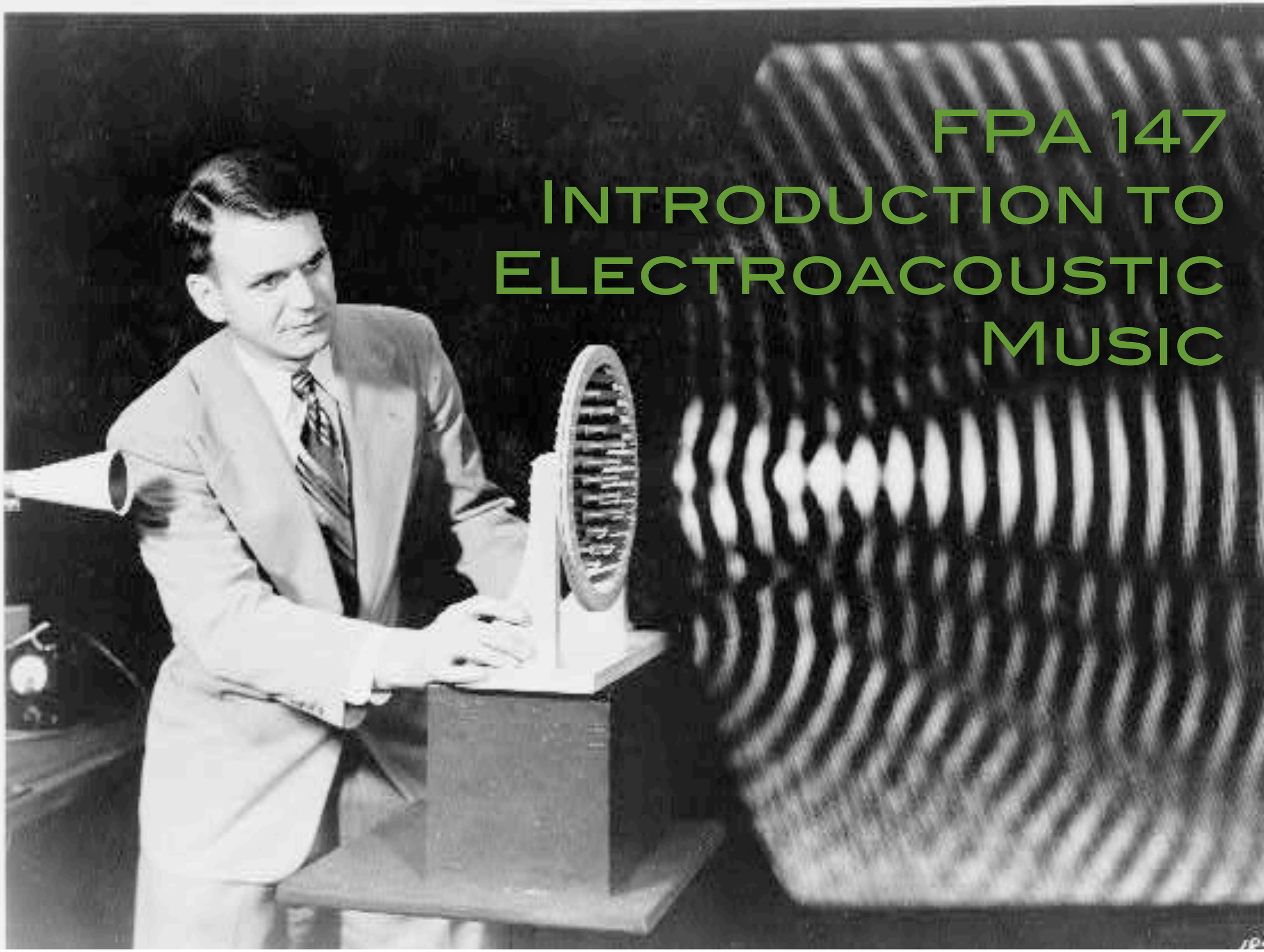
"We have also sound-houses, where we practise and demonstrate all sounds, and their generation. We have harmonies which you have not, of quarter-sounds, and lesser slides of sounds. Divers instruments of music likewise to you unknown, some sweeter than any you have, together with bells and rings that are dainty and sweet. We represent small sounds as great and deep; likewise great sounds extenuate and sharp; we make divers tremblings and warblings of sounds, which in their original are entire. We represent and imitate all articulate sounds and letters, and the voices and notes of beasts and birds. We have certain helps which set to the ear do further the hearing greatly. We have also divers strange and artificial echoes, reflecting the voice many times, and as it were tossing it: and some that give back the voice louder than it came, some shriller, and some deeper; yea, some rendering the voice differing in the letters or articulate sound from that they receive. We have also means to convey sounds in trunks and pipes, in strange lines and distances.

Sir Francis Bacon "The New Atlantis", 1624



FPA 147
Introduction to Electroacoustic Music

I believe that the use of noise to make music will continue and increase until we reach a music produced through the use of electrical instruments which will make available for musical purposes any and all sounds that can be heard. Photoelectric, film and mechanical mediums for the synthetic production of music will be explored.

John Cage, The Future of Music: Credo, 1937

Overview:
Important Info

Instructor: Martin Gotfrit, Professor, SCA

Contact: g o t f r i t @ s f u . c a

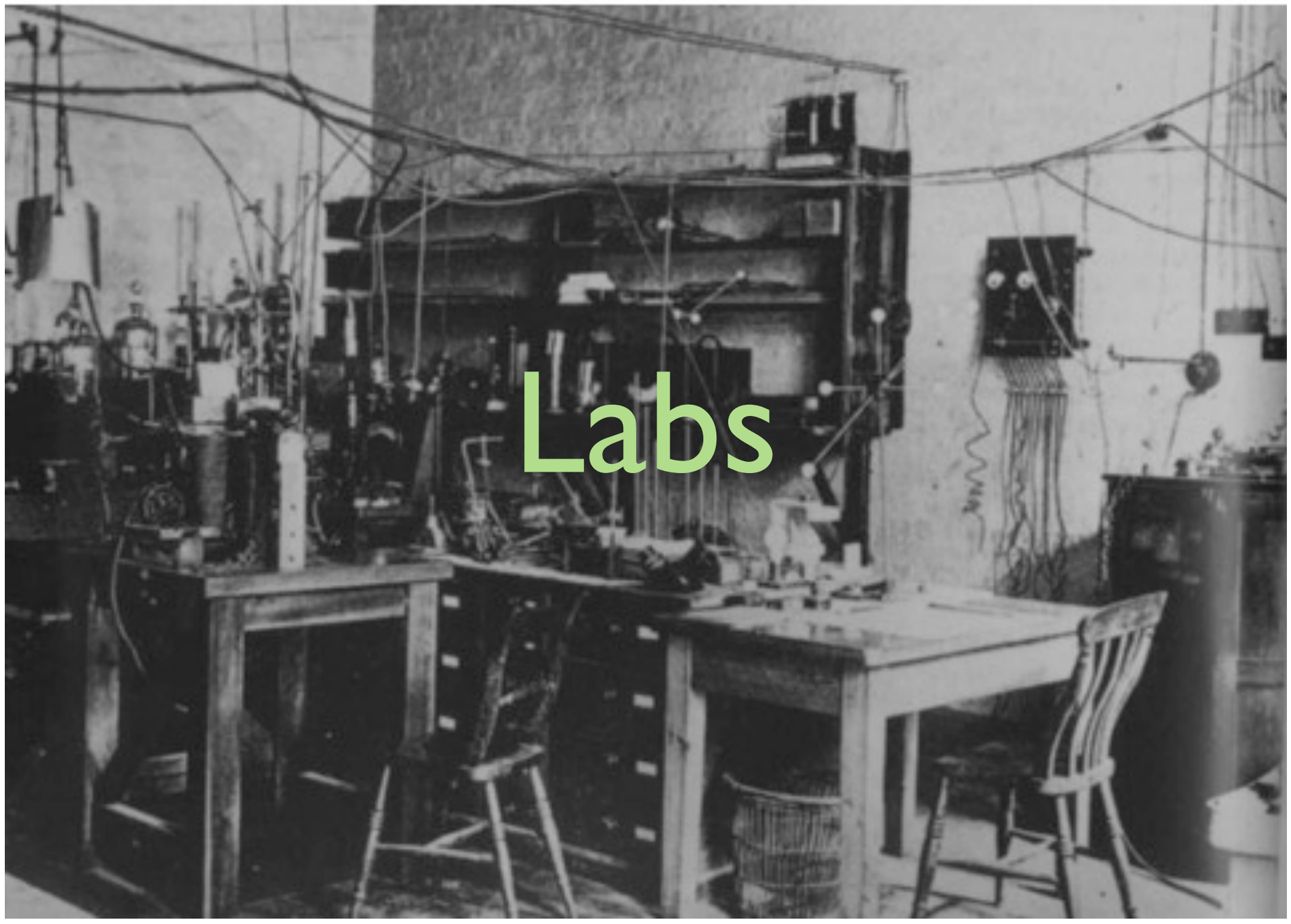
Web: http://www.sfu.ca/~gotfrit/147_12_main.htm

Assignments delivered via WebCT

Content of lectures, content of labs, assignments, resources, schedule
All material on line. Assignment delivery.

Topics/Schedule

Week	Topic
1-5 *(Jan. 8 - Feb. 5)*	Sound, signal processing, sound design
6 *(Feb. 12)*	Reading Week - *NO CLASS, NO LABS*
7&8 *(Feb. 19 - 26)*	Electroacoustic Music History & Practice
9 *(Mar. 5)*	Synthesis & Instruments
10&11 *(Mar. 12 - 19)*	Soundscape and Acousmatic Composition
12 *(Mar. 26)*	Computer Music
13&14 *(Apr. 2 - 9*	Live Performance Systems



The computer as working environment. Introduction to applications, storage, systems, etc.
Recording, editing and rendering. “Classic Studio” techniques as applied to the Assignments. Signal processing of spectrum, dynamics, time and frequency domains. Spatialization. Production techniques (mixing, equalization, spatialization, etc.).
Related techniques and art forms (film, pop music, etc.)

Assessment

Task	Due	Marking %
I: Editing voice	Feb. 5	10
II: Signal processing	Mar. 12	15
III: Composition Exercise	Mar. 19	20
IV: Listening Journal	Apr. 2	25
V: Final Composition	Apr. 9	30
		100%

http://www.sfu.ca/~gotfrit/147_12_assign-main.htm

Resources

www. sfu. ca / ~gotfrit / 147_12_main.htm

Belzburg & Bennet Library CDs, On-line sound libraries, WEB-CT?, gotfrit website including ZAP,

Music

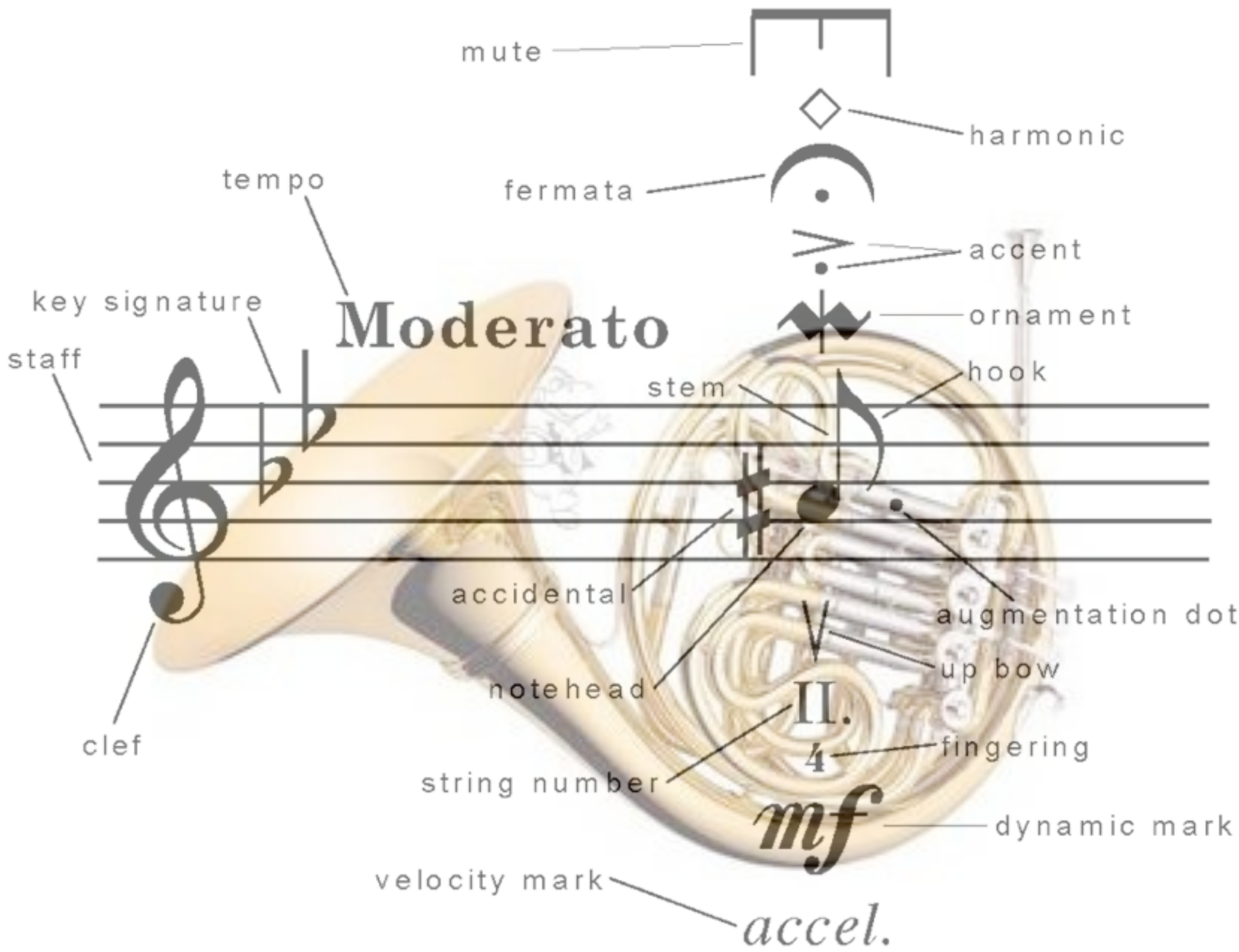
“the art of organizing tones to produce a coherent sequence of sounds intended to elicit an aesthetic response in a listener. Vocal or instrumental sounds having some degree of rhythm, melody and harmony”

The word music comes from the Greek mousikê (tekhnê) by way of the Latin musica. It is ultimately derived from mousa, the Greek word formuse. In ancient Greece, the word mousike was used to mean any of the arts or sciences governed by the Muses. Later, in Rome, ars musica embraced poetry as well as instrument-oriented music. In the European Middle Ages, musica was part of the mathematicalquadrivium: arithmetics, geometry, astronomy and musica. The concept of musica was split into four major kinds by the fifth century philosopher, Boethius: musica universalis, musica humana, musica instrumentalis, and musica divina. Of those, only musica instrumentalis referred to music as performed sound. (Terpsichore-Dance, Calliope-epic poetry, Euterpe-song&elegiac poetry)

"...wrinkles in the air..."

Ursula K. LeGuin

Music is the most abstract of the arts. Unlike painting, sculpture or even literature, but having much in common with the other performing arts or arts of time. A work of musical art is rarely an object. Its representations (score, media, etc.) may be possessed (though until very recently sound could not be stored). It remains merely "wrinkles in the air". (Ursula K. LeGuin)



Music (as sound) is considered apart from other sounds in most cultures. Special instruments make sounds just for music. Even the voice is used differently when singing. Music (through notation and description) has its own language.

Our appreciation seems very much to learned: New forms of music may be disturbing at first. Repeated listening teaches us what to expect and the subversion of those expectations provides great interest and engagement. (Mozart' Mom in the mornings).

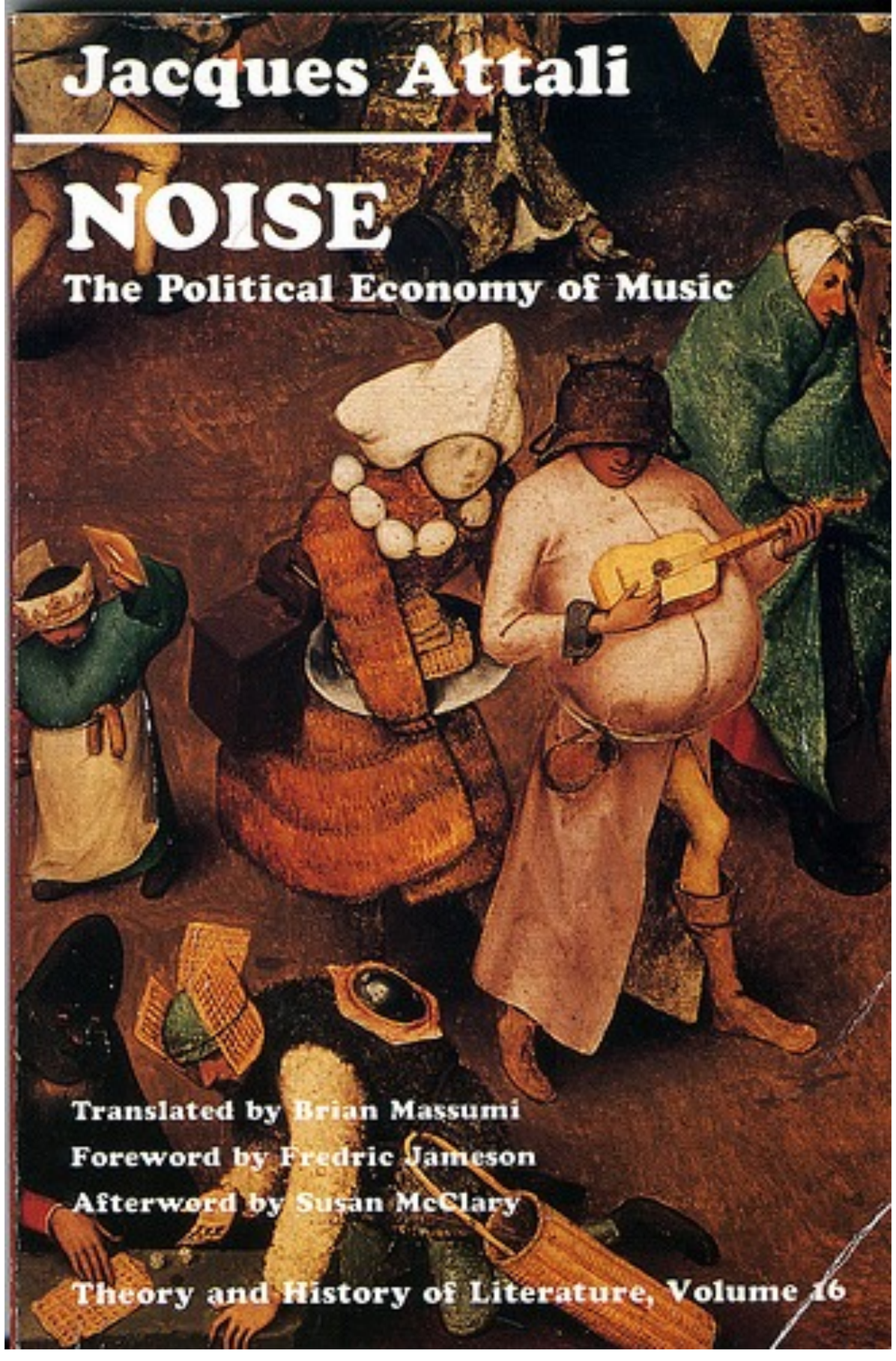
Our hearing is not physically directed or selective as sight is – we have no ear lids. Therefore sound may operate upon our deepest emotions in profound and subliminal ways.

Sound is one of the first experiences of the fetus and constitutes a major component of that environment.
Before we have language we have music.
Music gives the majority of us pleasure.

"A dialectical confrontation with the course of time"

Michel Serres, 1975

Music is a way of thinking about the world, a tool for understanding.



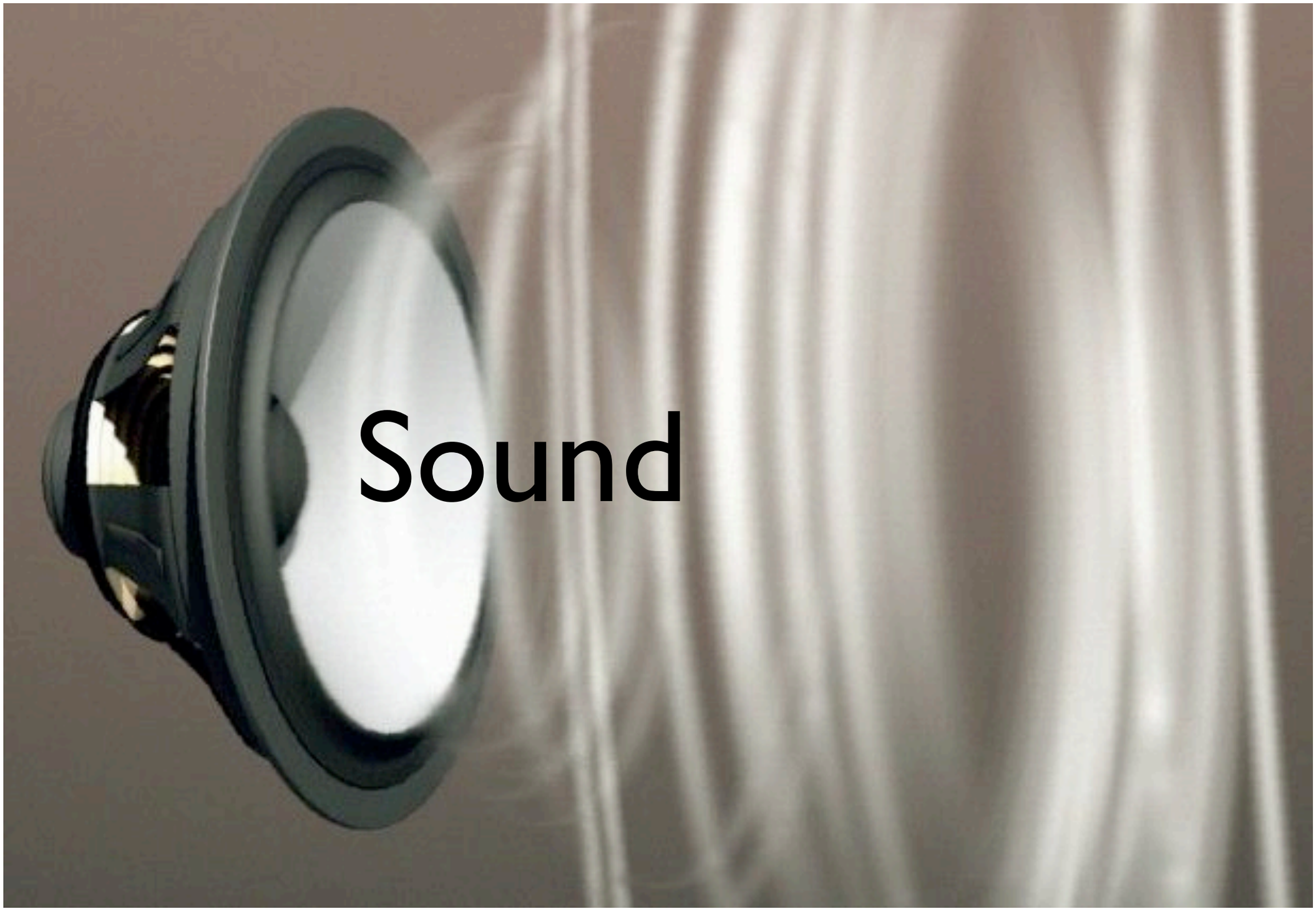
Music is prescient (Jacques Atali, from his book "Noise") its forms represent society as well as predict what is to come.

sound

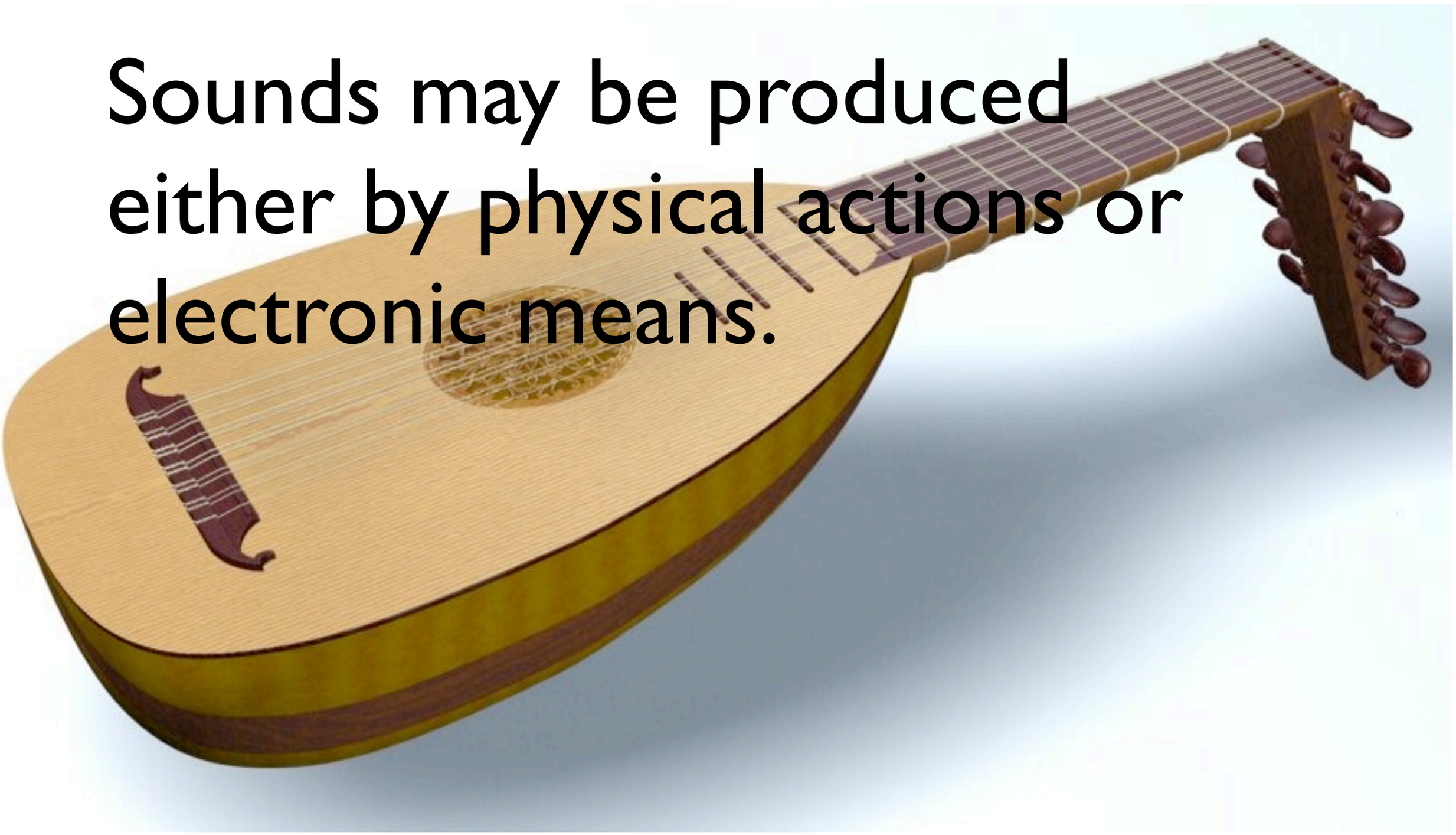
music

noise

Music is often thought of as one of two subcategories of larger phenomena called sound. Noise is the other subcategory and can be defined as disorganized sound or sound organized in a very complex manner. In any case these distinctions are **culturally based** and learned. Music has many elements of noise in it (percussion instruments, the initial **attack** of many instruments, etc.) The early twentieth century composer Edgar Varese called music "organized noise". The definition of noise could be the basis of an entire course.



What is sound?



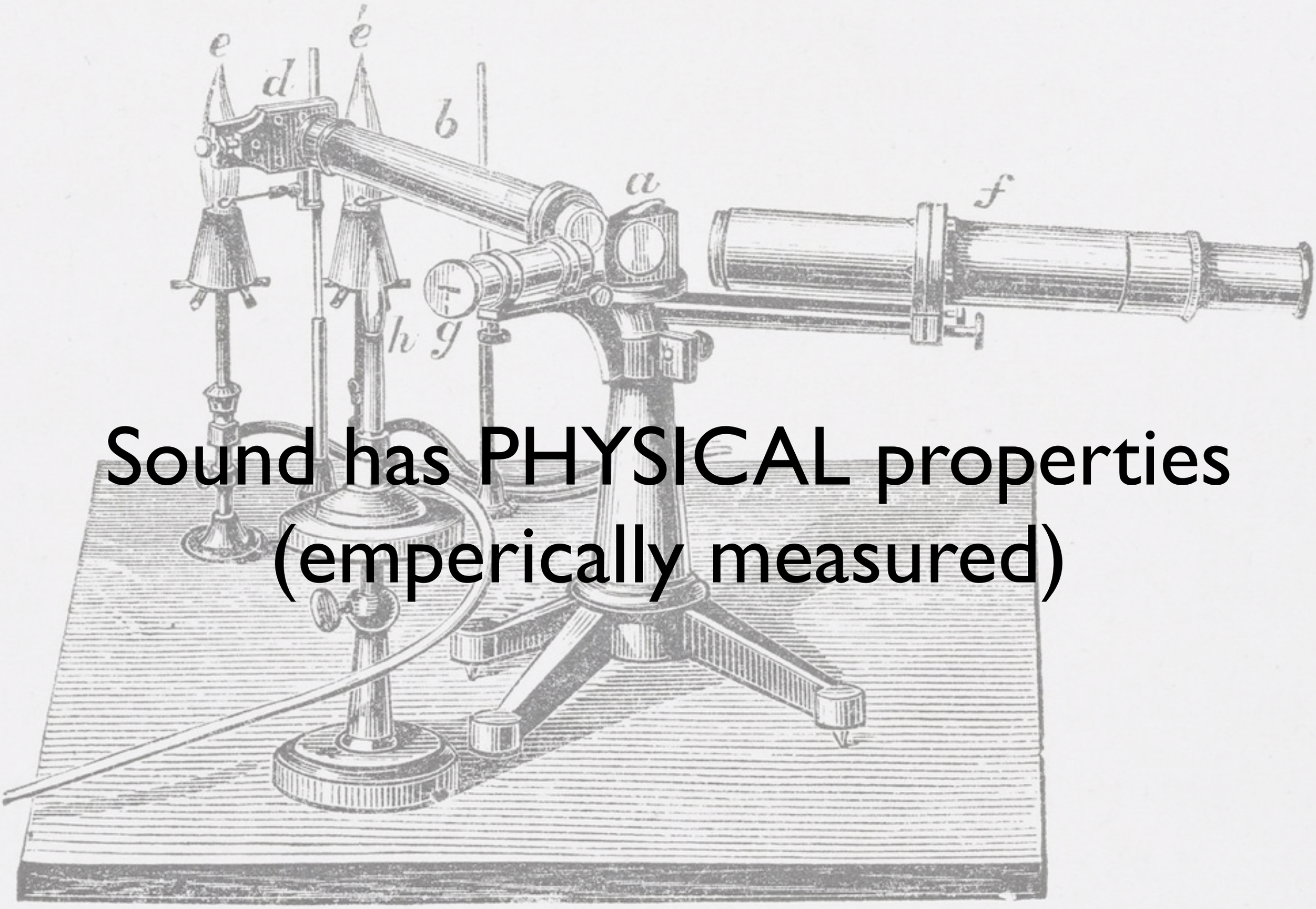
In acoustic based sounds energy is required to generate sound and to overcome the inertia of the object that vibrates. This initial energy might come from the breath, by striking or plucking (etc.) or through some mechanically assisted system such as the piano, pipe organ or celeste. We therefore use the term acoustic for an instrument or sound, which occurs without electronic amplification or other electronic means.

The distinction between electronic and acoustic sources is often quite blurred: is an acoustic guitar heard through a PA system "electronic"? Is a sampler playing back a digital recording of a 'cello electronic? Etc. Hence the handy term electroacoustic, which refers not only to the materials of the art but also the method.

Electronic sounds may be synthesized directly or derived from an amplified or electronically altered acoustic source or otherwise defined as sounds recorded and played back electronically.

More than anything else, electroacoustic music is a way of thinking about, creating, producing and presenting music. As time passes it becomes less of a distinctive means of expression while becoming a way of approaching music composition. It is also excellent ear training, an essential introduction to sound design for film, games, etc. and audio production in general

When an object, or part of one vibrates, it causes the material around it to vibrate. Through touch or through our ears we perceive the vibration as sound. *The vibration must occur quickly enough for us to perceive the change as sound (it would otherwise be a pressure change) and at least occur 20 times a second for it to be perceived as a continuous sound or tone.*

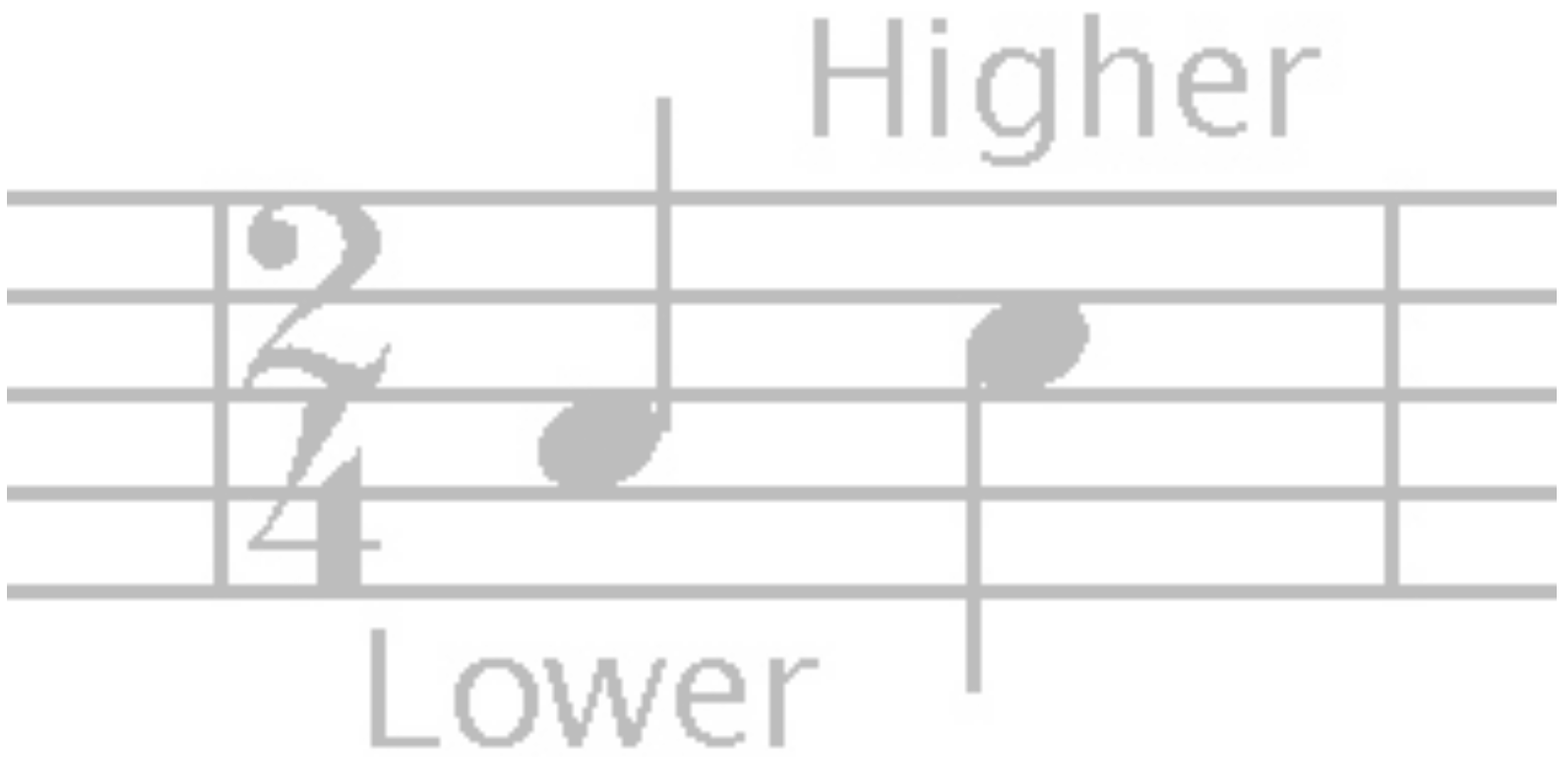


Sound has PHYSICAL properties
(emperically measured)

Fig. 21.

Sound has PHYSICAL properties (emperically measured)

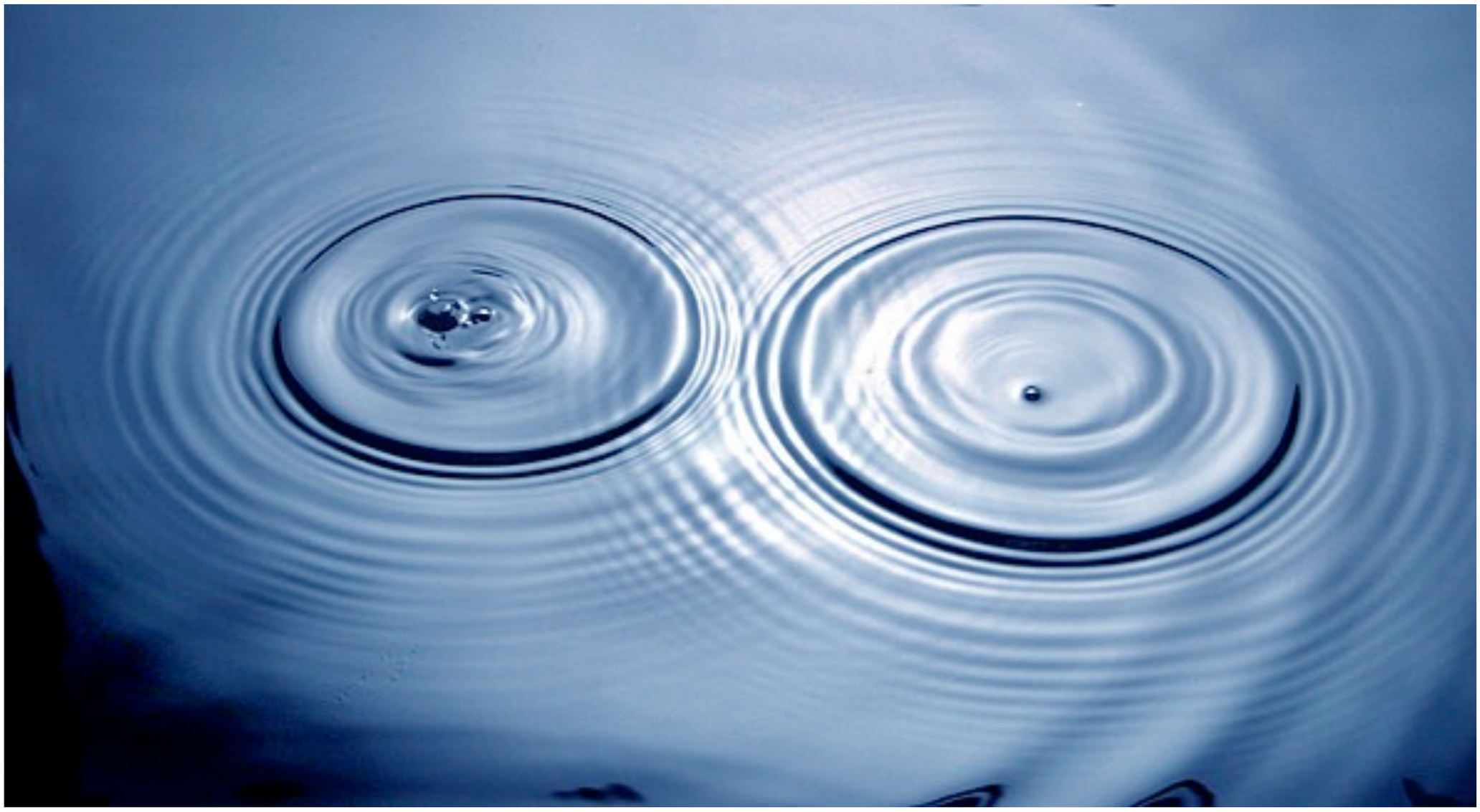
Sound has PSYCHOACOUSTIC properties (what we percieve)



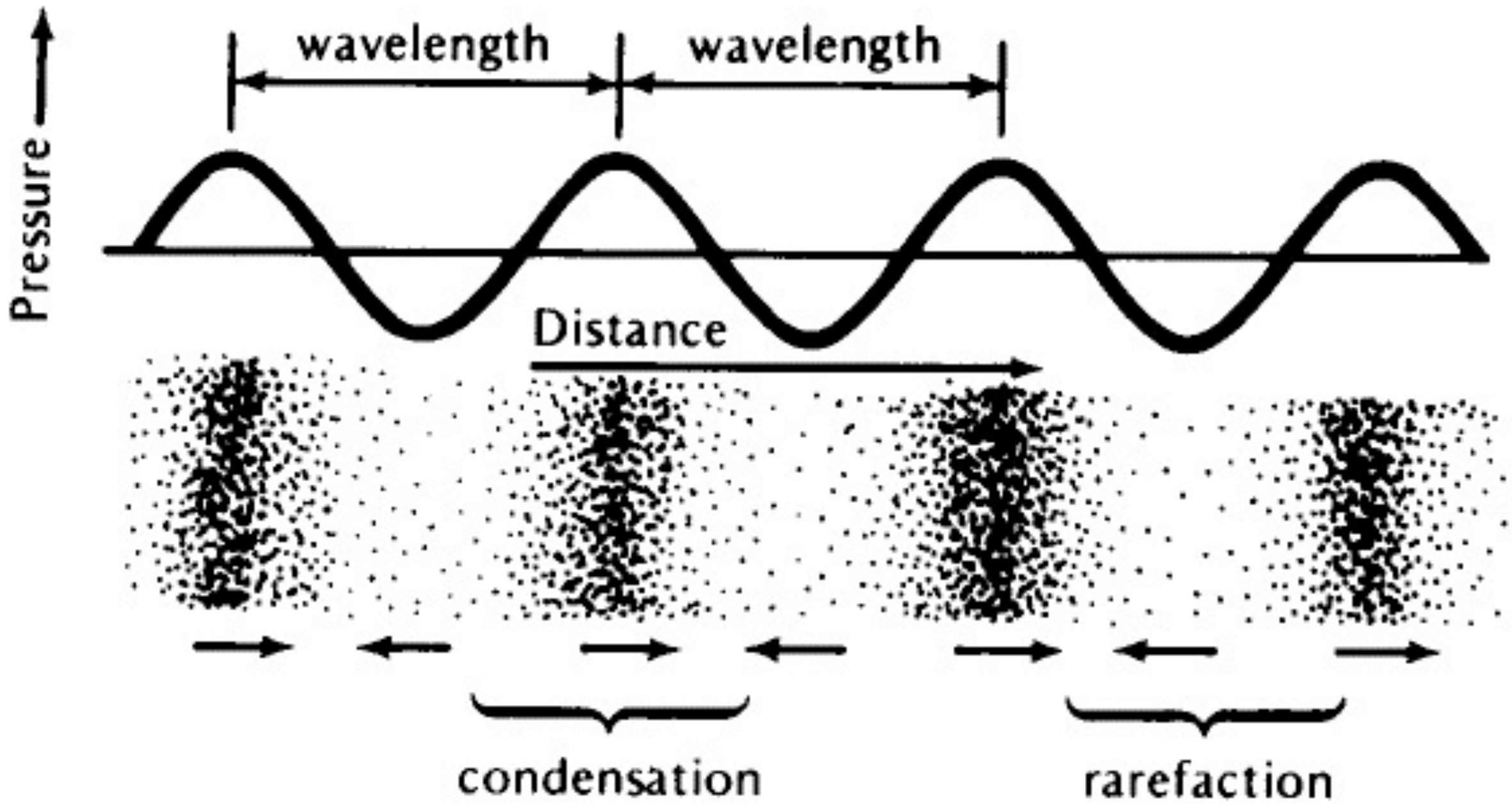
speed of sound

Medium	meter/sec	feet/sec
Air 20˚c	344	1,130
Air 35˚c	402	1,320
Helium	927	3,040
Water	1,437	4,714
Steel	5,000	16,400

We model these vibrations as travelling in a wave in a medium. It travels at different speeds in different mediums:



In the air sound acts as repeating waves or ripples in a pool. The waves are formed of compressed and rarefied regions of air. If it is a continuous tone, then the more waves in a given unit of time then the pitch is perceived as being higher. The greater the change in pressure, the louder the sound will appear.



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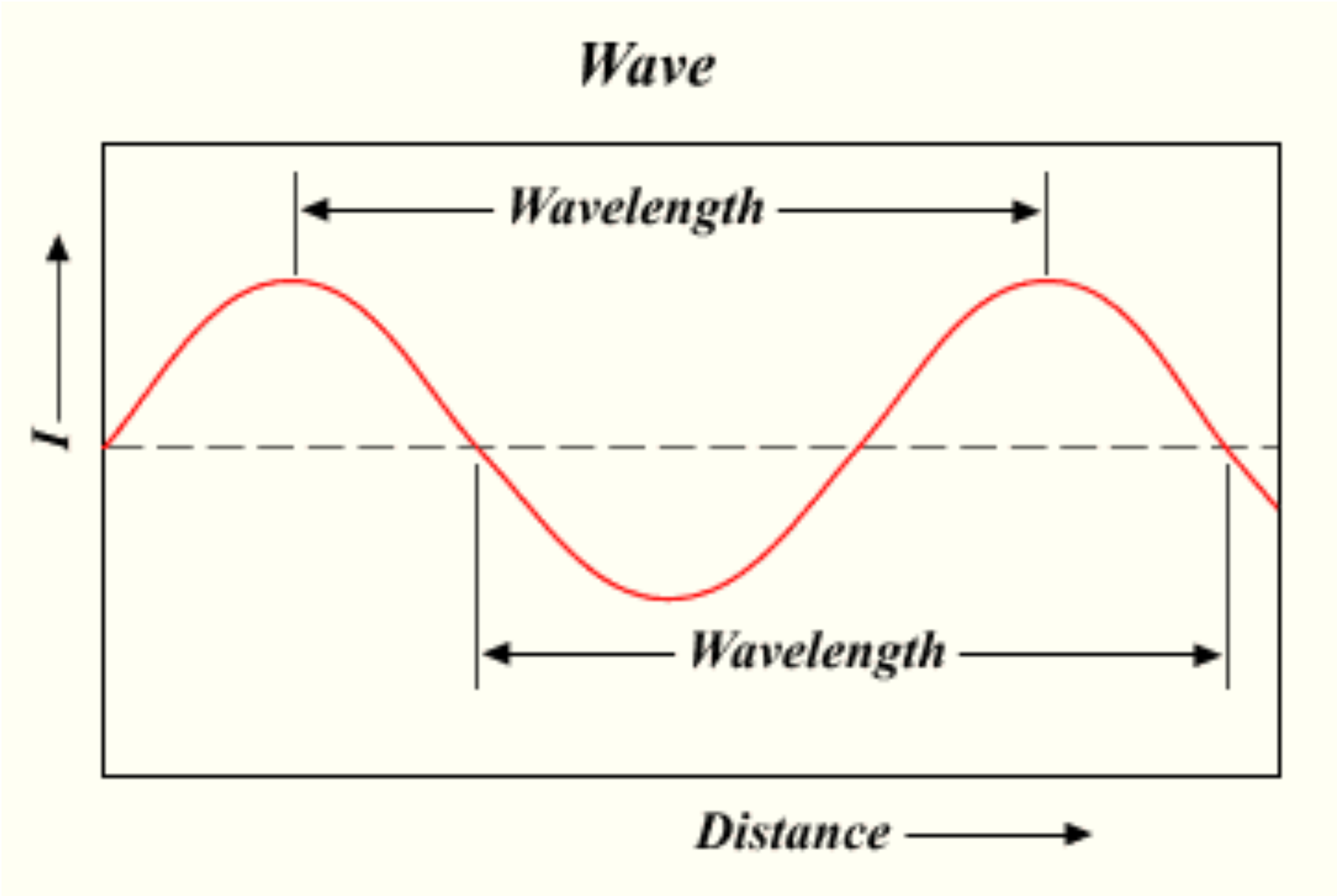
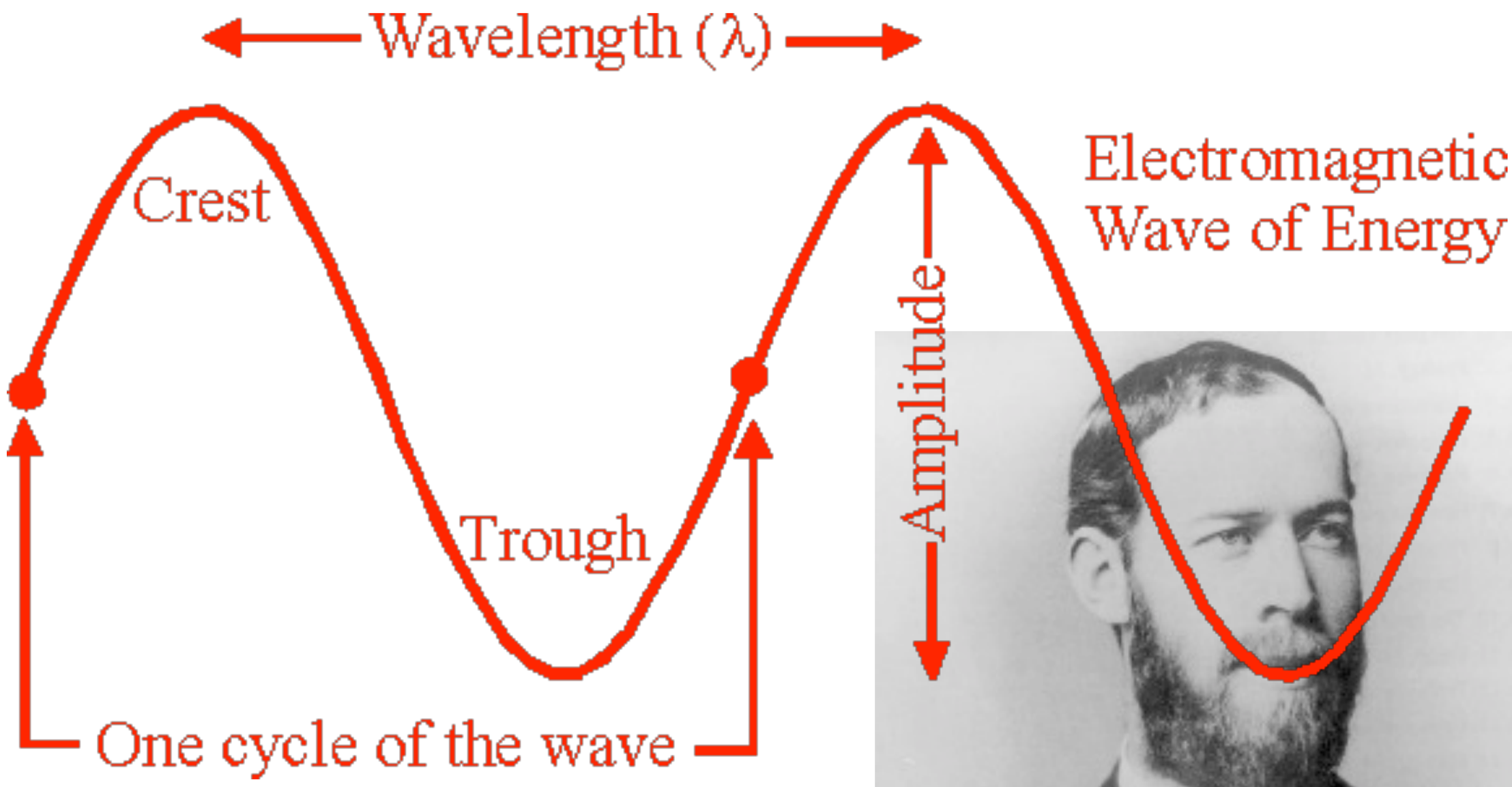


In physics, the **wavelength** of a sinusoidal wave is the spatial period of the wave—the distance over which the wave's shape repeats. It is usually determined by considering the distance between consecutive corresponding points of the same phase, such as crests, troughs, or zero crossings, and is a characteristic of both traveling waves and standing waves, as well as other spatial wave patterns. Wavelength is commonly designated by the Greek letter *lambda* (λ). The concept can also be applied to periodic waves of non-sinusoidal shape.



Electromagnetic
Wave of Energy

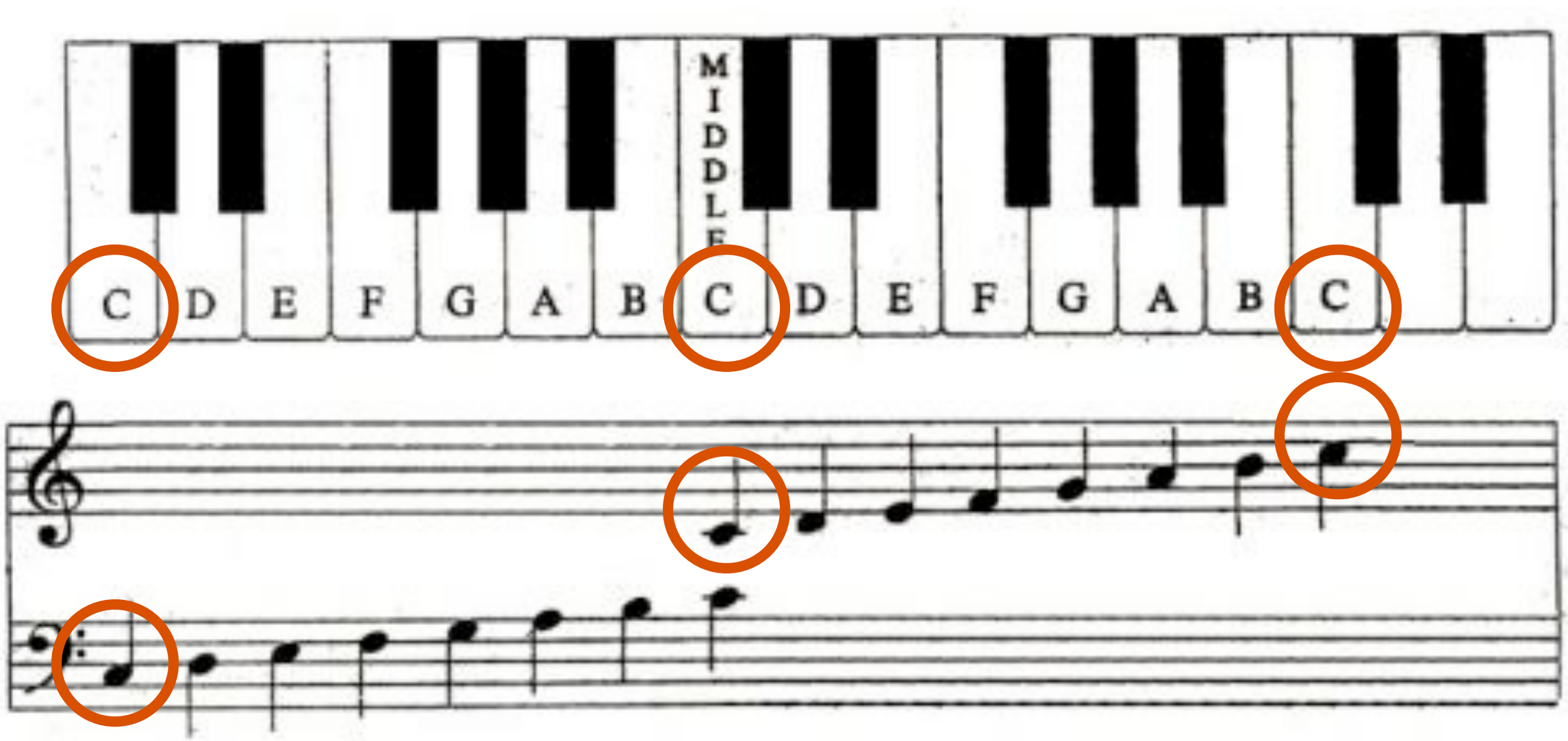
Cycle per second = Hertz

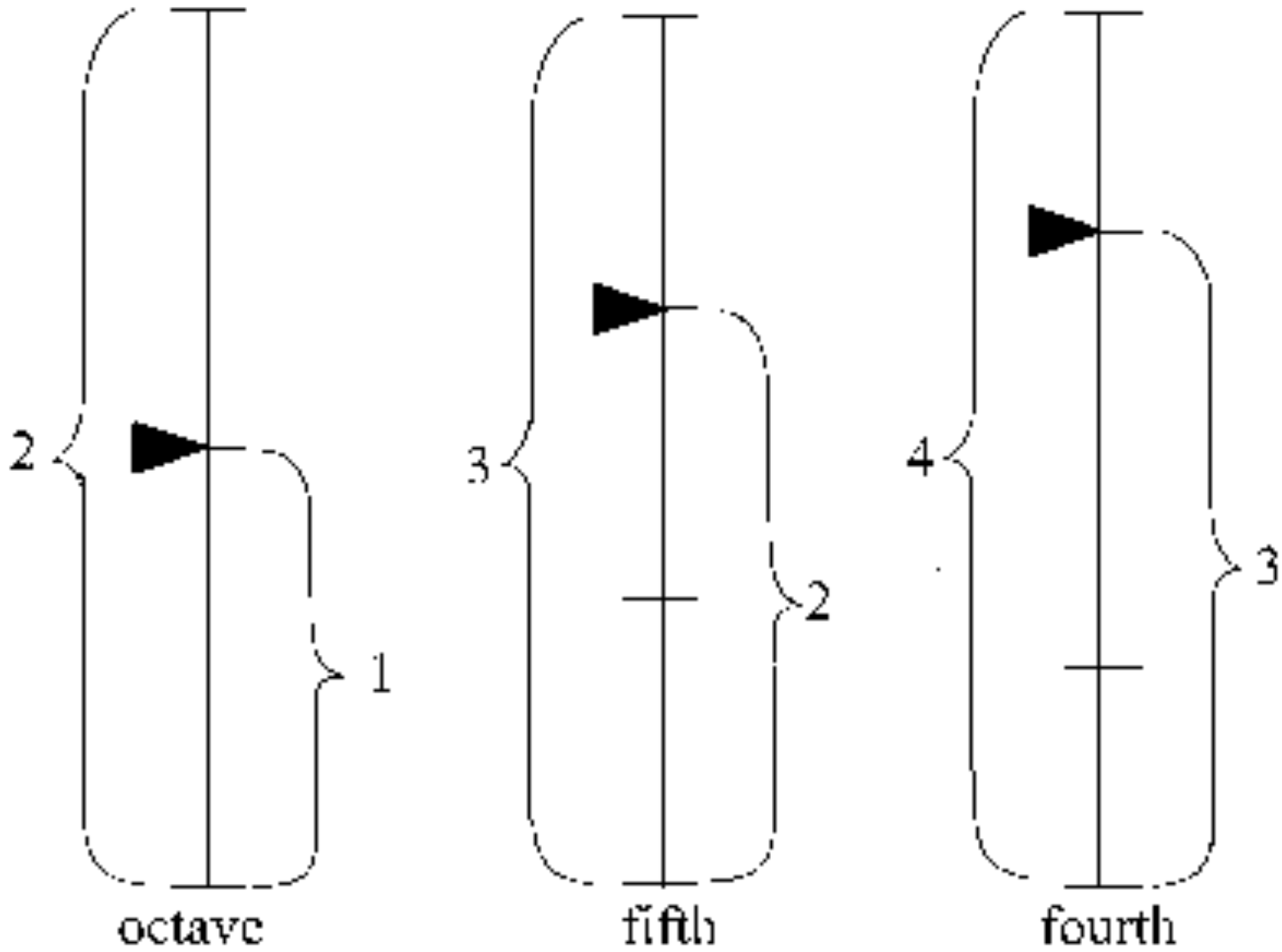
Cycle is also the period. Cycles per second is referred to now as Hertz

Frequency/Pitch

Low to high (subsonic to infrasonic). Frequency measured in Hertz, Pitch as notes with A reference at 440 Hz, “middle C” @ 261 Hz, etc. Tour with Max patch:

octave = 2X or 1/2 frequency



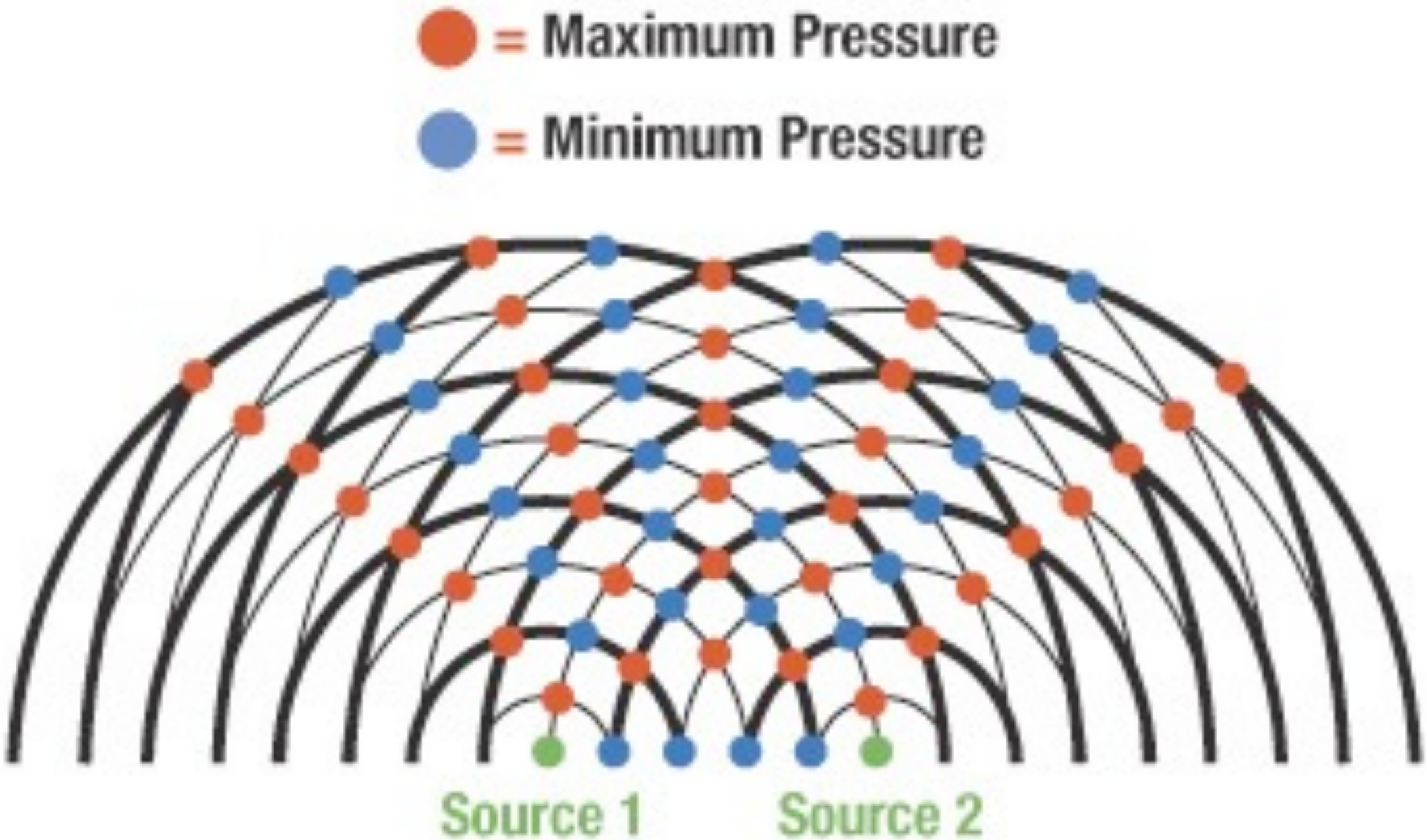


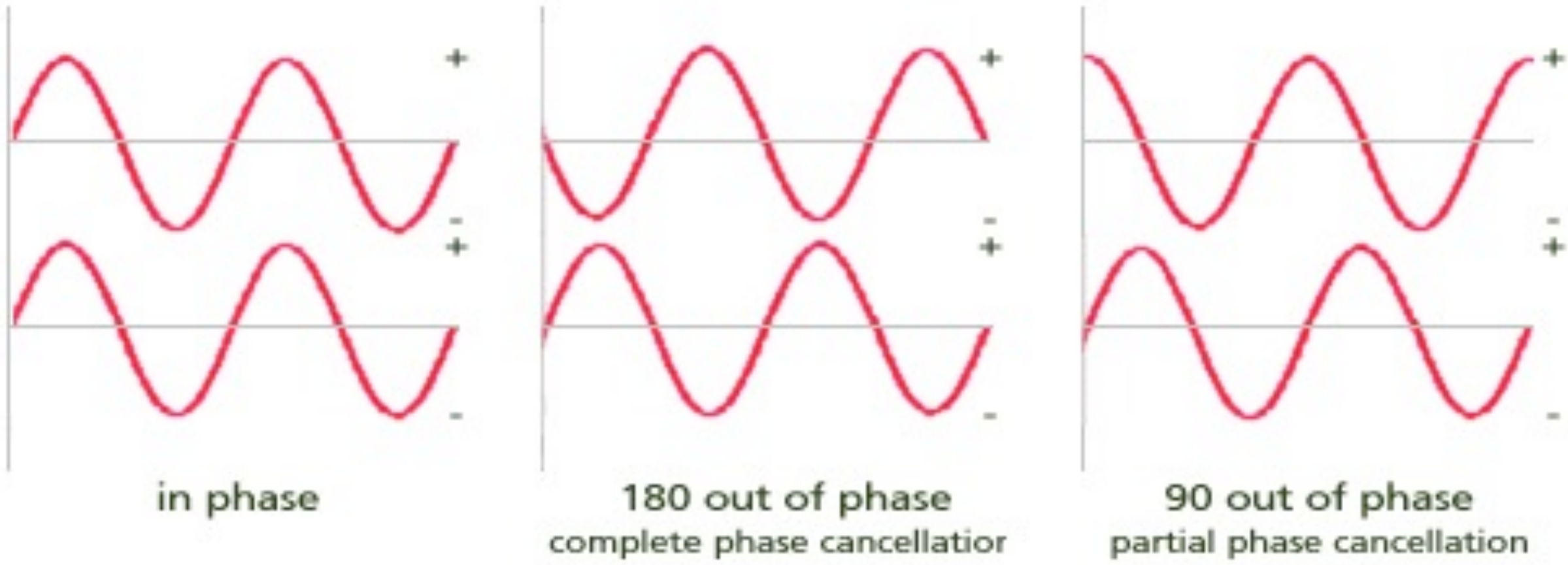
intervals

Pitch is perceived as a LOGARITHMIC function. Every time the frequency is doubled or halved we call this an "OCTAVE" and we perceive this tone as being of the same "PITCH CLASS" and almost equivalent. This is a cultural bias.

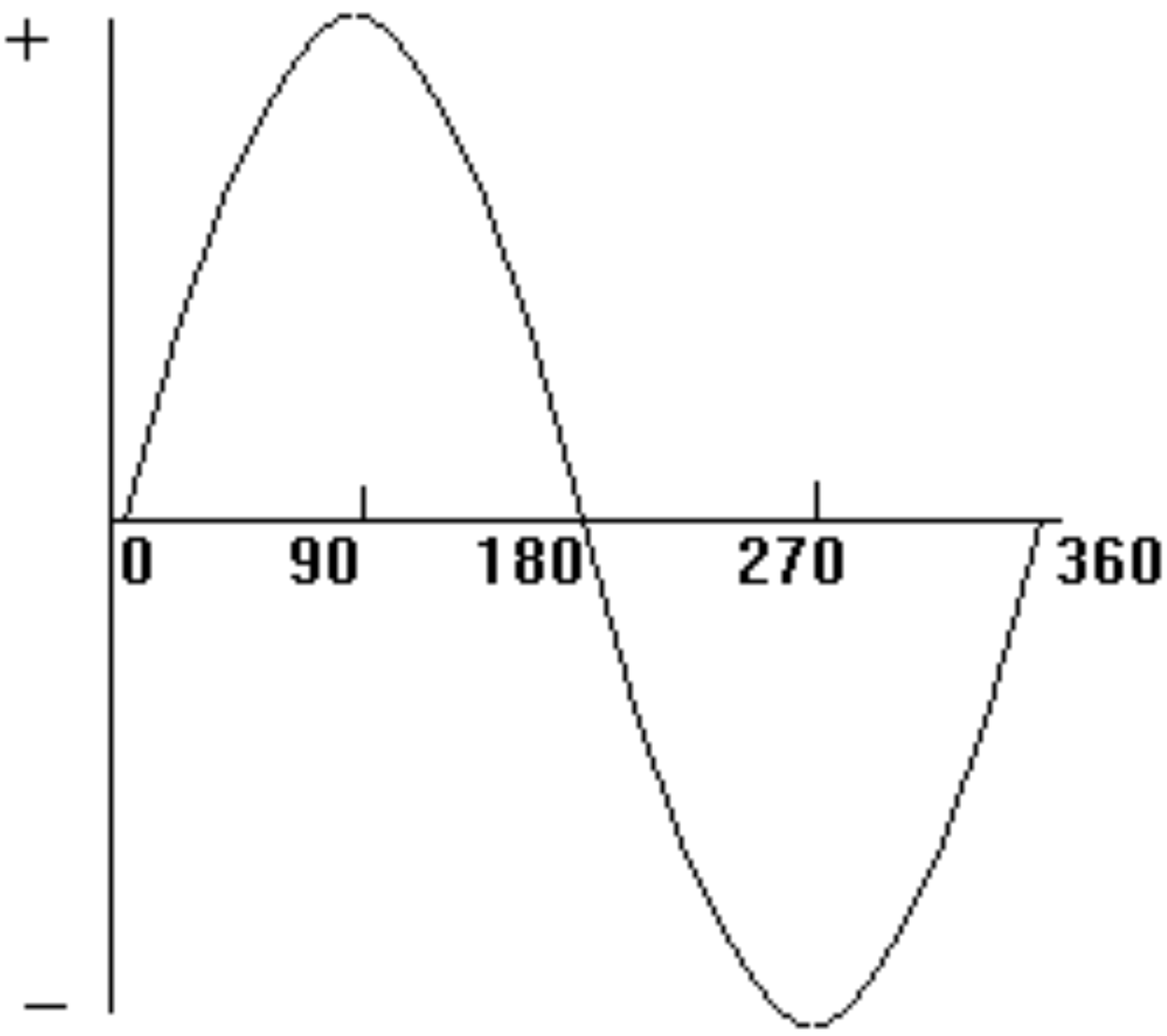
Since frequency is important to us as pitch (which is not continuously variable) then we privilege certain frequency intervals in this culture: Octave 2/1 or 1/2 ratio Fifth 3/2 ratio Fourth 4/3 ratio, etc. Pitch is a logarithmic function: We organize frequencies in octave groups.

Two-Point Source Interference Pattern





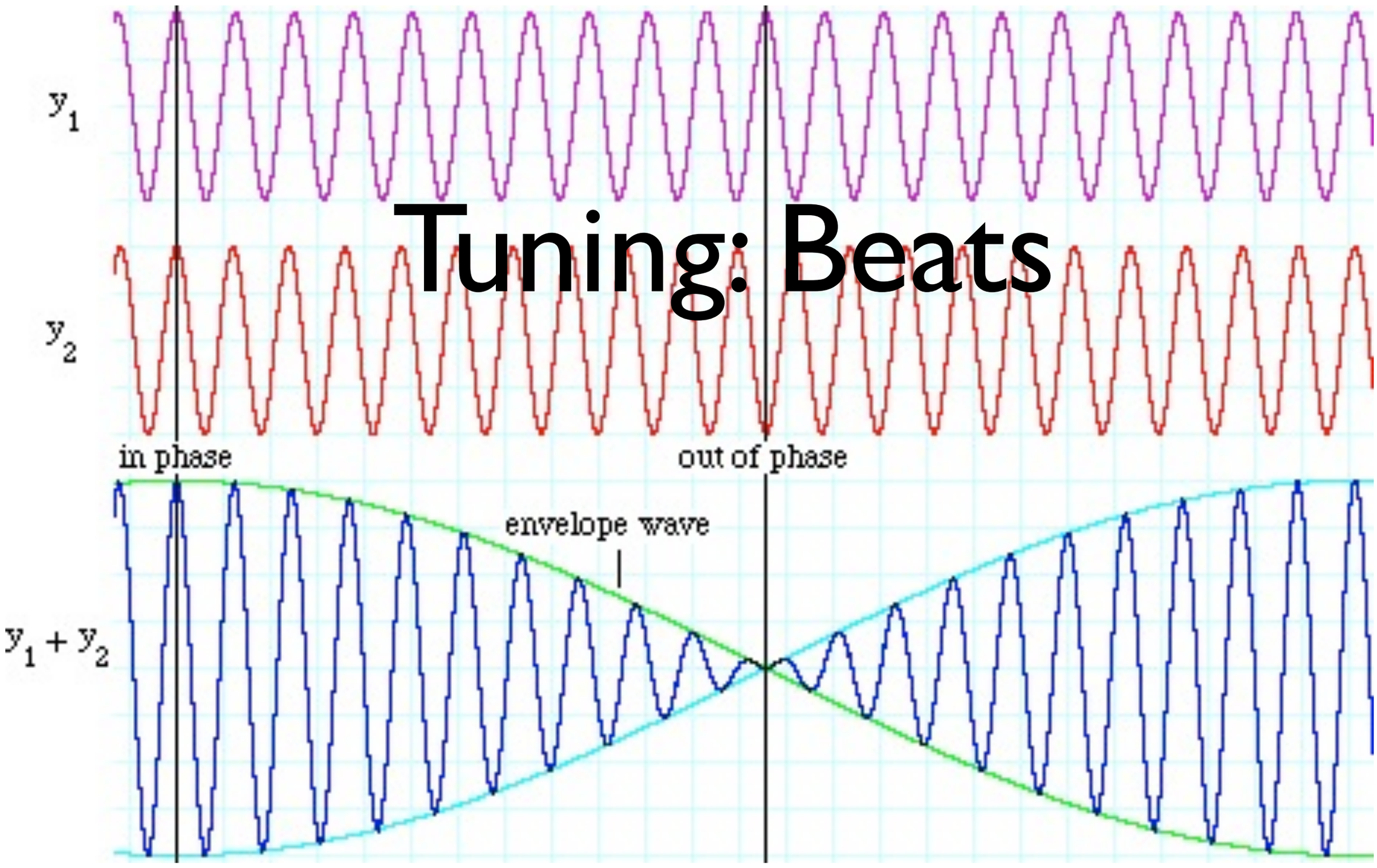
two waves with same frequency – when combined – the values +/–
if they are 180° out of phase then there can be complete cancellation.



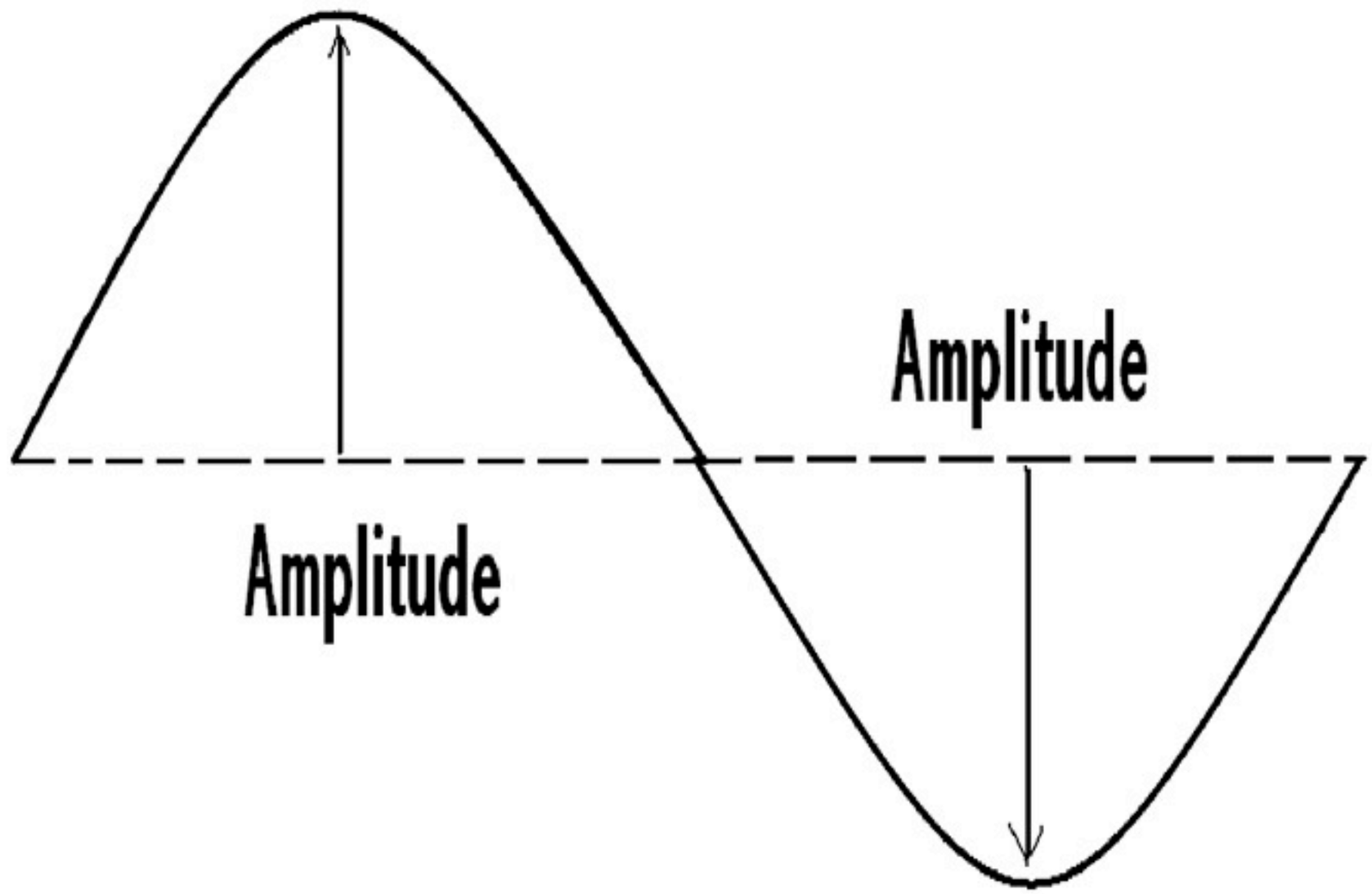
phase of a wave in degrees

http://www.sfu.ca/~gotfrit/ZAP_Sept.3_99/p/phase.html

Tuning: Beats



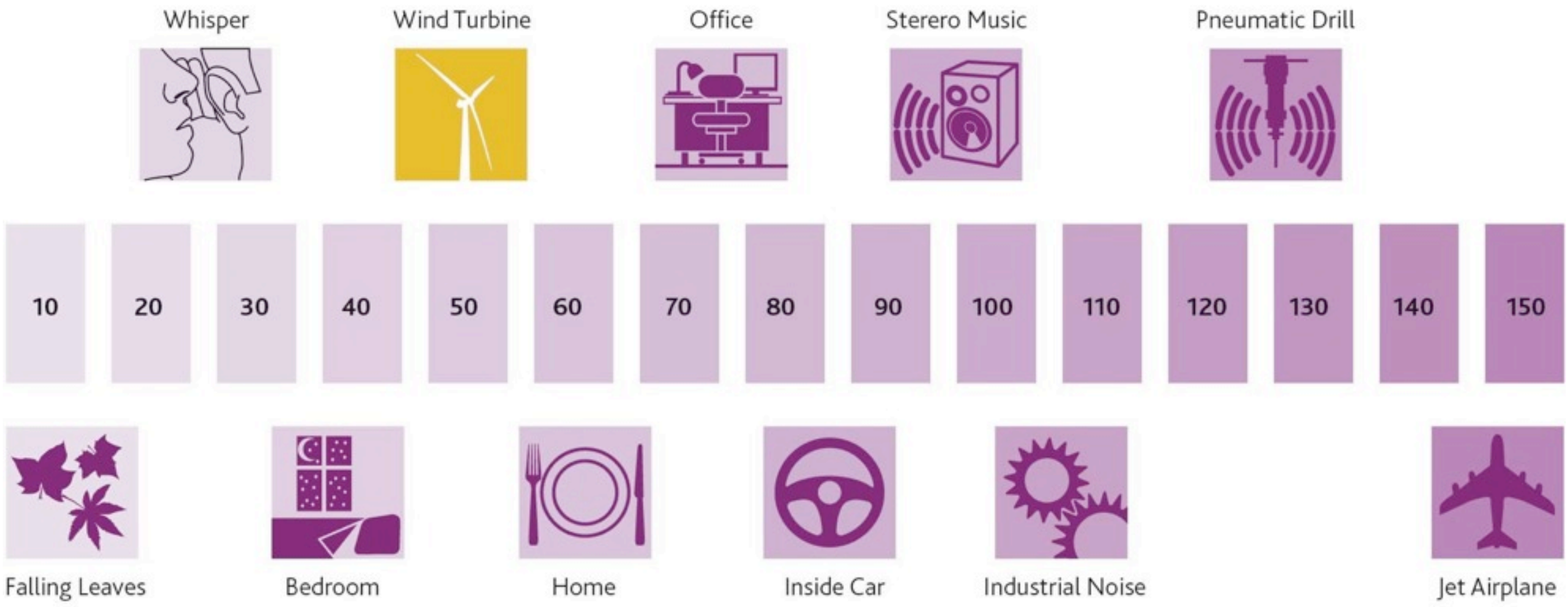
When two tones are approx. 15 Hz or less apart, we get the phenomena of “beating”. As the 2 waveforms go in and out of phase constructive and destructive interference occurs creating a periodic change of amplitude.



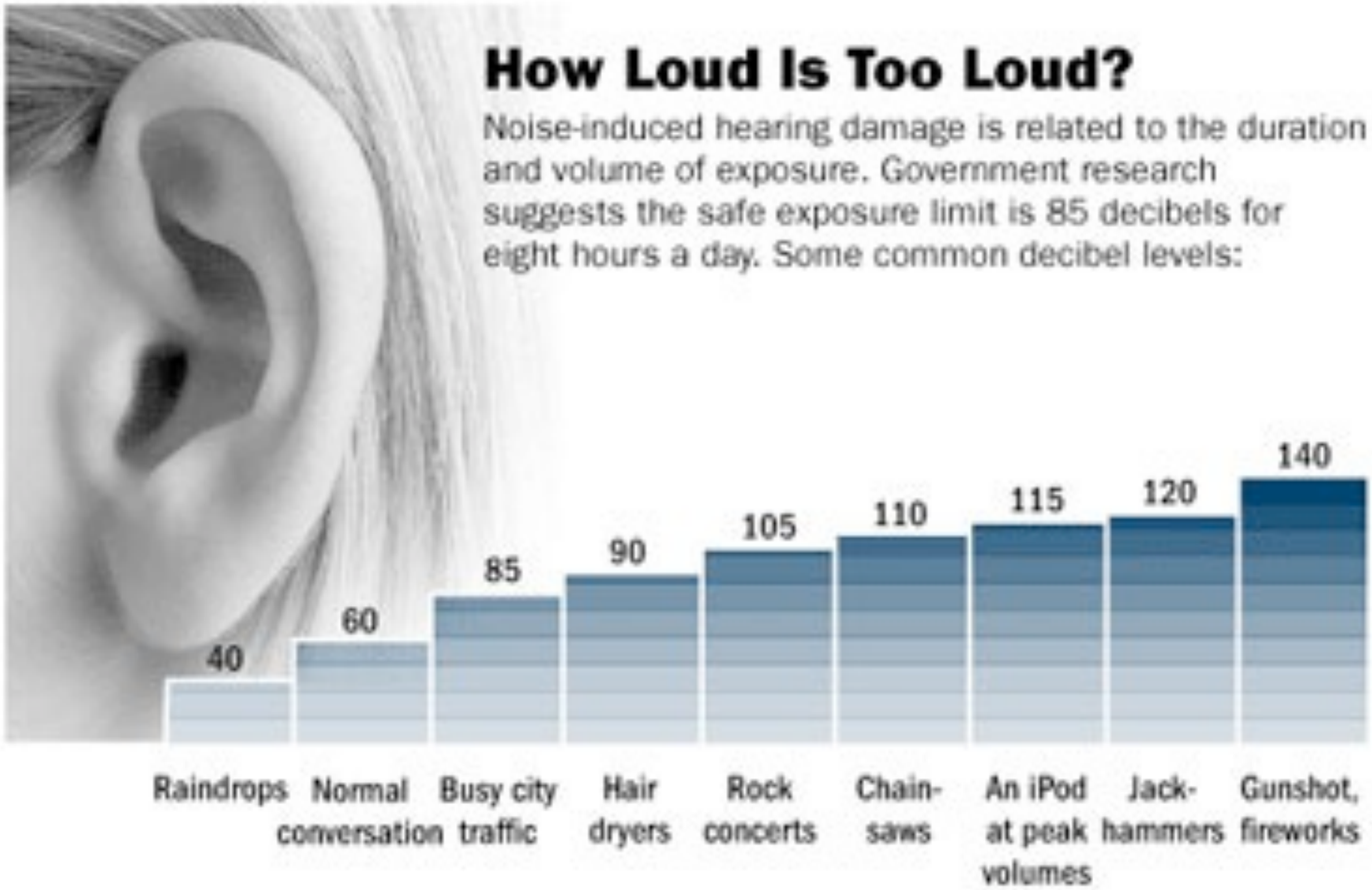
Amplitude/Loudness

Amplitude is measured in decibels. Chart on next slide. Loudness is related to pitch and in musical terms goes from ppp to fff.

DECIBEL CHART



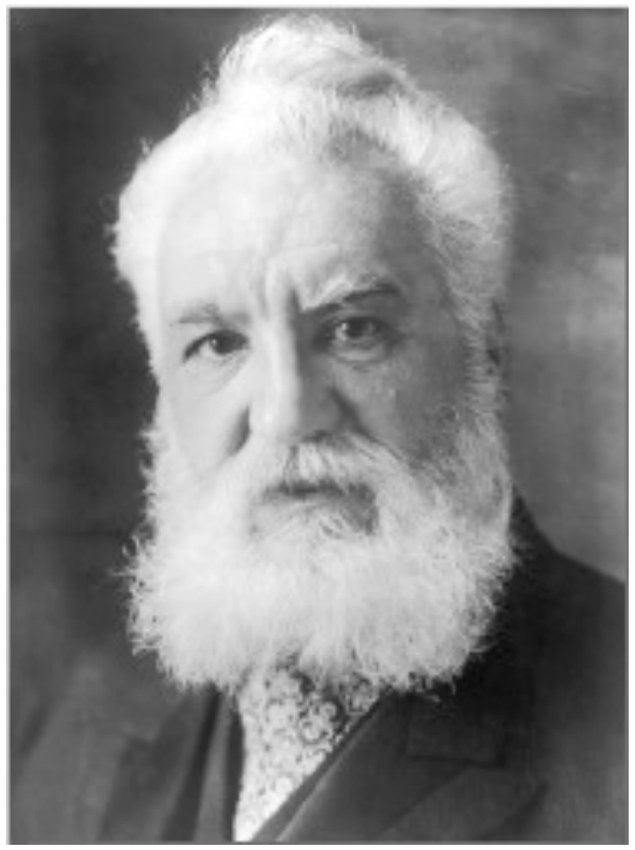
Source: AWEA



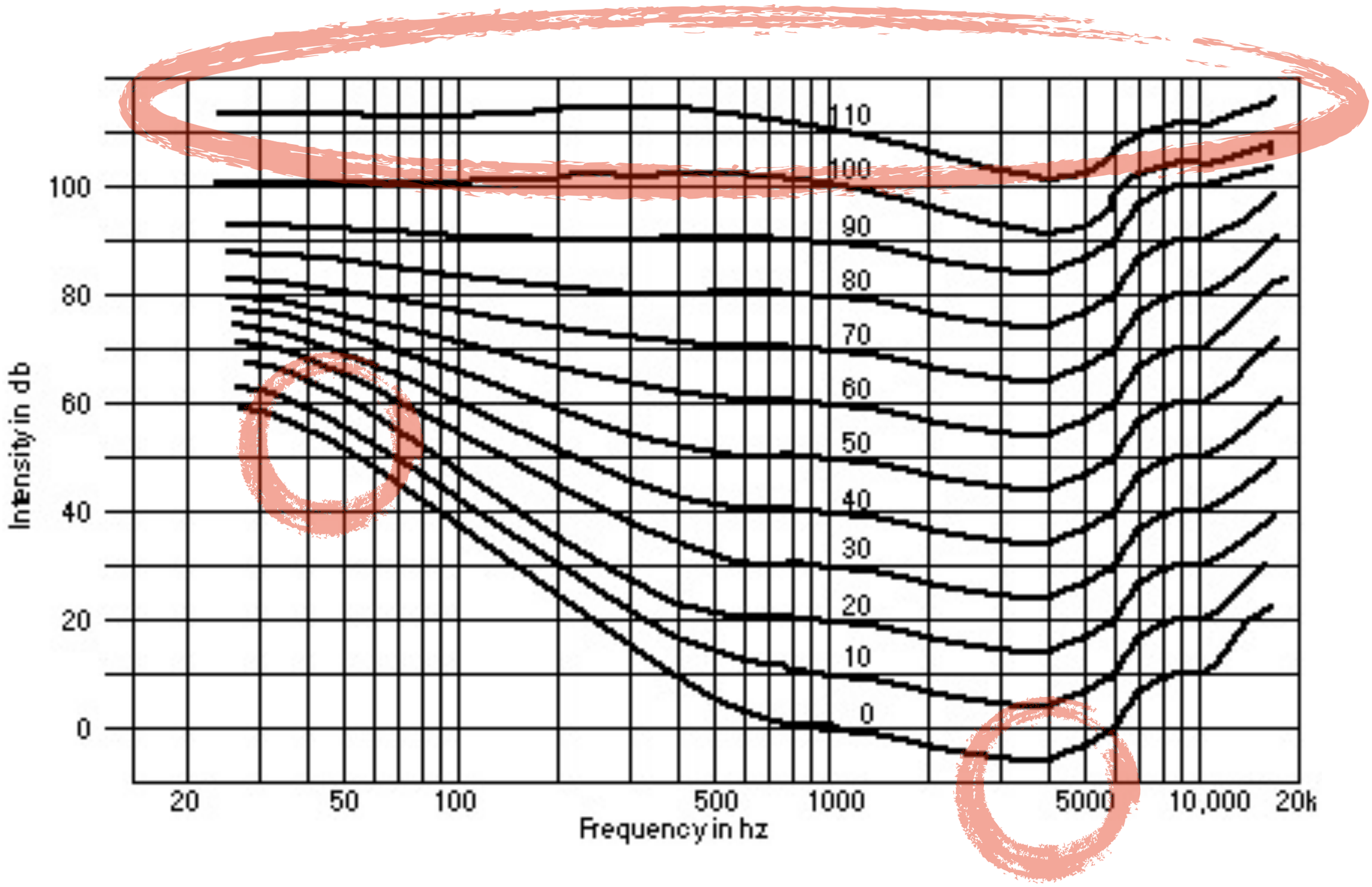
safe exposure

The decibel (db) is a measure of the relative intensity or power level of a signal.

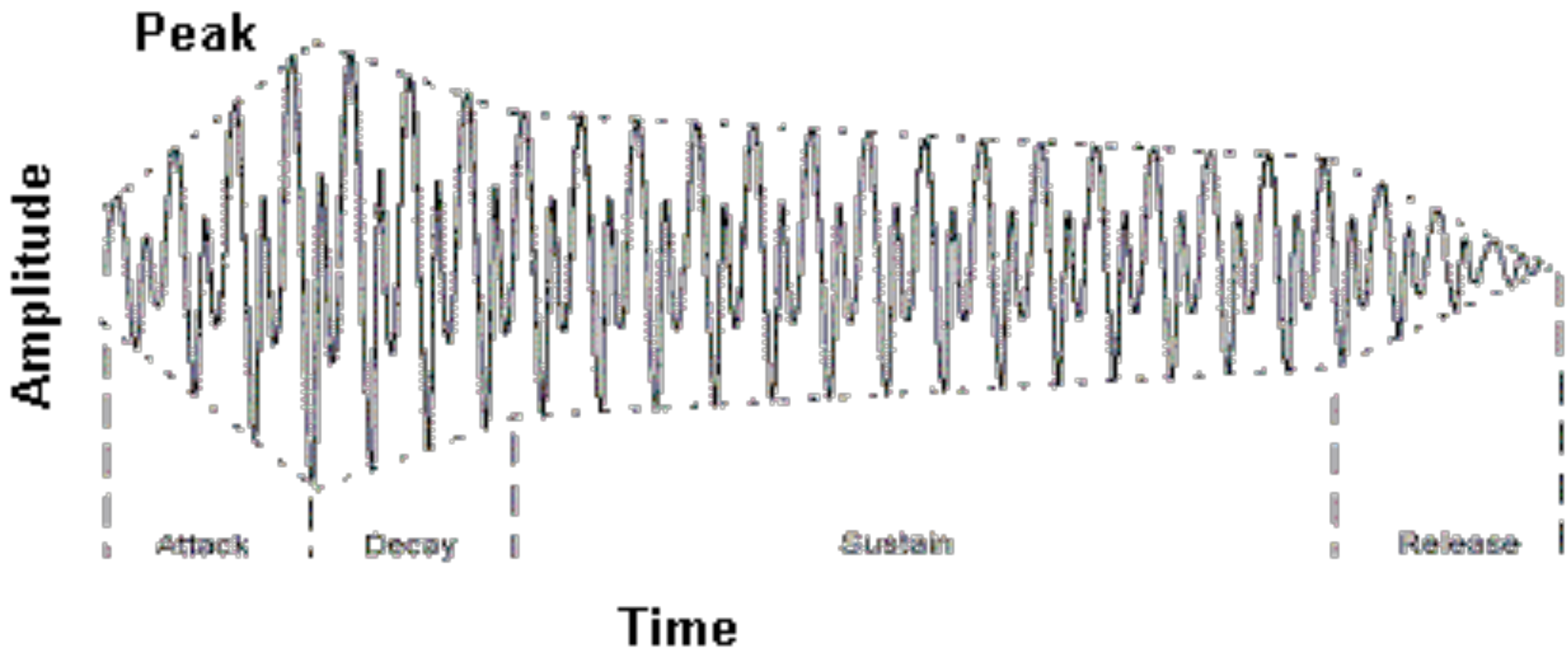
Alexander Graham Bell (bel)



http://www.sfu.ca/~gotfrit/ZAP_Sept.3_99/d/decibel.html



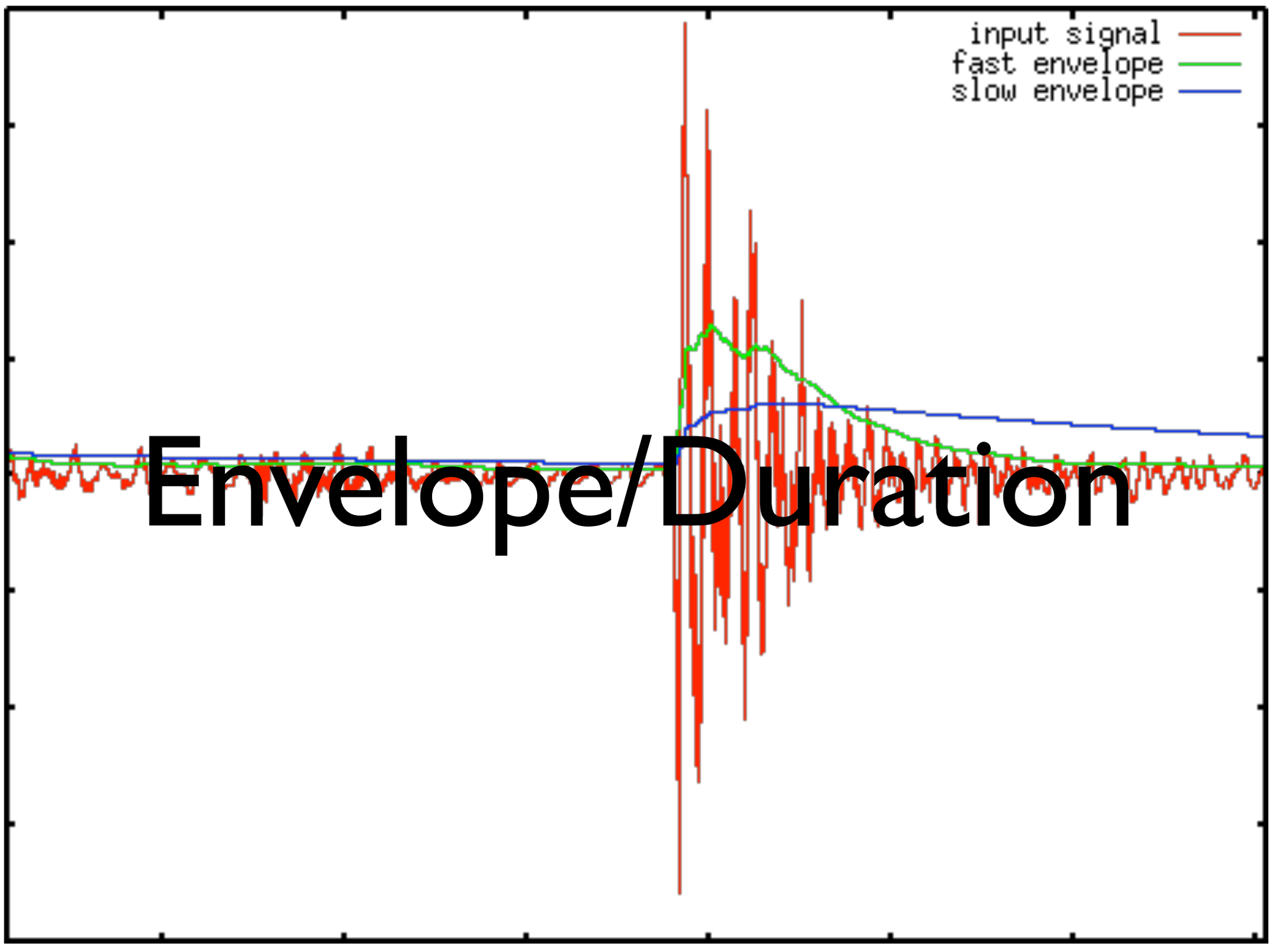
Amplitude and pitch perception are co-related - equal loudness contours & Fletcher Munson curve...



Envelope

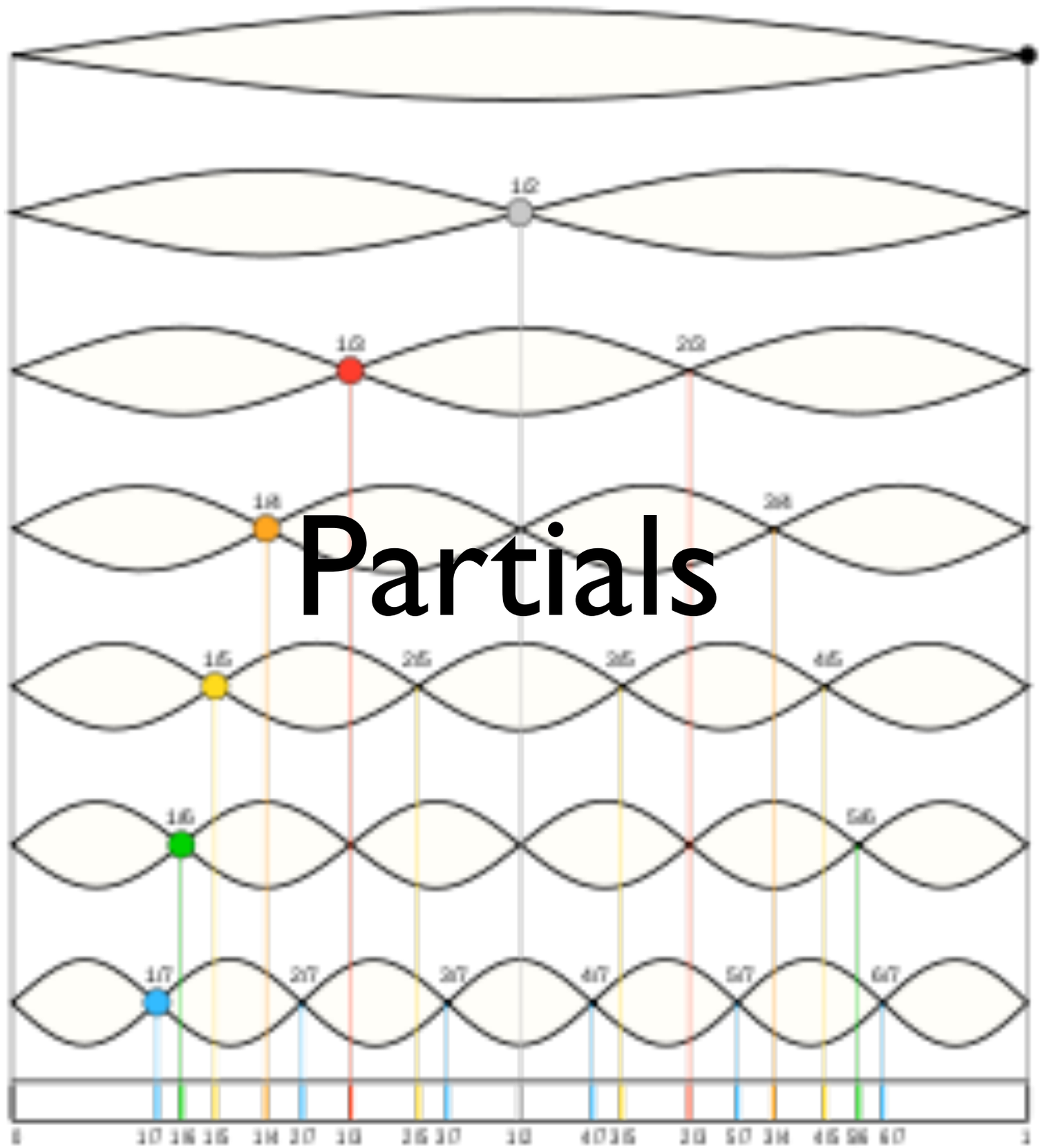
attack (including onset transients) (most energy & identifier), an initial decay, stationary state or sustain, final decay. Usually will contain internal dynamics. Greatest energy almost always at the attack. Need to overcome the inertia of the object which is to vibrate – also the most complex timbre is usually at this time.

Envelope/Duration



When the duration of an object is less than the time threshold required for pitch recognition it is heard as a "click". Perception of frequency = inverse of total duration in milliseconds.10 milliseconds = ±100hz, 40 ± 25hz

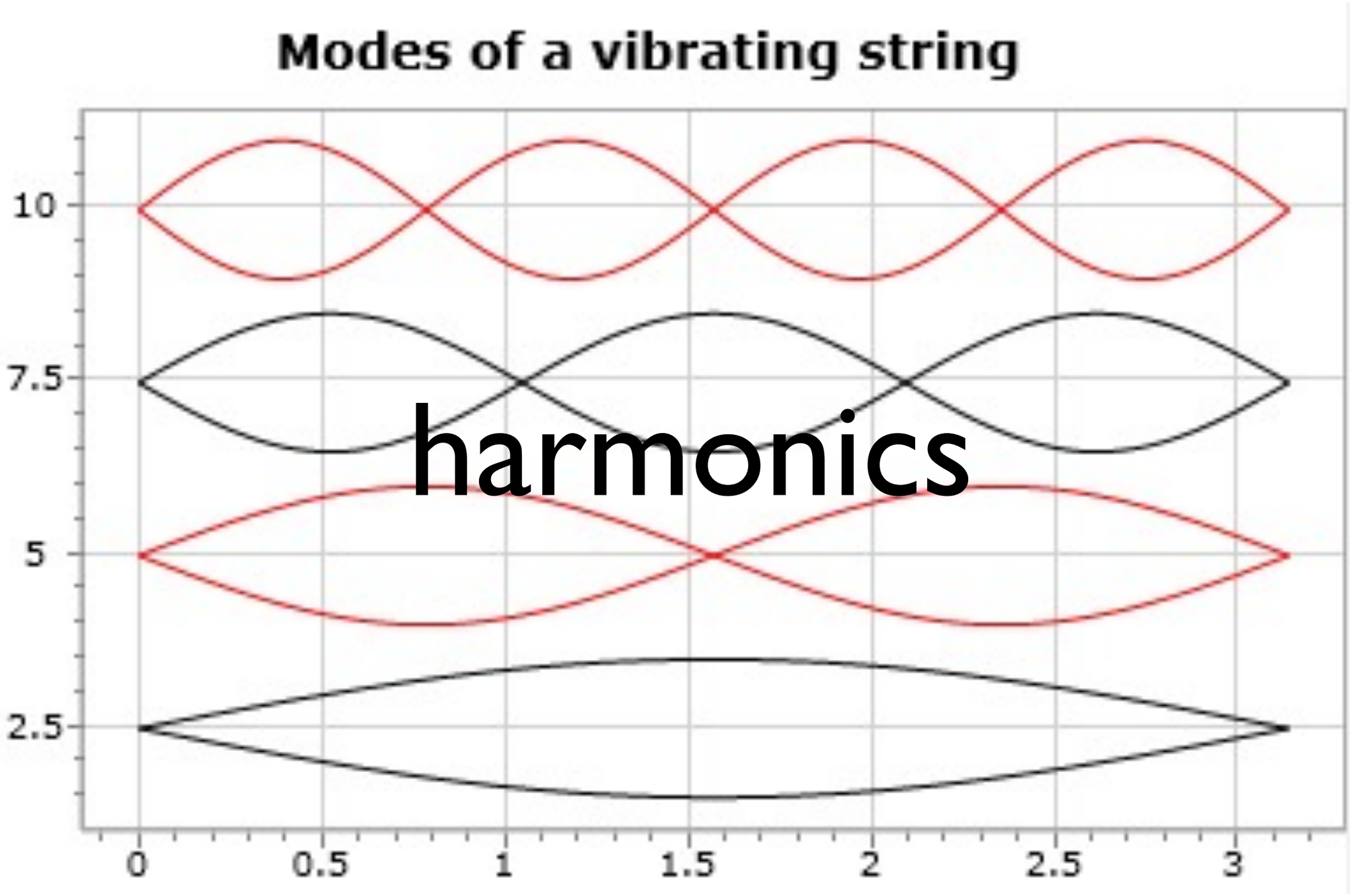
Timbre (the quality that differentiates a clarinet and violin playing exactly the same pitch). Can be called “colour”. A function of the dynamic envelope as well as the components that make up the complex sound of the individual “note”.



Any periodic sound (except for a sine wave) can be viewed as an amalgamation of sine waves of different frequencies, amplitudes, envelopes and phases. (Joseph Fourier). The components of a complex, periodic sound are called partials. Thus the combination of the various partials results in a complex waveform

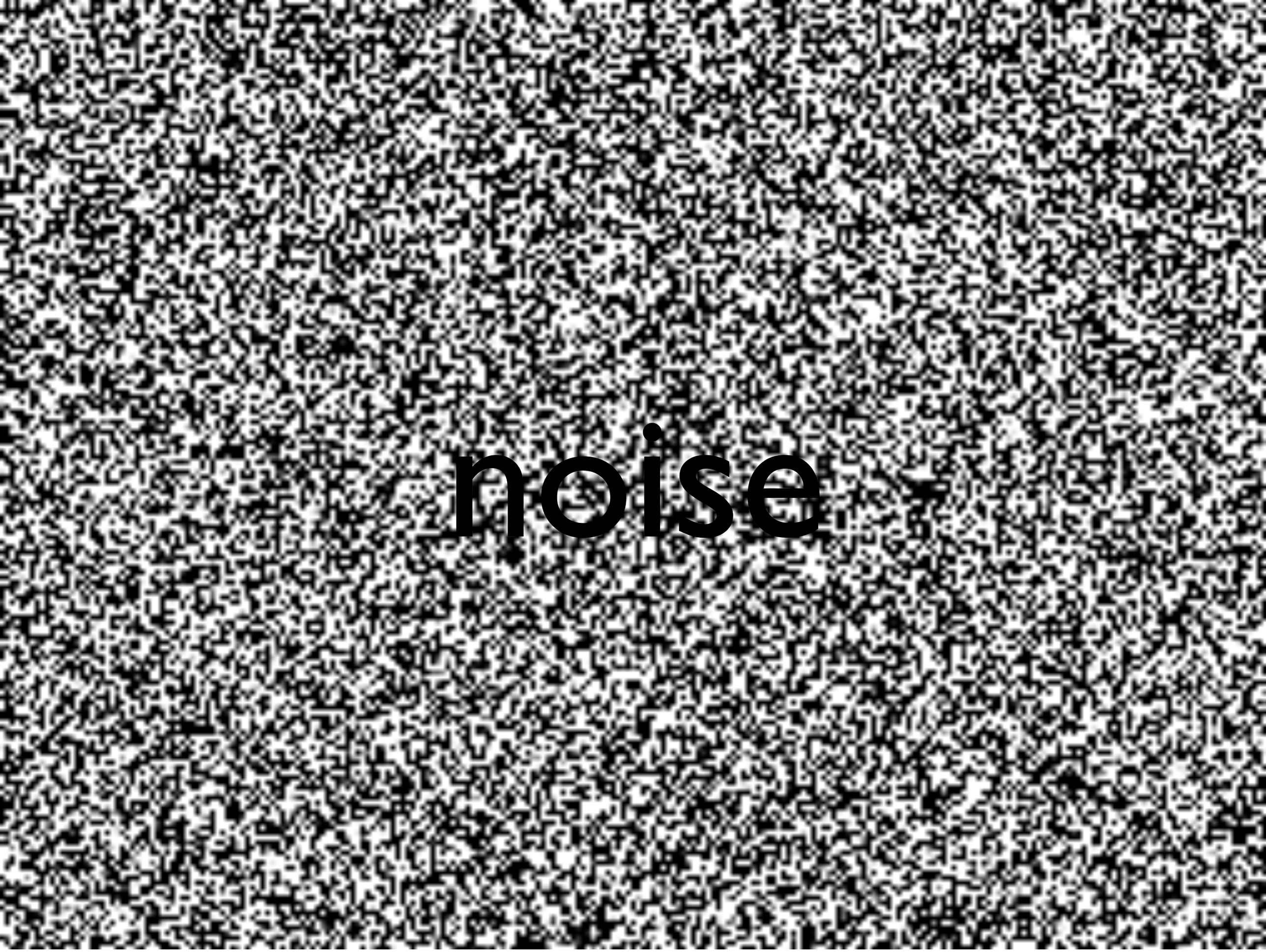
harmonic, inharmonic and noise-based sounds

Generally sounds which have an identifiable pitch are considered “harmonic” (see next slide) while those without an identifiable pitch are considered inharmonic or noise – depending on the amount of coherency of the various partials.
This presence and distribution of the partials (harmonic or inharmonic) and their onset, growth and decay in time = the distinct tonal quality of a sound we call timbre.



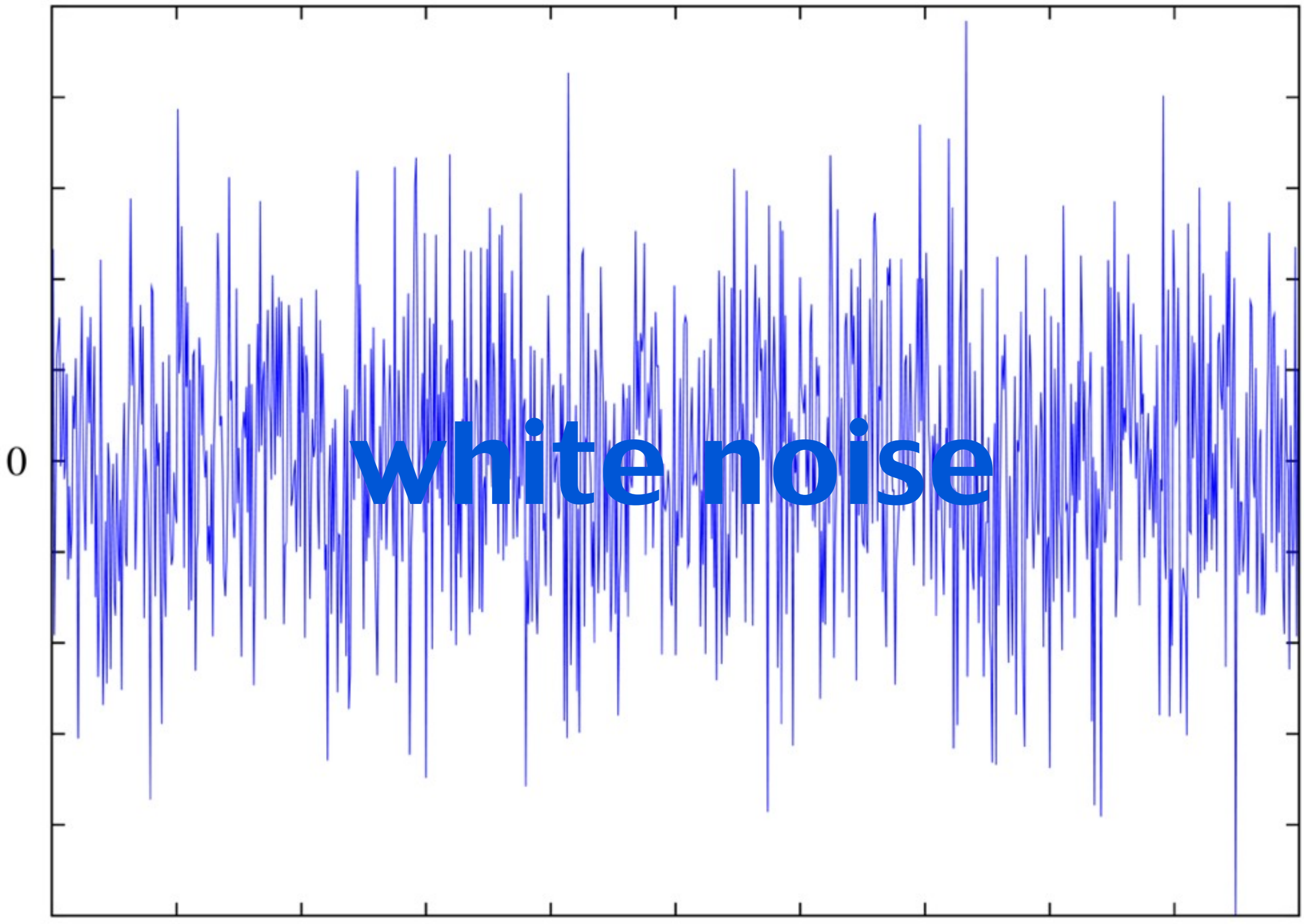
harmonics

In acoustics the term "harmonic" is a noun used to describe an overtone or partial whose frequency is an integer multiple of the fundamental frequency. Usually the lowest harmonic is perceived as the pitch. We call the fundamental the 1st harmonic. The 2nd harmonic is 2x the f. and is an octave higher, etc.

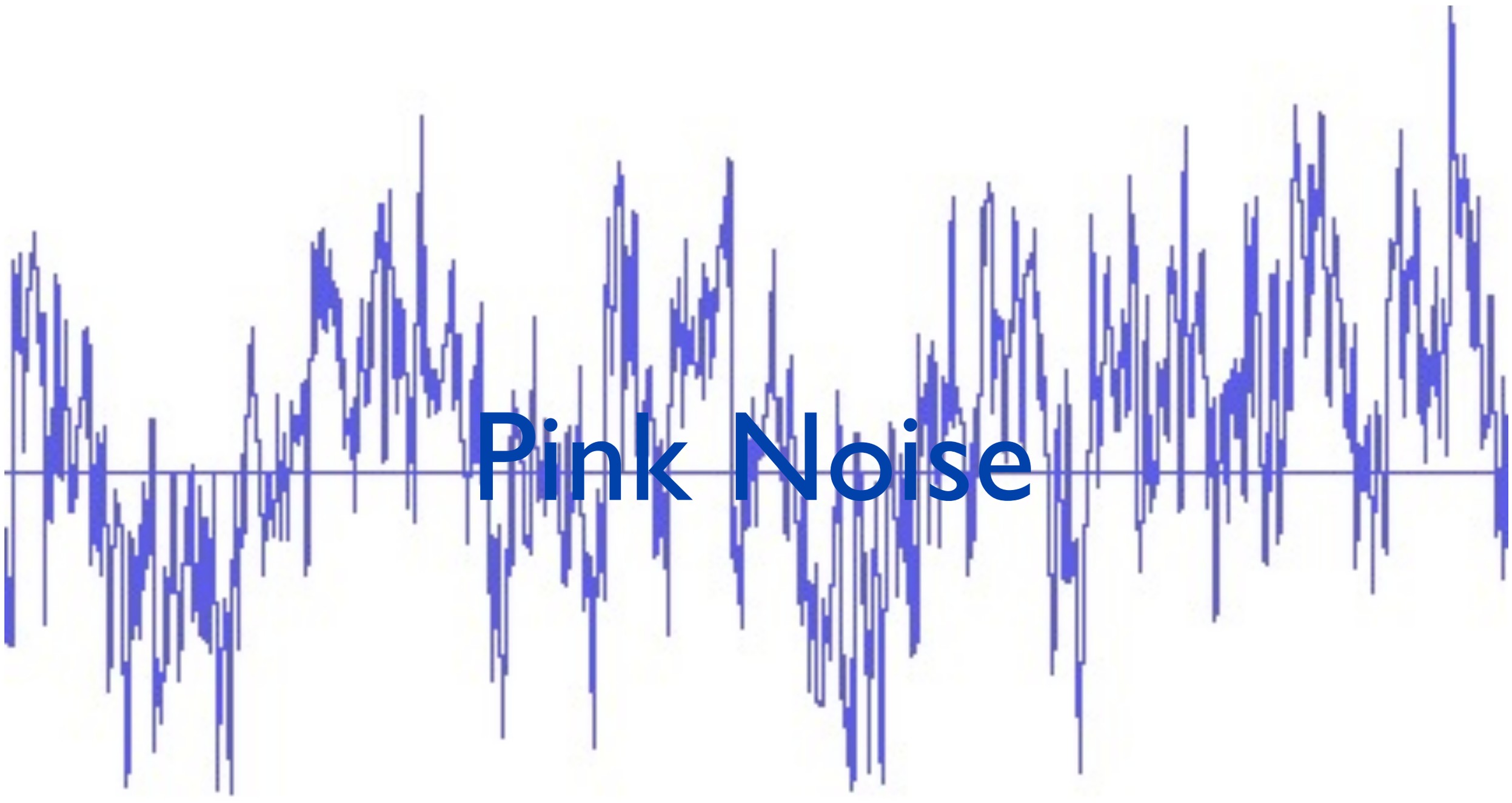


noise

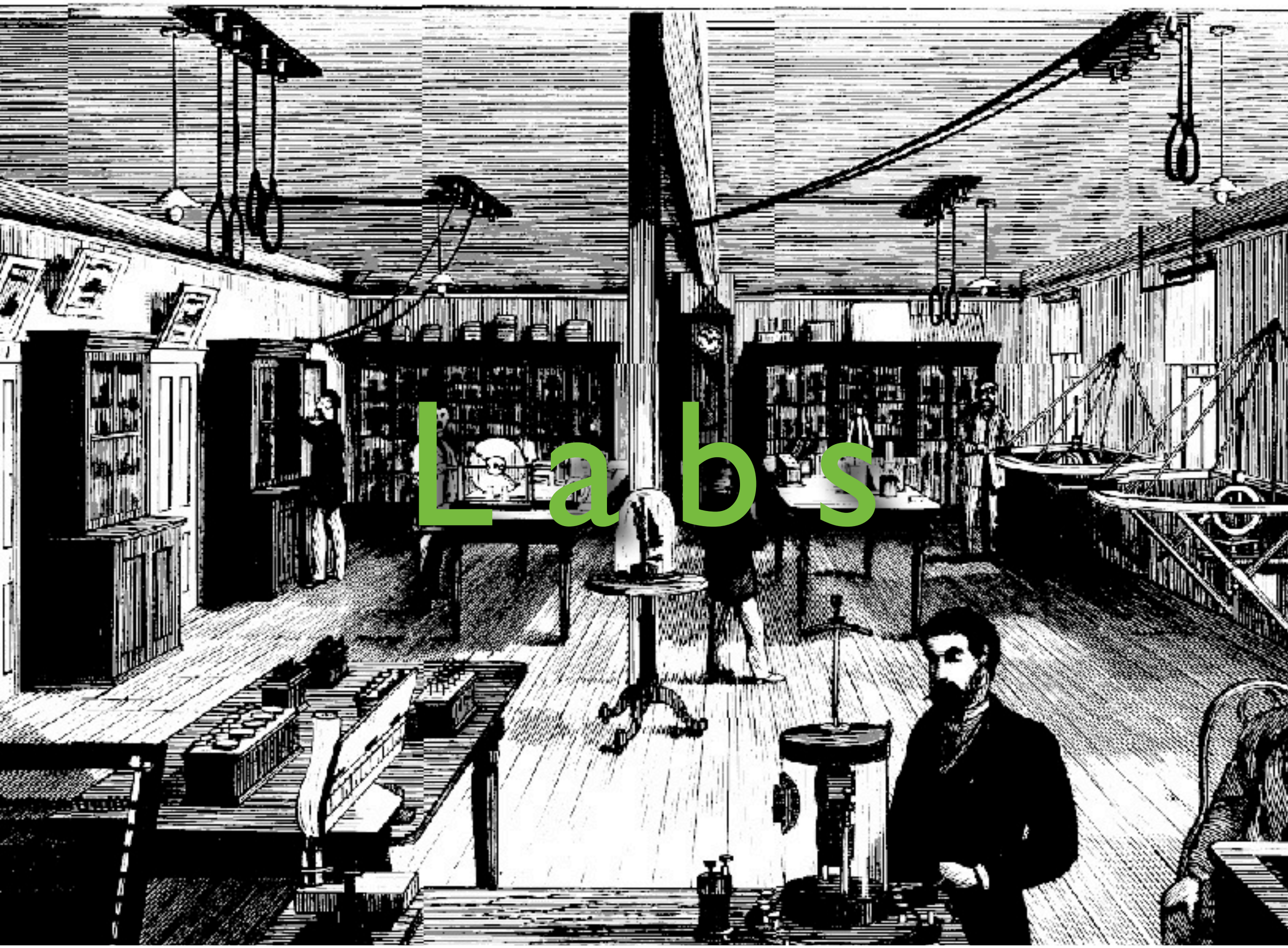
unwanted sound, unmusical sound, any overly loud sound, disturbance in a communication system. BROADBAND noise has its energy distributed over a large range of the audio spectrum (hiss, rumble, etc.) Examples from nature: wind, surf, rain, etc.



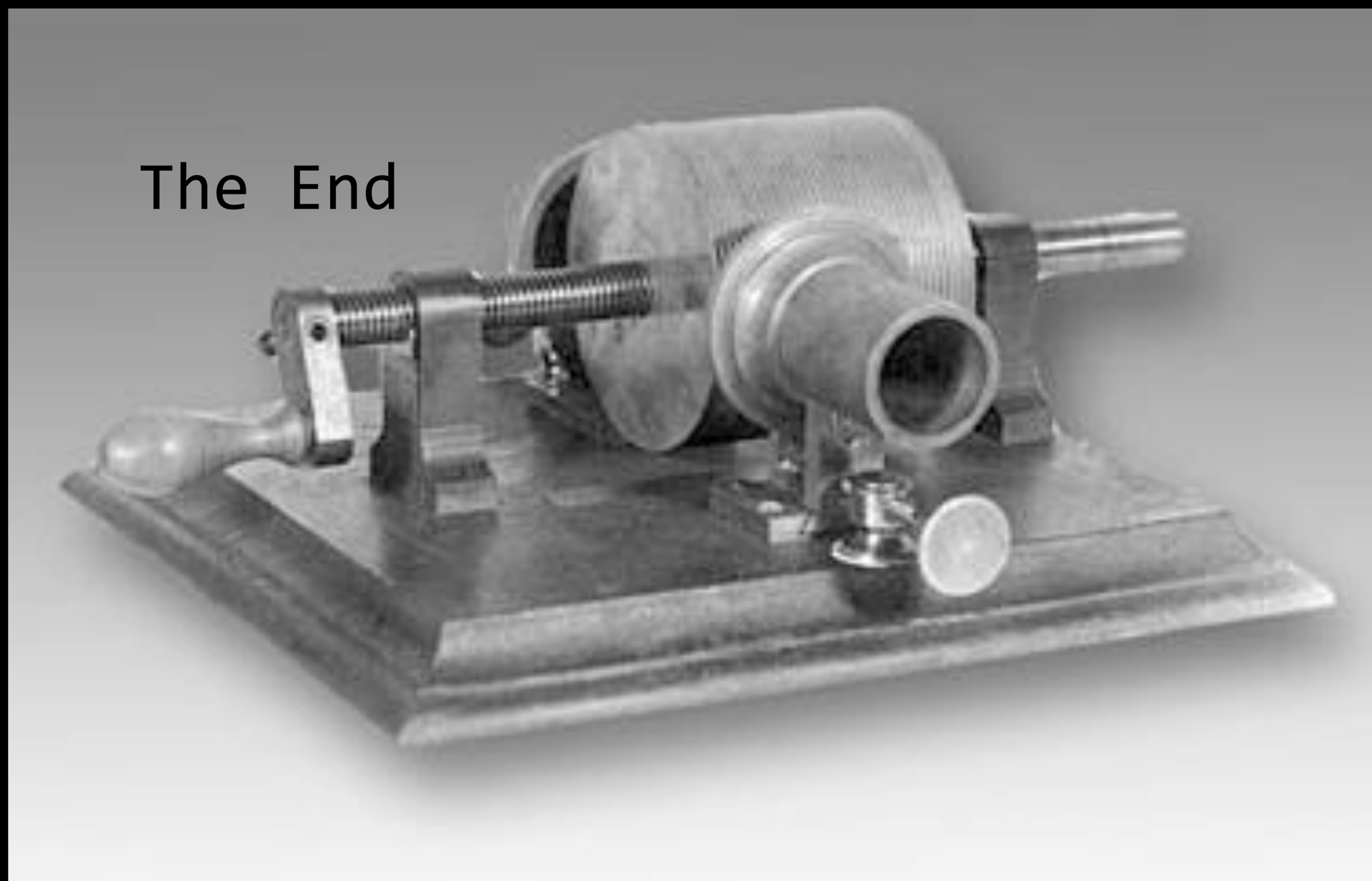
Random noise or audio rate voltage which has equal energy per Hertz in the 20 - 20,000 Hertz range. Rain, a shower, a waterfall, etc. are natural examples which resemble white noise. WHite noise tends to have a distinct high frequency colour to humans as half the energy is in the highest octave which we can perceive: 10,000-20,000 Hertz.



A type of noise with equal energy in each octave vs white noise which has its energy distributed throughout the frequency range of audio. Pink noise more closely approximates the frequency/energy distribution of conventional music.



Bring headphones! Good idea to have good ones! Thumb or other USB drive or access to personal web space... Labs will prepare you for the successful completion of the assignments. All of the iMacs have Logic which what we'll teach but you may use other applications if you prefer to work at home.


The End