AUDIO TRENDS
L E A R N I N G C E N T R E

The Physics of Sound prepared by Darren Springthorpe

Sound and Audio

Understanding the basics of audio production and reproduction is a good place to start for anyone wanting to learn more about sound, in either amateur or professional situations.

What is "Audio"?

Audio means "of sound" or "of the reproduction of sound". Specifically, it refers to the range of frequencies detectable by the human ear — approximately 20Hz to 20kHz. — 20Hz is the lowest-pitched (bass) sound we can hear, 20kHz is the highest pitch (treble) we can hear.

To understand audio we must have a grasp of two things:

Sound Waves: What they are, how they are produced and how we hear them.

Sound Equipment: What the different components are, what they do, how to choose the correct equipment.

Technical note: In physics, sound is a form of energy known as *acoustical energy*.

Professional Fields of Audio

The field of audio is vast, with many areas of specialty. Audio professionals can be found in a huge range of vocations including:

- Audio Engineer Studio
- Audio Engineer Live
- Audio Engineer Field
- Audio Editor
- Audio Consultant
- Post-Production Audio Creator

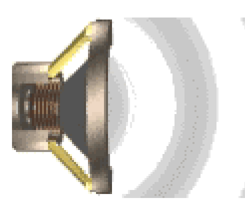
It is important to recognise the importance of audio in film and video. A common mistake amongst amateurs is to concentrate only on the vision and assume that as long as the speakers are working the audio will be fine. However, satisfactory audio requires skill and effort.

Sound is *critical* to the flow of the programme, indeed in many situations high quality sound is more important than high quality video.

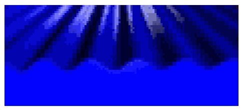
Sound Waves

It is very important to understand how sound *waves* work. This knowledge will form the foundation of audio System design and performance.

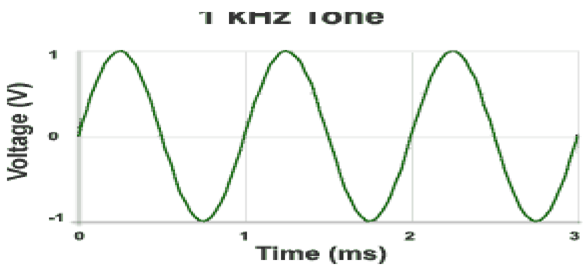
Sound waves exist as variations of pressure in a medium such as air. They are created by the vibration of an object, which causes the air surrounding it to vibrate. The vibrating air then causes the human eardrum to vibrate, which the brain interprets as sound. The illustration on the left shows a speaker creating sound waves.



Sound waves travel through air in much the same way as water wave's travel through water. In fact, since water waves are easy to see and understand, they are often used as an analogy to illustrate how sound waves behave.



Sound waves can also be shown in a standard *x vs y* graph, as shown here.



This allows us to visualise and work with waves from a mathematical point of view.

The resulting curves are known as the "waveform" (i.e. the form of the wave.)

Waveform

The wave shown, represents a constant tone at a set frequency. You may have heard this noise being used as a "test tone", creating a nice smooth wave which is ideal for technical purposes. Other sounds create far more erratic waves.

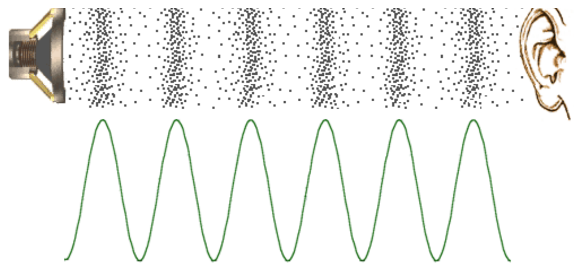
In the real world sound waves are three-dimensional. The graph indicates a wave traveling along a path from left to right, (two dimensional) but real sound waves travel in an expanding sphere from the source.

However the 2-dimensional model works fairly well when thinking about how sound travels from one place to another.

In the diagram below, the black dots represent air molecules. As the loudspeaker vibrates, it causes the surrounding molecules to vibrate in a particular pattern represented by the waveform. The vibrating air then causes the listener's eardrum to vibrate in the same pattern. Viola — Sound!

Variations in Air Pressure and Corresponding Waveform

Note that air molecules do not actually travel from the loudspeaker to the ear (that would be wind). Each individual molecule only moves a small distance as it vibrates, but it causes the adjacent molecules to vibrate in a rippling effect all the way to the ear.

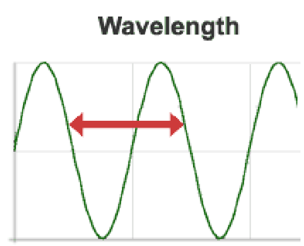


All audio equipment is about manipulating sound waves. The end result is this series of high and low pressure zones. That's why it's so important to understand how they work - they are the "material" sound.

Sound Wave Properties

All waves have certain properties. The three most important ones for audio work are shown here:

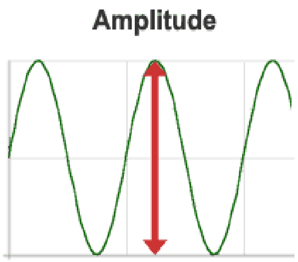
Wavelength:



The wavelength is the distance between any two corresponding points on a wave. Low frequencies have a longer wavelength than high frequencies.

Eg 20Hz wavelength is 17.2 meters 200Hz is 1.72 meters and 2000Hz (2 KHz) is .172 meters Wavelength, is literally the length of the wave.

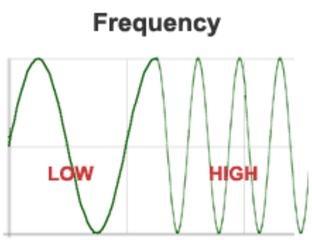
Amplitude:



The amplitude of a wave refers to the strength or power of a wave. The "height" of a wave when viewed as a graph shows the waves "Volume" intensity.

Higher amplitudes are interpreted as a higher volume, "amplifiers" are a device which increases amplitude.

Frequency:



The number of times the wavelength occurs in one second is measured in hertz (Hz), or cycles per second. The faster the sound source vibrates, the higher the frequency.

Higher frequencies are interpreted as a higher pitch.

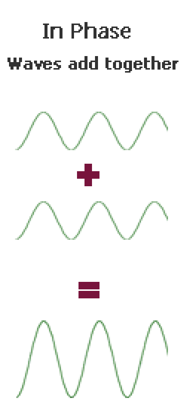
Sound Waves Interaction

When different waves collide (e.g. sound from different sources) they interfere with each other. This is called, unsurprisingly, wave interference.

Phasing

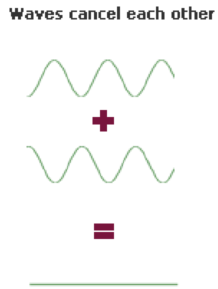
The following table illustrates how sound waves (or any other waves) interfere with each other depending on their phase relationship:

In Phase



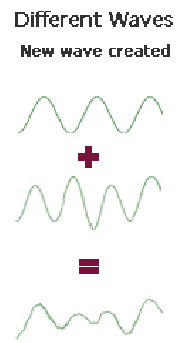
Sound waves which are exactly in phase add together to produce a stronger wave.

Out of Phase



Sound waves which are exactly inverted, or 180 degrees out of phase, cancel each other out and produce silence. This is how many noise-cancellation devices work.

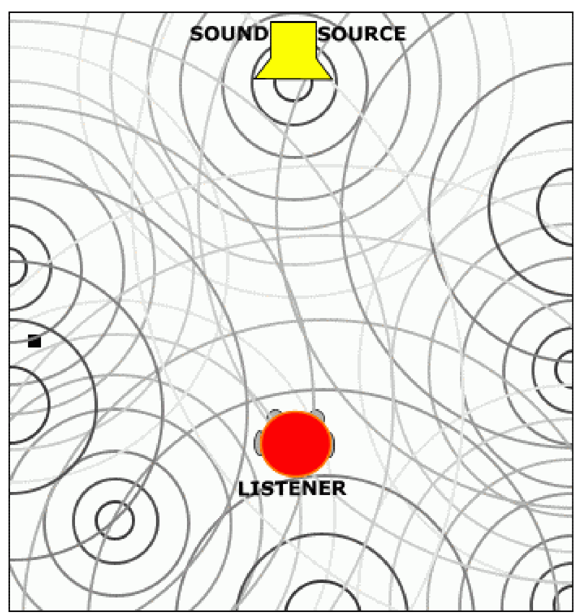
Differentiation



Sound waves which have varying phase relationships produce differing sound effects.

Room influence on the sound wave

The acoustic values of any given room will influence the sound wave dramatically, as the diagram shows reflections of sound from walls within the space occur. The sound bounces around the room radically changing the original sound of the speaker to a very confused acoustic mess.



The following subject title headings are areas that are as equally important to consider when addressing the physics a audio performance from any given audio system the physics remain the same regardless of price.

Direct Sound

Early Reflections

Absorption of Early Reflections

Later Reflections

Reverberant Field

Direct Sound to Reverberant Field

Steady State Reverb Level

Critical Distance

Reverberation Time

Room Size Issues

Small Rooms

Reverberation Faults

Reverberation Time with Frequency

Reverberation Time with Mixed Surfaces

Equivalent Open Window Area

Reverberation Time Design

Issues in Reverberation Design

Early Decay Time

Lateral Reflections

Early Reflection Foldback

Air Absorption

Standing Waves.

Room modes

Modal frequencies.

Axial Modes

Tangential Modes

Oblique Modes

Favourable Room Dimensions.

Critical Frequency

The Cut-Off Region

The Modal Region

The Diffuse Field Region

Ideal Live Room Characteristics

Ideal Control Room Characteristics