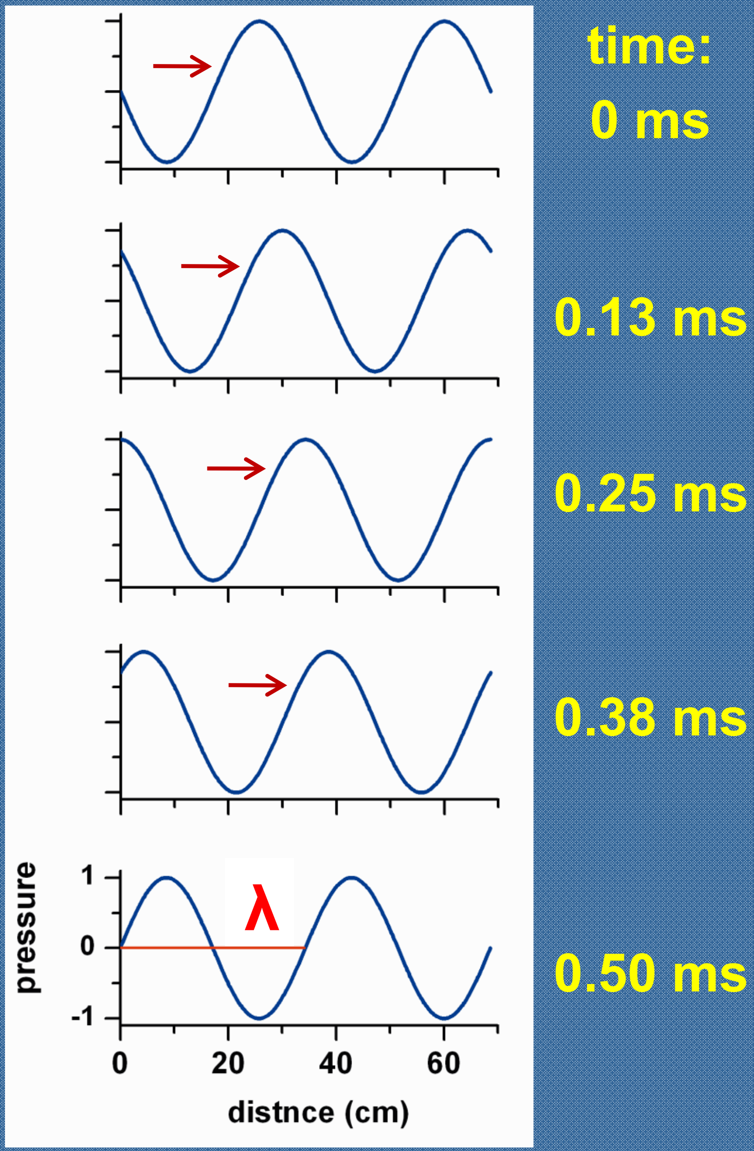
synthesized

original

Sound waves are compression waves.

The air particles are compressed and rarefied cyclically.





plane wave; f = 1 kHz

$$p(x,t) = P*\sin(2*\pi*f*(t-x/c))$$

t: time (sec)

x: distance (m)

f; frequency (Hz, or sec^{-1})

c = 343 m/sec in air, 20°C

c = f * λ (m/sec)

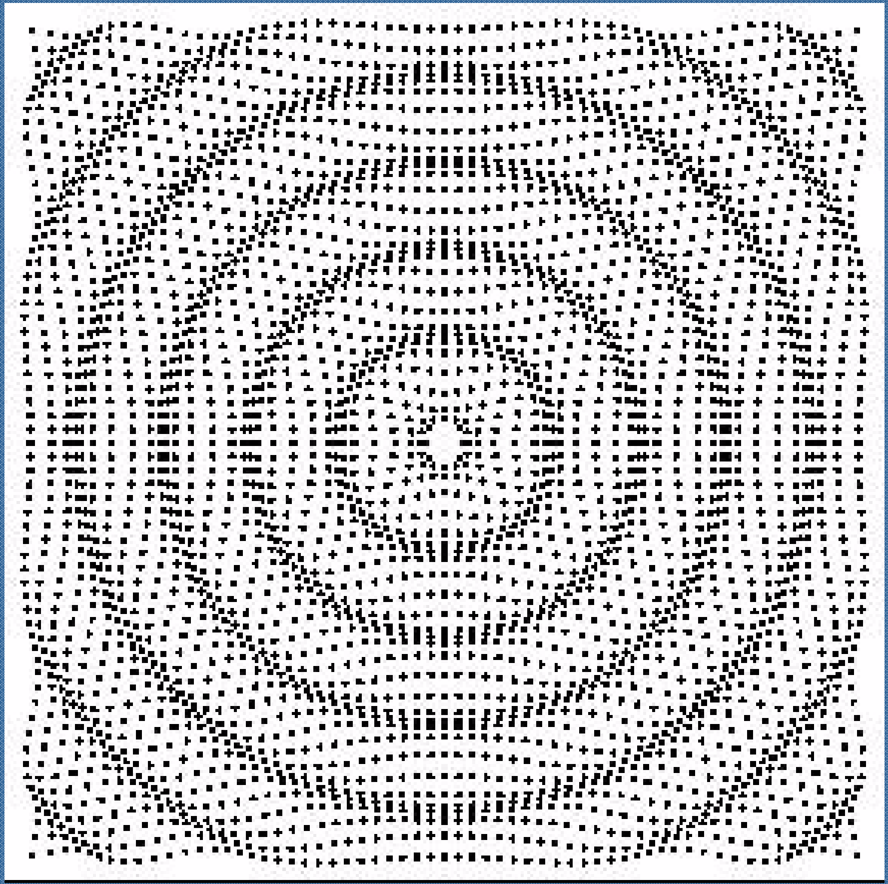
λ = c / f; wavelength (m)

0.343 m for 1 kHz

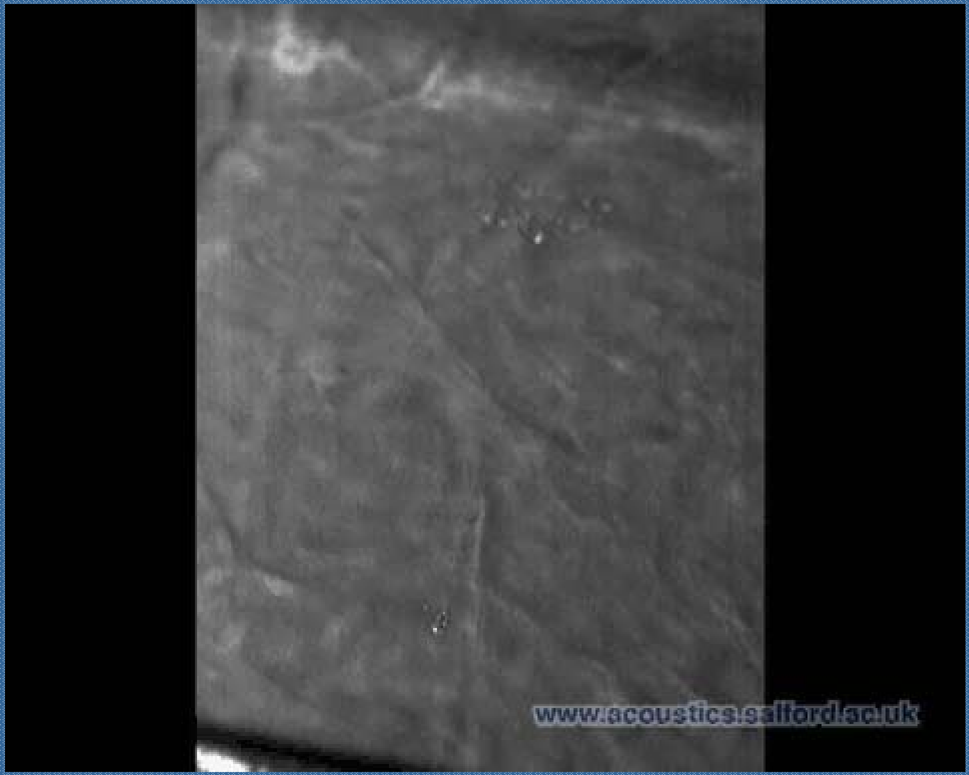
speed of sound waves

medium	speed (m/sec)
air at 0°C	331
air at 20°C	343
water at 20°C	1482
steel	5962

propagation of a radial (spherical) wave



propagation of a radial (spherical) wave
water drip



www.acoustics.salford.ac.uk

“sound field”:
distribution of sound in space
in any environment

“acoustic free field”:
a sound field without any reflections
e.g., sound field in an anechoic room

(Yost, 2007)

SPL: sound pressure level

dB: decibel

dB SPL = 20* log(pressure / 20 μPa)

0 dB SPL: normal hearing threshold at mid-frequency
10 dB SPL: normal breathing
20 dB SPL: whispering
40 dB SPL: a quiet room
50 dB SPL: rainfall
60 dB SPL: normal conversation
110 dB SPL: shouting in an ear
120 dB SPL: thunder

Yost, 2007, Table 3.1