

THE SCIENCE OF SOUND

Definition of sound

sound¹

sound/

noun

noun: **sound**; noun: **musical sound**; plural noun: **musical sounds**

1.1.

vibrations that travel through the air or another medium and can be heard when they reach a person's or animal's ear.

"light travels faster than sound"

- a thing that can be heard.

plural noun: **sounds**

"she heard the sound of voices in the hall"

- the area or distance within which something can be heard.

"we were always **within sound of** the train whistles"

2.2.

sound produced by continuous and regular vibrations, as opposed to noise.

- short for speech sound.

3.3.

music, speech, and sound effects when recorded, used to accompany a film or video production, or broadcast.

"a sound studio"

- broadcasting by radio as distinct from television.
- the distinctive quality of the music of a particular composer or performer or of the sound produced by a particular musical instrument.

"the sound of the Beatles"

- informal*

music, especially popular music.

plural noun: **sounds**

"sounds of the sixties"

Origin

Middle English *soun*, from Anglo-Norman French *soun* (noun), *suner* (verb), from Latin *sonus*. The form with *-d* was established in the 16th cent.

Sound waves

When sound travels through a medium (gas, liquid, or solid), it travels in “waves” – a compression (increased pressure) and rarefaction (decreased pressure) of particles, producing a waveform.

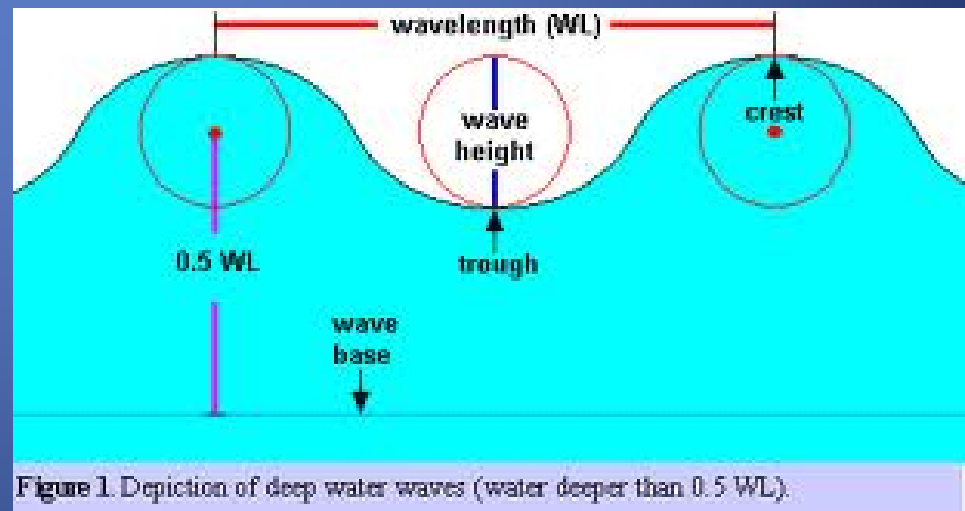
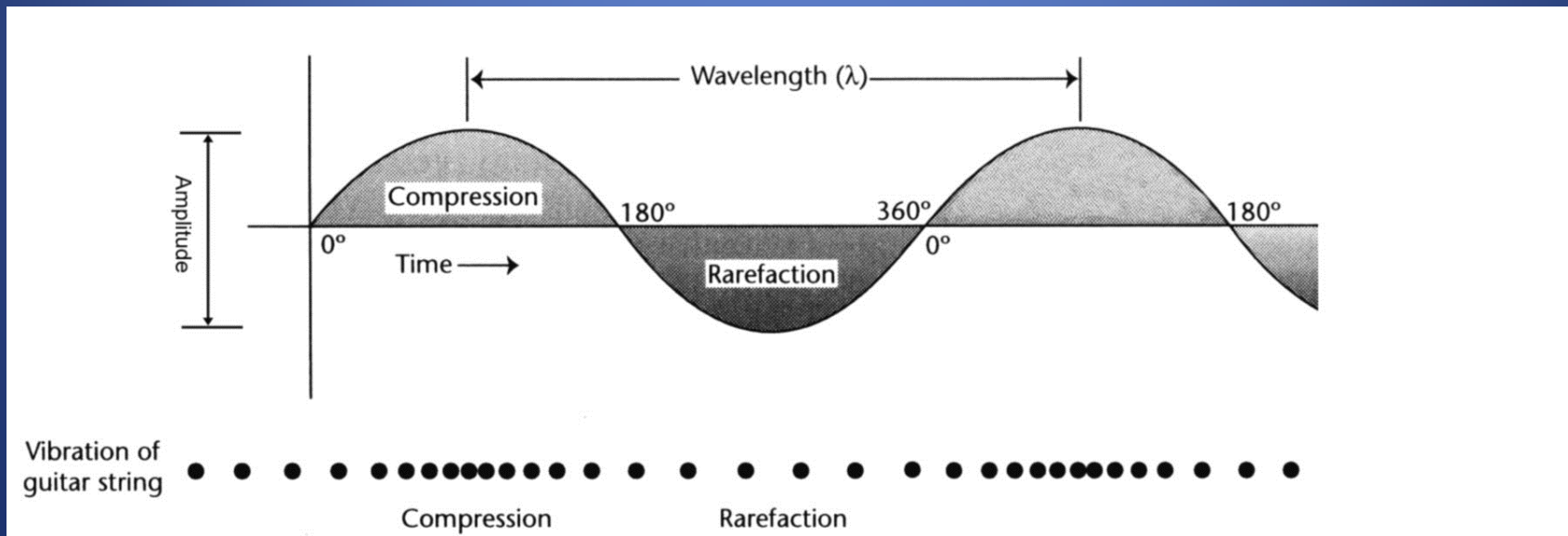


Figure 1. Depiction of deep water waves (water deeper than 0.5 WL).

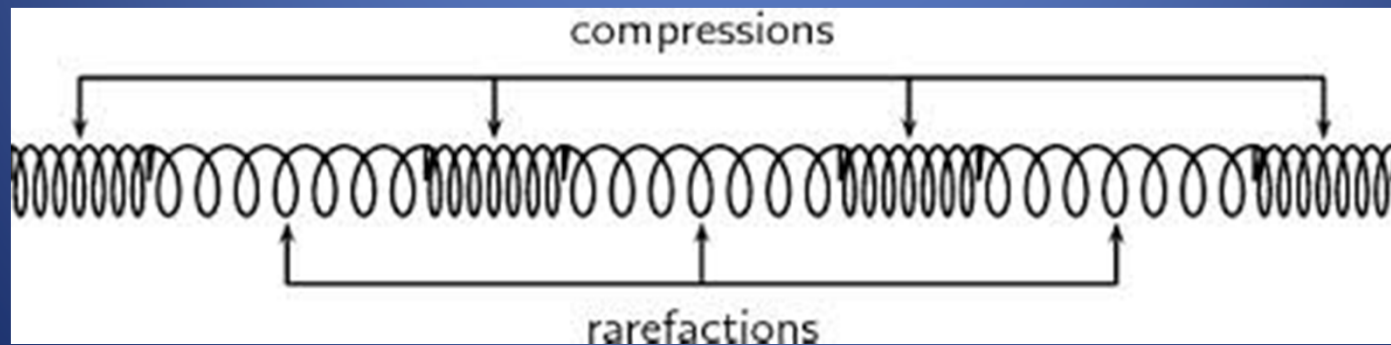
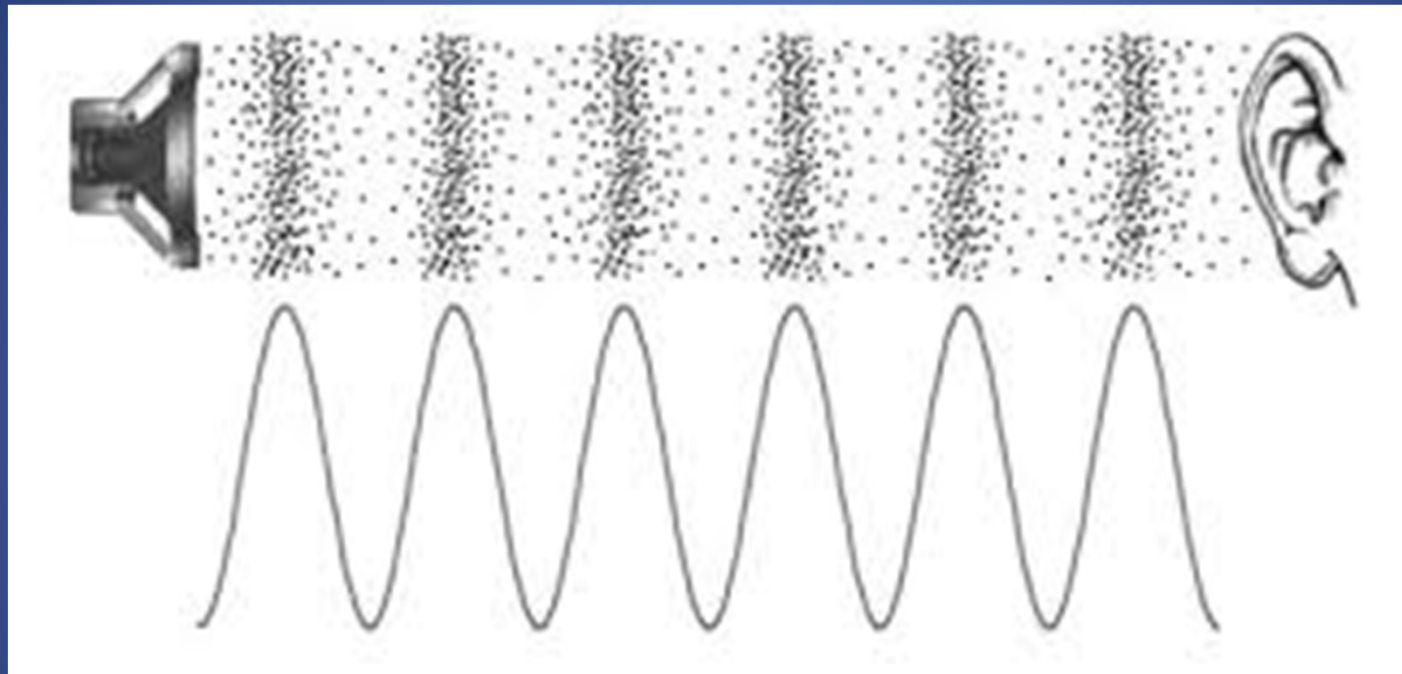
Compression and Rarefaction

Compression - increased pressure

Rarefaction - decreased pressure

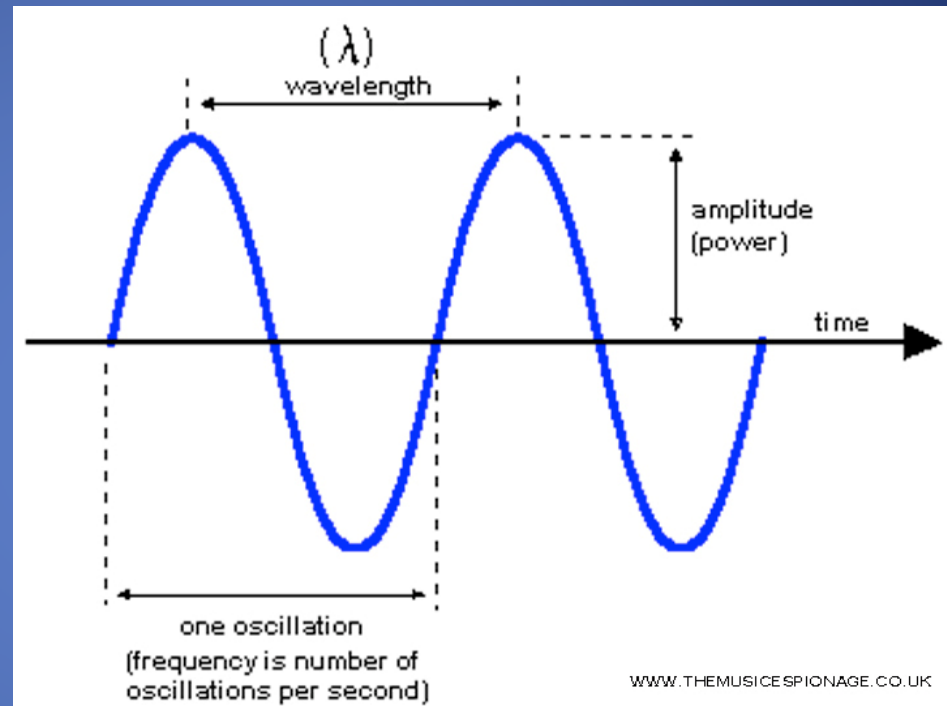


Compression and Rarefaction



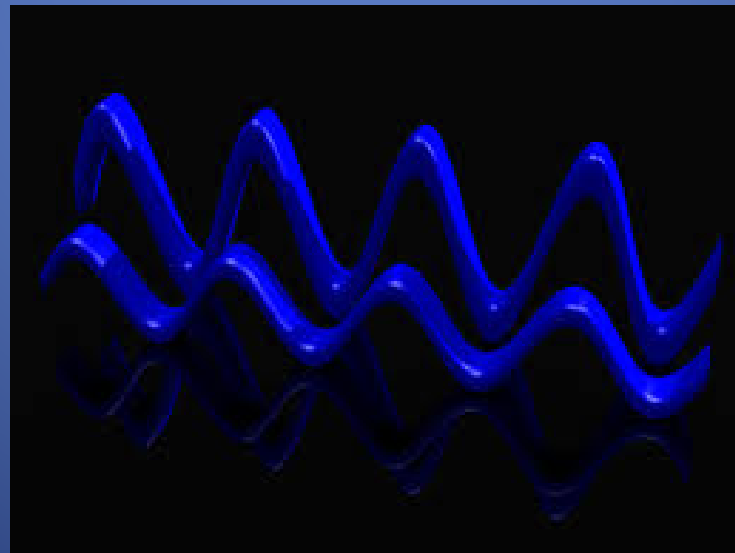
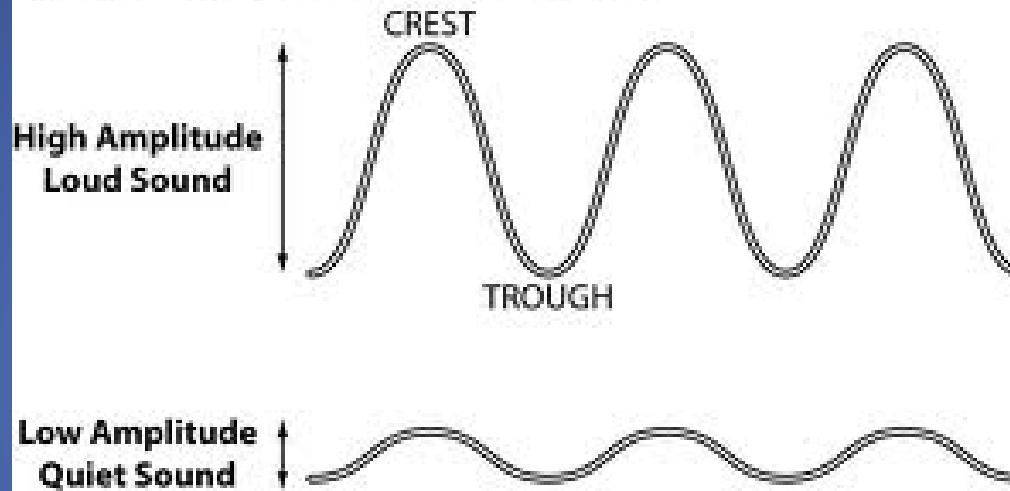
Amplitude

Amplitude – the maximum height of a sound wave



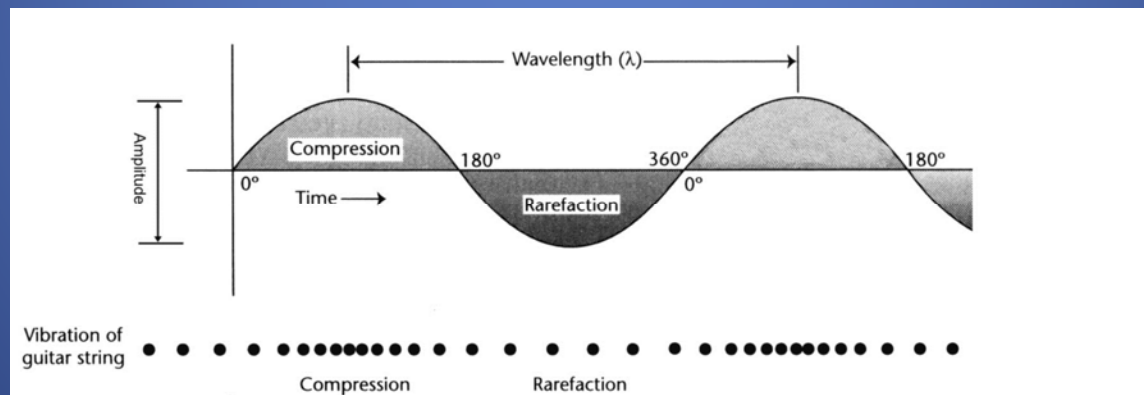
Amplitude

Amplitude of Sound Waves



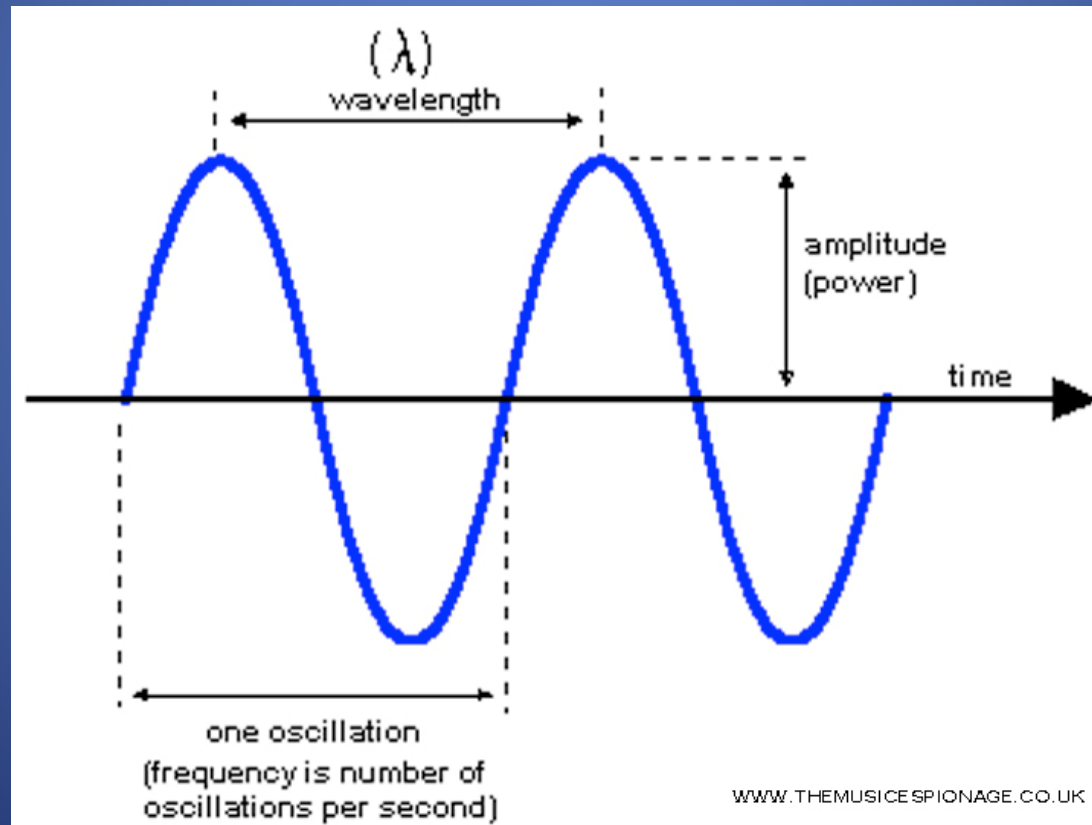
Wavelength

Wavelength – measurement of the distance (time) from one wave to the same part of the next wave (crest to crest, trough to trough)...



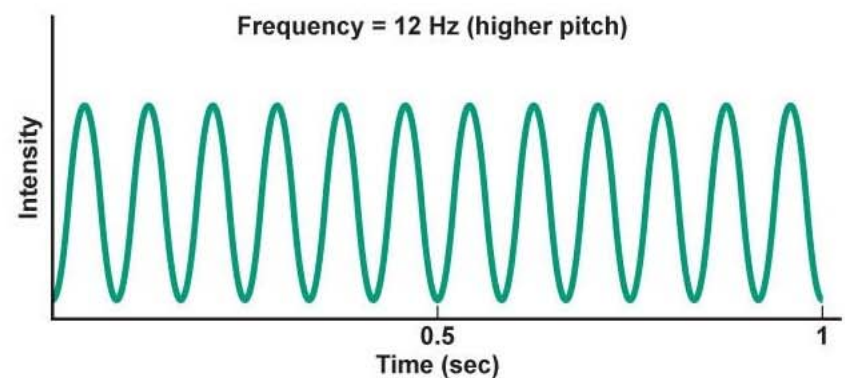
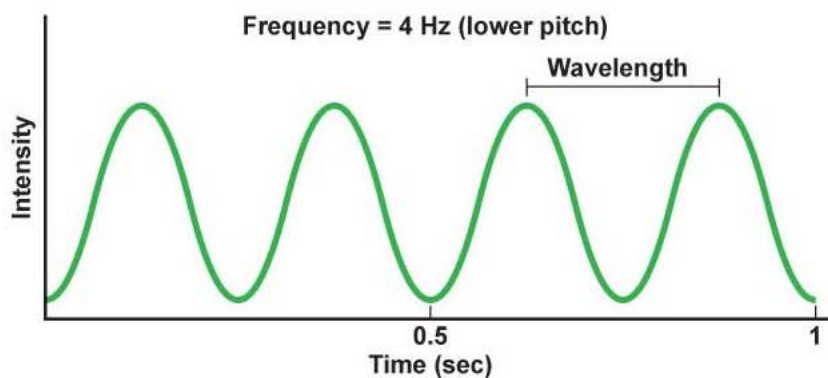
Wavelength

....OR a single oscillation



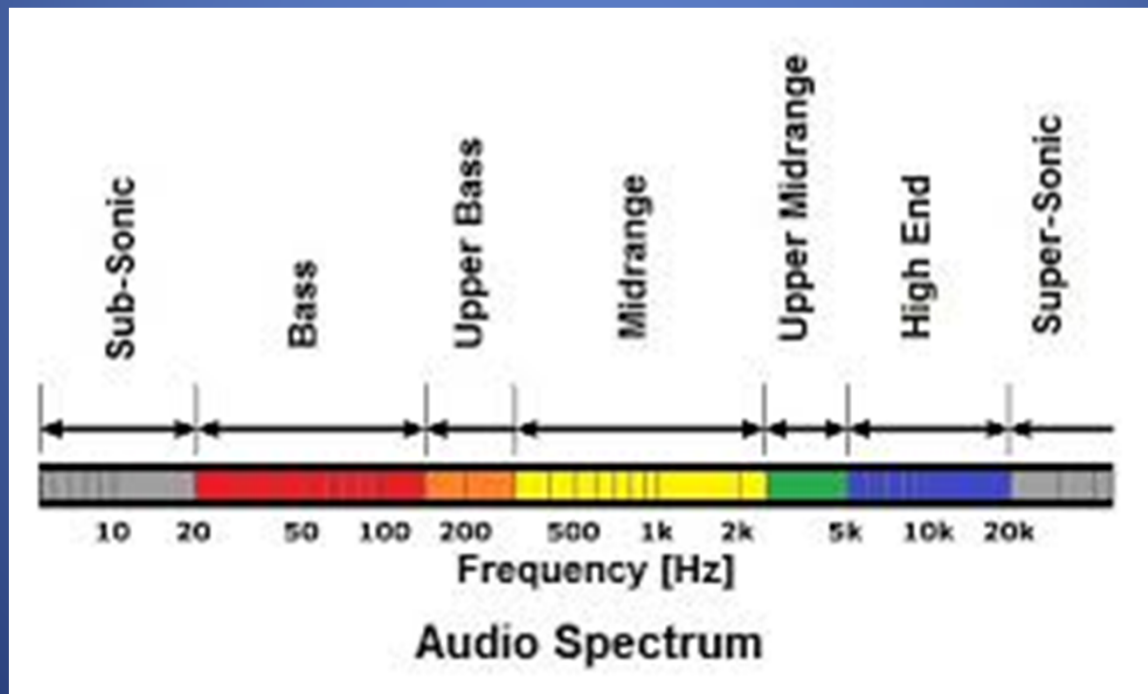
Frequency

Frequency is the number of waves (oscillations) that occur within a certain amount of time (second). The measurement unit “Hertz” (abbreviated hz) is defined as oscillations per second. E.g. 440hz – 440 oscillations/second



Frequency

The normal human ear can detect frequency ranges from 20hz to 20,000hz.



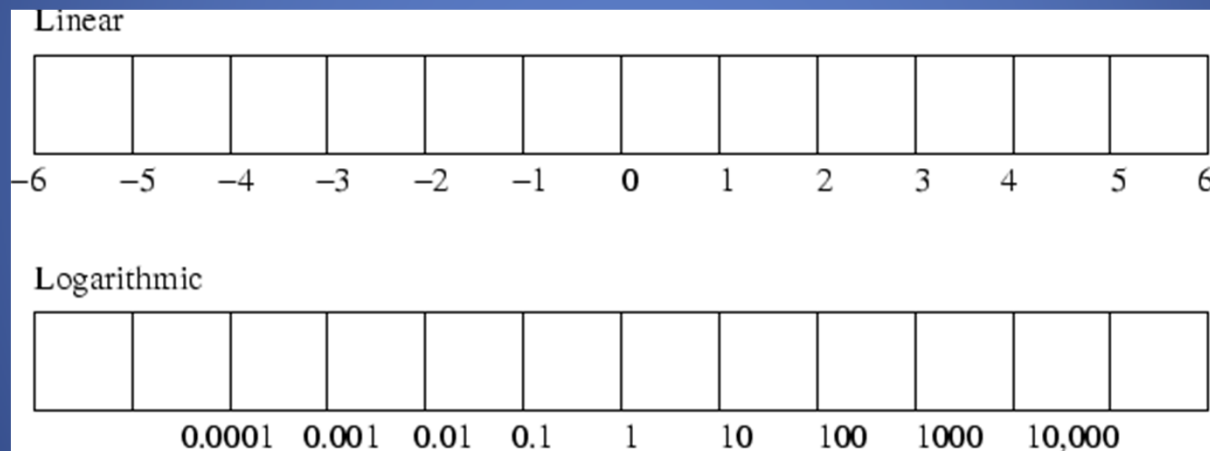
Decibels

The **decibel (dB)** is a measurement unit used to express the ratio between two values of a physical quantity, often power ratio and amplitude ratio.

dB	power ratio	amplitude ratio
100	10 000 000 000	100 000
90	1 000 000 000	31 620
80	100 000 000	10 000
70	10 000 000	3 162
60	1 000 000	1 000
50	100 000	316.2
40	10 000	100
30	1 000	31.62
20	100	10
10	10	3.162
3	1.995	1.413
1	1.259	1.122
0	1	1
-10	0.1	0.316 2
-20	0.01	0.1
-30	0.001	0.031 62
-40	0.000 1	0.01
-50	0.000 01	0.003 162
-60	0.000 001	0.001
-70	0.000 000 1	0.000 316 2
-80	0.000 000 01	0.000 1
-90	0.000 000 001	0.000 031 62
-100	0.000 000 000 1	0.000 01

Decibels

The decibel scale is a logarithmic scale, not a linear scale.



$$1 \text{ dB} = \frac{1}{20 \log_{10} e} \text{ Np} \approx 0.115129254 \text{ Np}$$

Decibels

The decibel scale is a logarithmic scale, not a linear scale. Similar to the Richter earthquake rating scale, small numbers represent enormous changes.

The decibel (dB) scale is a logarithmic scale, not a linear scale

83 If the noise source is doubled

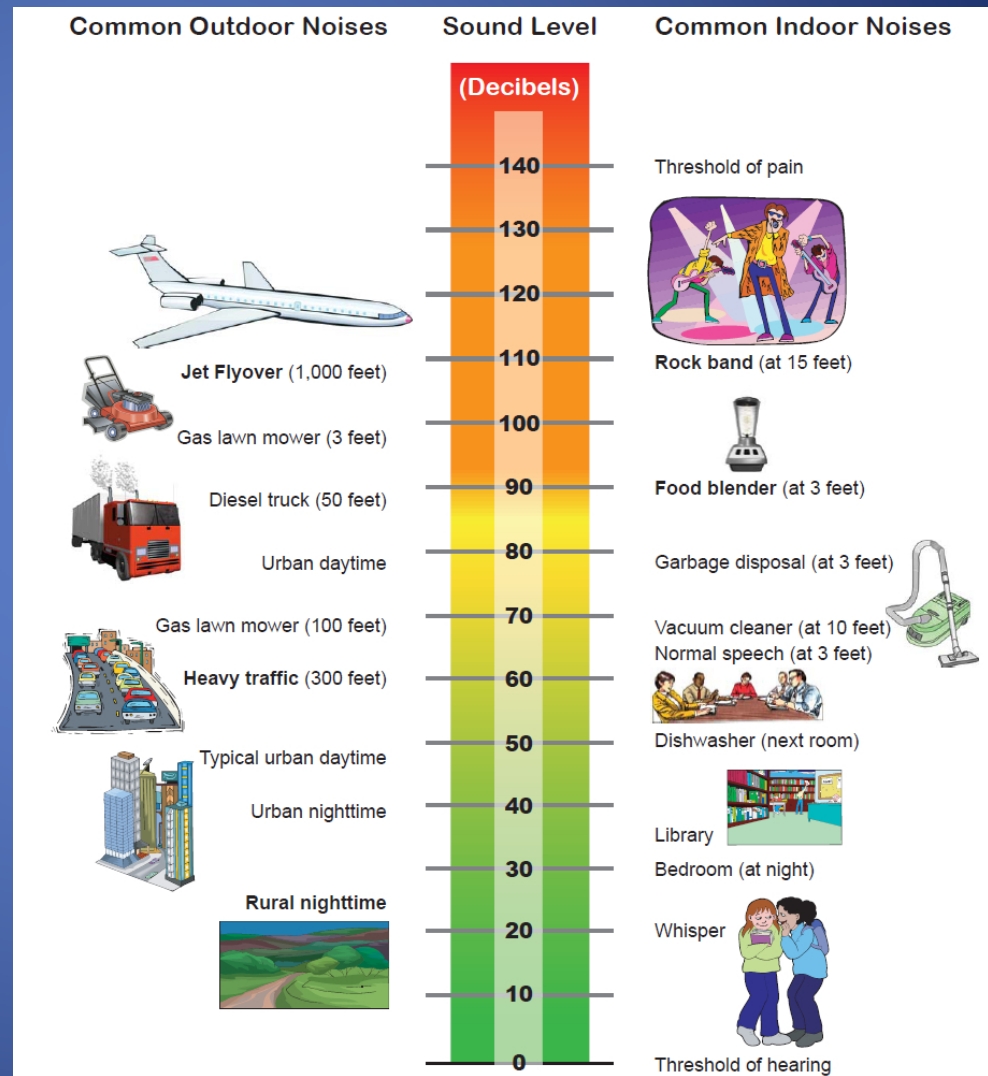
86 The noise level only

89
Small
increases
in decibel
level

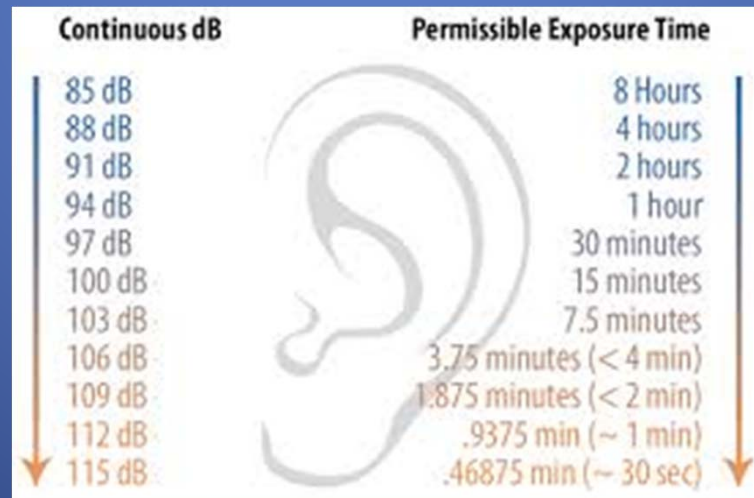
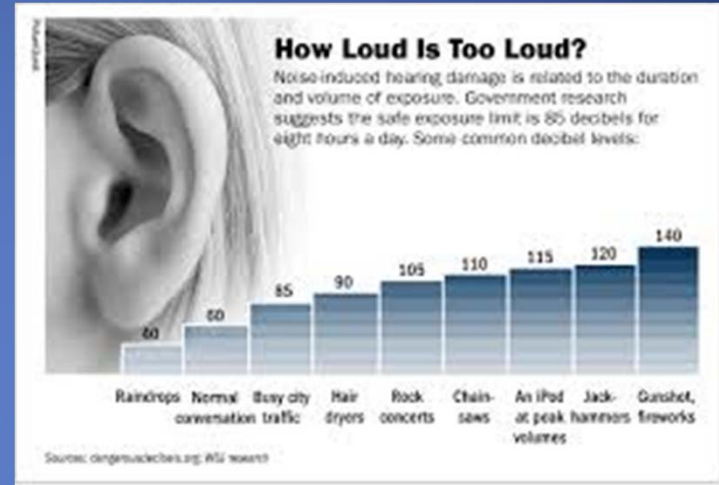
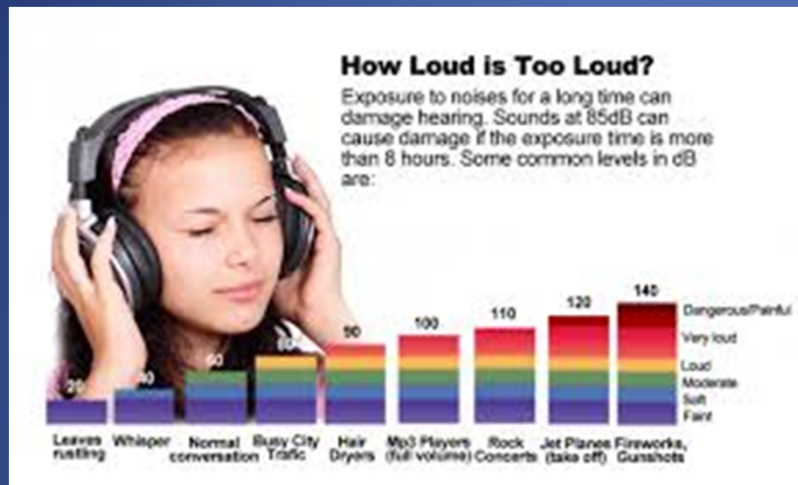
92
Represent enormous
increases in noise level
and risk

Decibels

The human ear has its limitations – protect your hearing by understanding how much is too much.

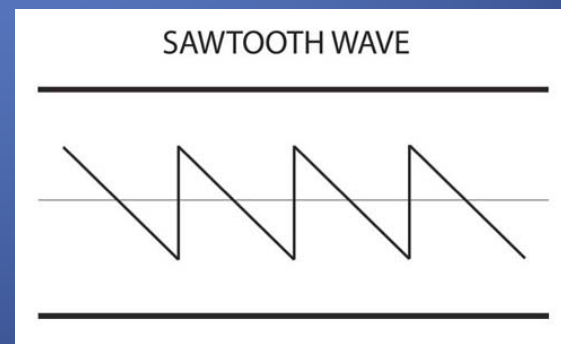
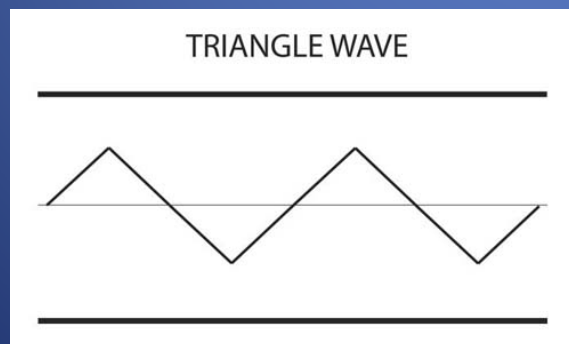
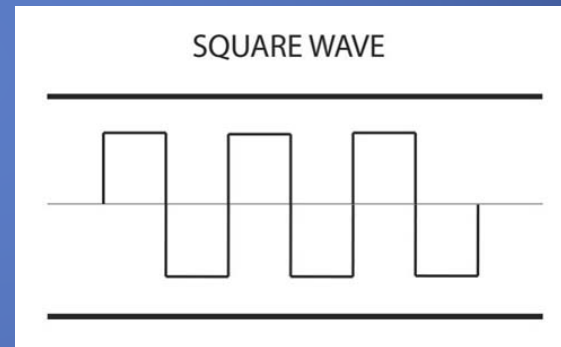
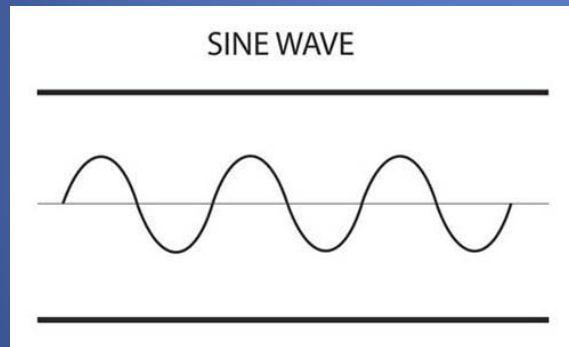


Decibels



Waveforms

Sound waves can take on different shapes due to their attack (shape of compression) and release (shape of rarefaction).



Waveforms

Each waveform has its own distinct sound. Early in electronic music, waveforms were the basis for constructing different types of sounds on computers, synthesizers, and other devices.

Waveforms

Composers begin using recorded playback with live performance as early as 1907....

Edgard Varese – Poeme Electronique



....and as recently as today's pop music.

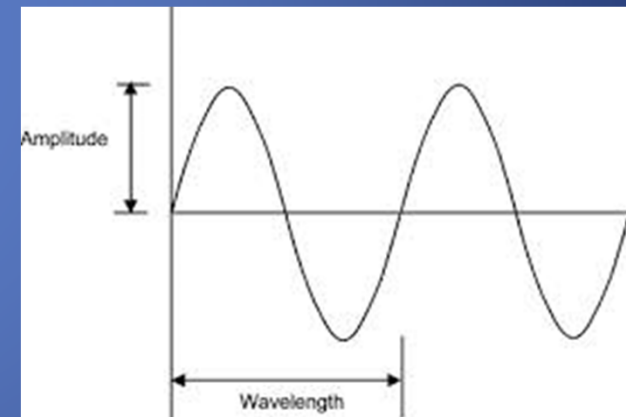
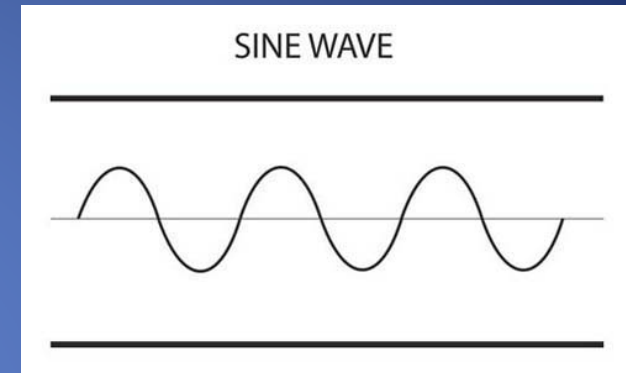
Imagine Dragons - Radioactive (Synchronice Dubstep Remix)



Sine Wave

noun: **sine wave**

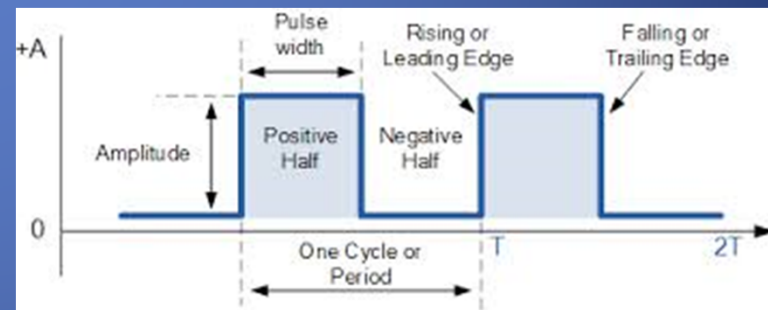
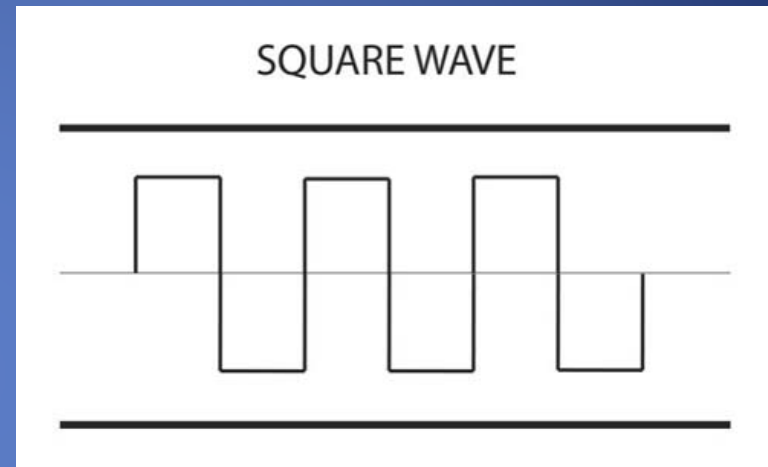
a curve representing periodic oscillations of constant amplitude as given by a sine function.



Square Wave

noun: **square wave**; plural noun: **square waves**

a periodic wave that varies abruptly in amplitude between two fixed values, spending equal times at each.



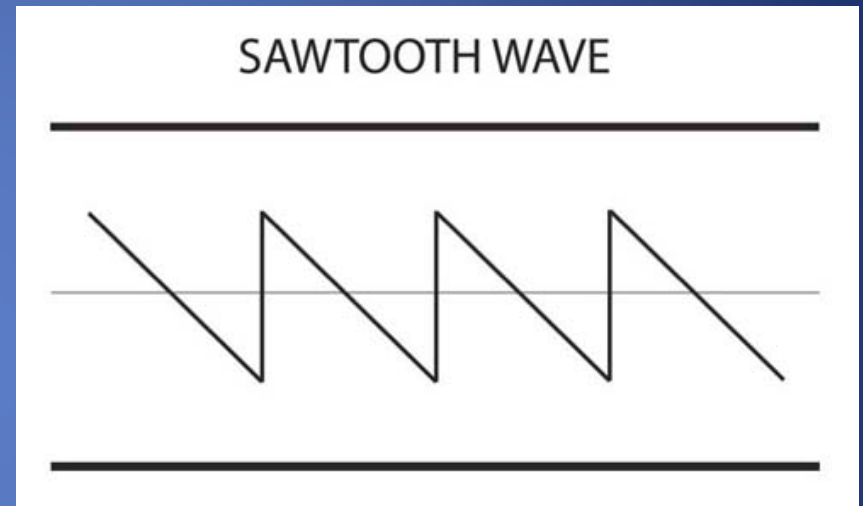
Sawtooth Wave

Noun

a periodic wave that varies in amplitude between two fixed values, gradually changing between the two.

It is so named based on its resemblance to the teeth of a saw.

The convention is that a sawtooth wave ramps upward and then sharply drops.



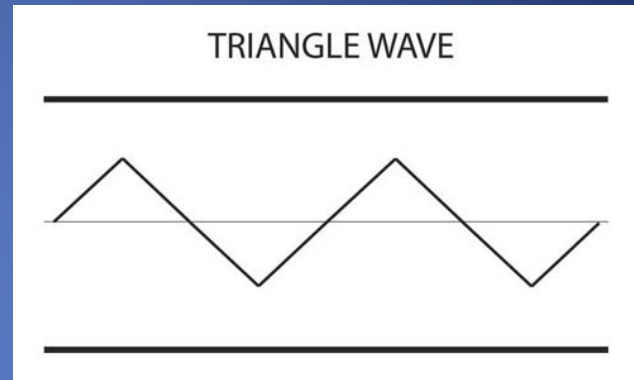
Triangle Wave

Noun

a periodic wave that varies in amplitude between two fixed values, gradually changing between the two.

It is so named based on its resemblance to a triangular shape.

Unlike the sawtooth wave, the triangle wave gradually changes both up and down, instead of the quick ramp (upward motion) of the sawtooth wave.

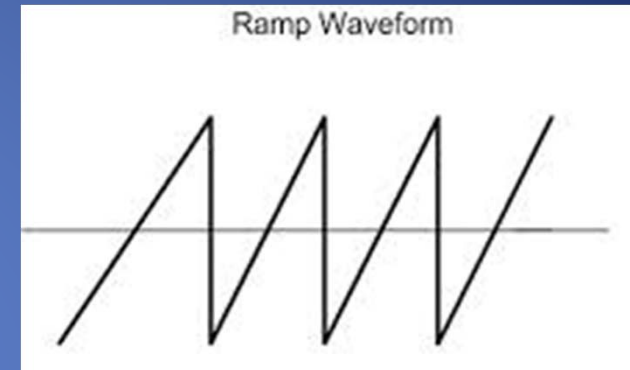


Ramp (Reverse Sawtooth) Wave

Noun

a periodic wave that varies in amplitude between two fixed values, gradually changing between the two.

However, as opposed to a sawtooth wave, a ramp wave (sometimes called a "reverse (or inverse) sawtooth wave", the wave ramps downward and then sharply rises.



White Noise

White noise is a sound that contains every frequency within the range of human hearing (generally from 20 hertz to 20 kHz) in equal amounts.



Pink Noise

Pink noise is random noise having equal energy per octave, and so having more low-frequency components than white noise.



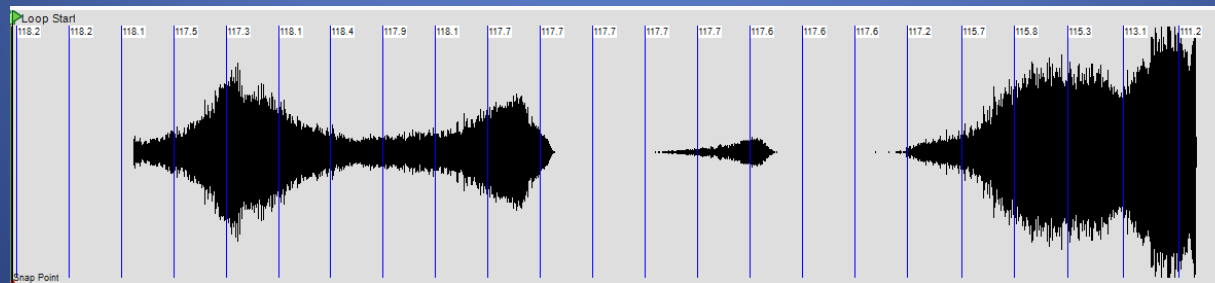
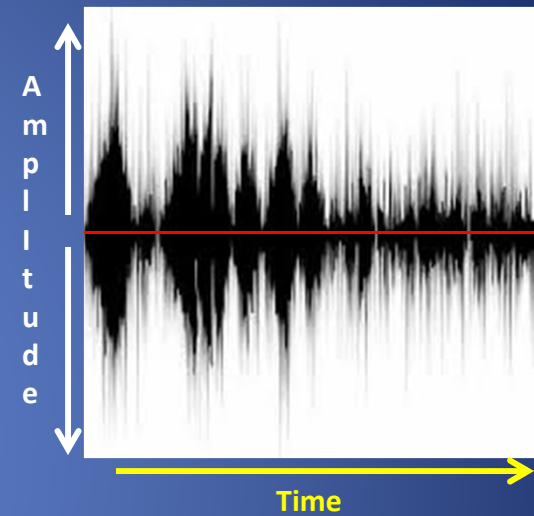
Brown Noise

Brown noise is a random signal that has been filtered in order to generate a lot of energy at low frequencies. Its power density is inversely proportional to f^2 and decreases by 6 dB per octave.



Sound Wave

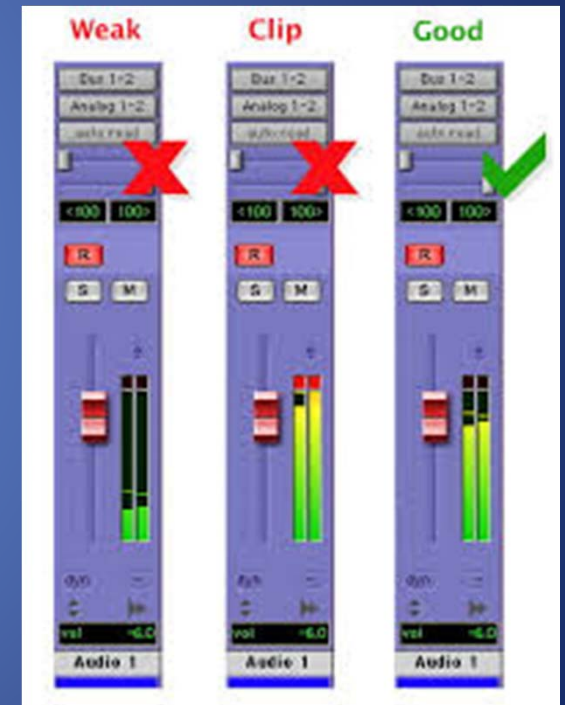
The depiction of a sound wave (see figure to the right) is a visual representation of a recorded wave file with regard to its amplitude (volume) over time.



The Relation to DAW Software

Gain/Fader Volume

Gain and fader volume directly relate to loudness (amplitude, decibels). Recording/playback volume will be displayed on meters. They are usually colored green (safe), yellow (caution) and red (overload – known as “clip”). A clip will distort the sound. A good recording volume will be between green and yellow.

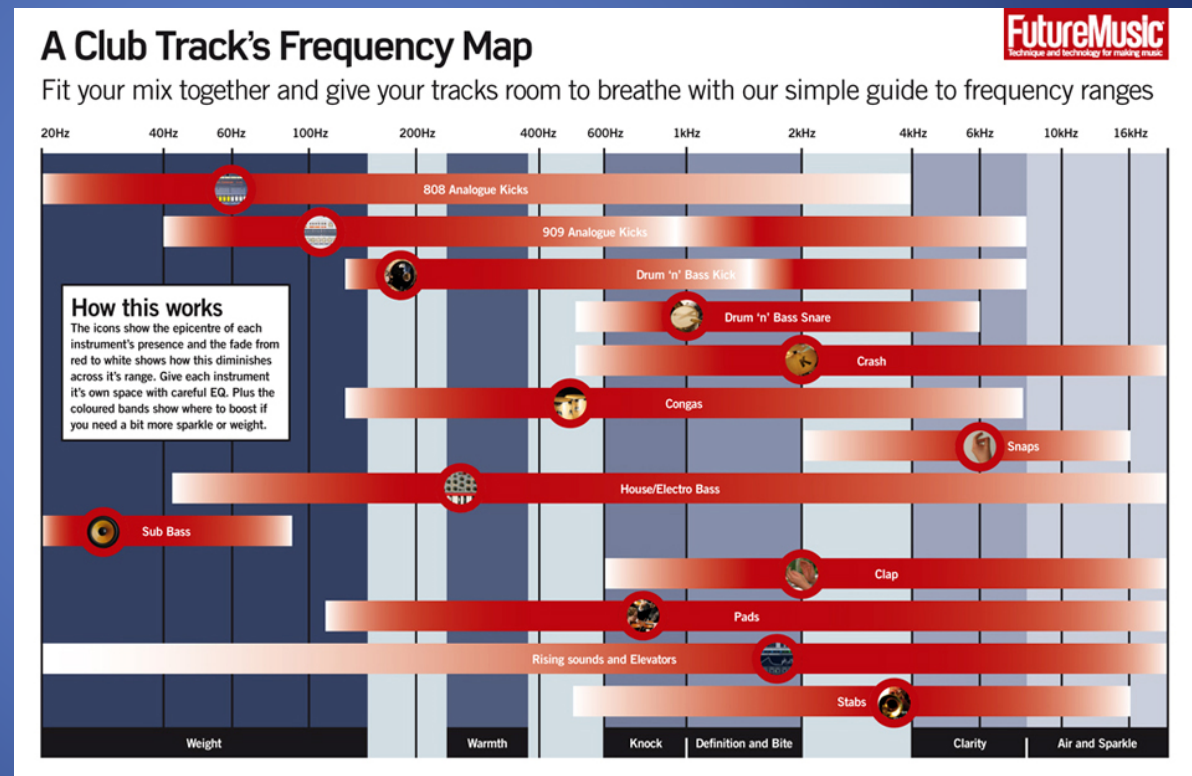


Mixcraft 6 Play/Rec Meters

The screenshot displays the Mixcraft 6.1 software interface. The top section shows the project name "Blood Pressurize - Remote Tree Children - Featuring Glen Phillips of Toad the Wet Sprocket" and the tempo "192.0 4/4 A". Below this, there are five tracks: 1 Lead Vocal, 2 Background Vocals, 3 Crunchy Vox, 4 VB3 Organ, and 5 Drum Mix. Each track has a play/rec meter (a green bar with a red vertical line) circled in red. The bottom section shows the mixer with 15 channels, each with its own play/rec meter circled in red. A yellow box labeled "Master Volume" points to a play/rec meter in the center of the mixer. The system tray at the bottom shows the taskbar, system clock (2:26 PM 7/21/2014), and system status (CPU: Mixcraft 2%, System 12%).

Frequency Boost/Reduction

When recording many instruments, certain frequencies may be too cluttered with too many sounds. When this happens (like at 1kHz with 10 different instruments), one can adjust a sound by augmenting or reducing certain frequencies within the sound – bringing out the “highs, mids, and low” of a sound.

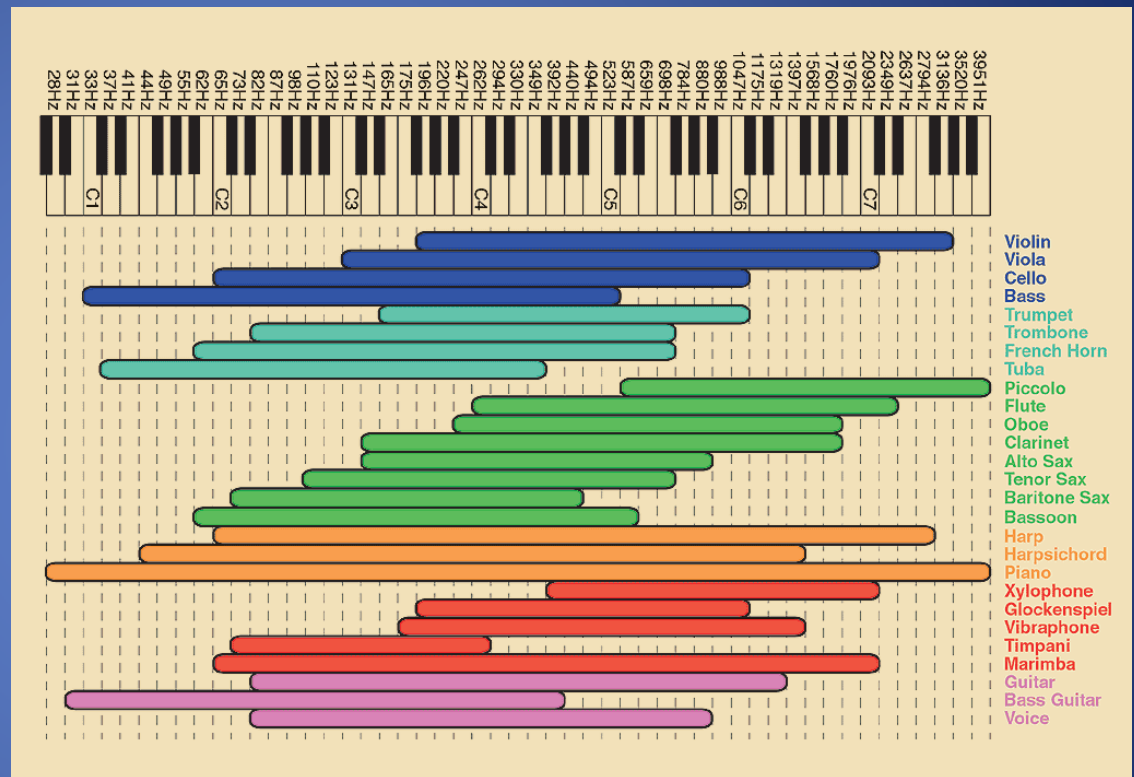


Frequency Boost Reduction

In doing so, you give each sound a better chance of being heard in its own frequency, or space.

In order to do this, each sound may need the use of a graphic equalizer.

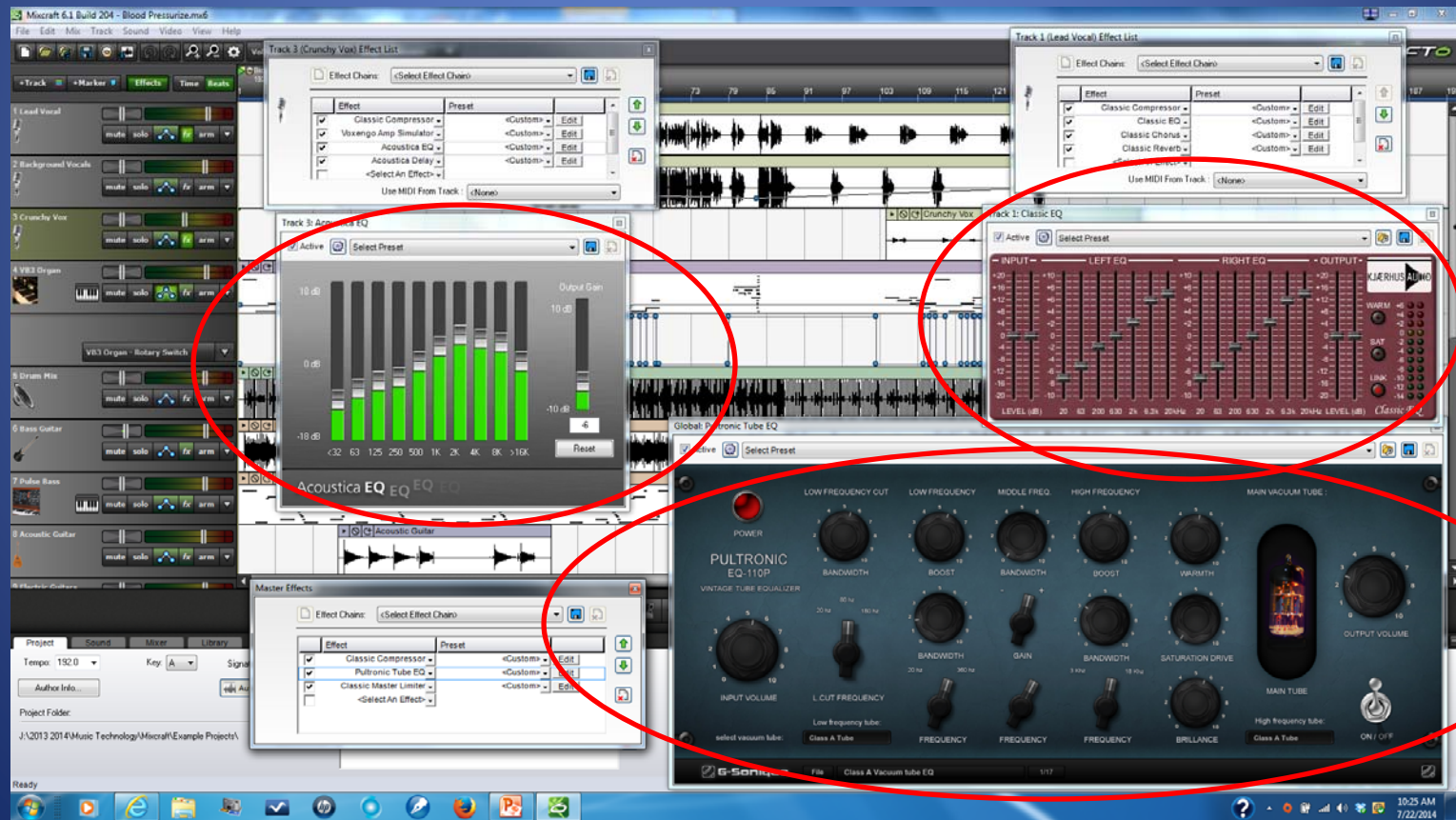
Graphic equalization is one of the first “effects” (or “fx”) that you will be utilizing in the recording studio



← Lows Mids Highs →

Graphic Equalization

With graphic equalization (EQ) – you can raise or lower certain frequency ranges within a sound.



Sound Synthesis/Manipulation

When using “virtual” instruments or sounds, in order to get a more realistic sound, many use the art of “sampling” an instrument.

Sampling, in this instance, takes multiple recordings of single notes being played, and assigns them to certain ranges, or in the case of a synthesizer, piano keys.

Sound Synthesis/Manipulation

However, some sounds are generated from the use of different waveforms (sine, square, sawtooth, etc.) or a combination of them and passing them through filters and other “effects” in order to come to a desirable, unique sound.

These sounds were how many early synthesizers created their sound, and they continue to use some of these sound synthesis techniques ...

Sound Synthesis/Manipulation

...from “classic rock” to the music of today.

Herbie Hancock
“Chameleon” Live - 1975



Imagine Dragons
Radioactive (Synchronice Dubstep Remix)

