Chapter 3 Sound Basics

Sound Basics

Learning Outcomes:

A basic understanding of how sound works is the building block for music, mixing and most concepts in this course.

Introduction to Sound

Sound, as humans perceive it, is the detection and interpretation of vibrating acoustical energy. Waveforms are created by minute periodic changes in pressure.

An increase in pressure is called compression (speaker pushes out, positive numbers in digital editing). This compression is not to be confused with dynamic compression.

A decrease in pressure is rarefaction (speaker pulls in, negative numbers in digital editing).

Psychoacoustics play a factor in how our brains interpret sound. Psychoacoustics, for example, is the way in which our brain localizes sound based on both the time delay between sound arriving at our left and right ears and the frequency difference between the sound arriving at both ears.

Sound is periodic in nature: **CYCLE** (it arises and subsides like all things in life and in the universe)

Sound can be measured and/or described by:

- Amplitude – volume – the distance away from zero pressure: **dB**
- Frequency – pitch – the time it takes to complete a cycle: **Hz**
- Velocity – the speed at which sound travels through objects
- Wavelength – the distance sound travels to complete one cycle
- Phase – a measure of where a sound is in it's cycle
- Harmonic Content – timbre or sound colour
- Envelope – how the sound develops over time (attack, decay, sustain, release)

For our purposes, we are mainly concerned with: **Amplitude, Frequency, Timbre, and Envelope.**

Amplitude: volume measured in decibels – dB

The dB scale is logarithmic meaning that every 6 dB doubles the perceived intensity of the sound as heard while 3 dB doubles the electrical power of a sound.

0 dB	- Threshold of Hearing
60 dB	- Conversation
120 dB	- Band Practice
140 dB	- Threshold of Pain
150 dB	- Jet taking off

Frequency

Frequency is pitch or cycles per second measured in Hertz – Hz. Frequency, in the most basic sense, is how often something happens. Our ears can hear anything that happens between 20 and 20,000 times per second. If you hear the hum of fluorescent lights, you are hearing electrical voltage cycle 60 times per second within the light. The same is true of any motion; if you move your hand up and down 20 or more times per second, as impossible as that may sound, you will actually hear the motion.

Theoretical hearing range of humans: 20 Hz – 20 kHz
Average hearing range: 30 Hz – 18 kHz
Females typically have a broader hearing range than males.

Timbre

Timbre or tone is the harmonic content or overtones of a sound. The theory of sound is that all sounds at their most basic level are comprised of sine waves of different pitch (frequency) and volume (amplitude). This theory is the basis of **Additive Synthesis**. Timbre allows the ear to distinguish between sounds of equal pitch and amplitude. For example, timbre allows us to hear the difference between a piano and a guitar playing the same note.

Timbre is closely related to the Natural Harmonic Series described below:

Natural Harmonic Series

The Natural Harmonic Series is the naturally occurring overtones determined by physics.

Fundament - lowest harmonic determining pitch.

Overtone	Relationship	Pitch Ratio
Fundamental		1:1
1st overtone	8va	2:1
2nd overtone	8va + 5th	3:1
3rd overtone	2 octaves above	4:1
4th overtone	2 octaves plus a 3rd	5:1

It is important to note that the Natural Harmonic Series continues to infinity.

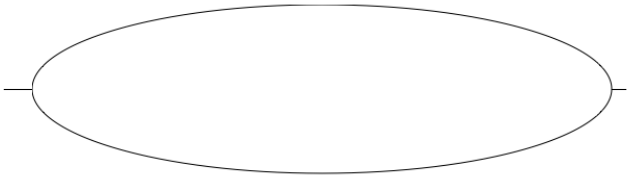
The basis of additive synthesis is the building (adding) of sine waves at varying frequencies and amplitudes to recreate the characteristics of naturally occurring sound or to create new textures not occurring in naturally in nature.

The natural harmonic series relates to all aspects of music. It determines our musical scales, choices of harmony, affects the sound of the instruments we play etc…

String Resonance at the natural overtones (Harmonic Series)

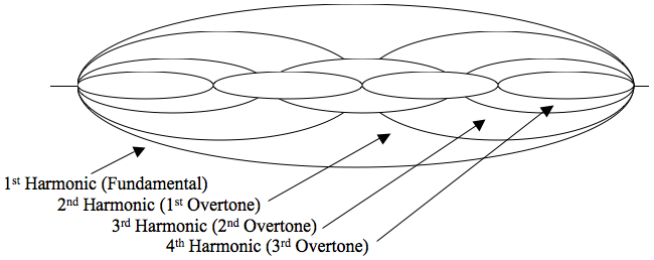
Tensioned string at rest: Hmm that's interesting… A straight line…

But… The moment the string is initiated, it will vibrate back and forth forming the *fundamental pitch* of the string:



The ***fundamental*** determines the pitch of the sound. The ***overtones*** determine the sound colour or timbre. *Overtones* provide additional waves at lower sound intensities that mathematically relate to the fundamental and therefore add *timbre* to the sound. This gives the instrument identifiable character. ***Timbre*** allows the listener to determine the difference between two sounds of equal pitch and amplitude such as allowing the listener to differentiate two different people singing the exact same note.

Tensioned string in motion showing the *fundamental* and first three *overtones*:

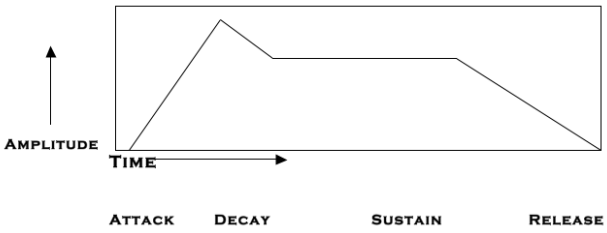


Envelope

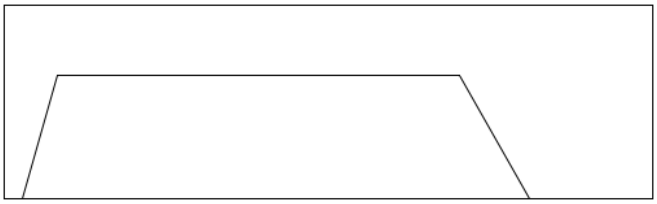
Envelope is how sound changes over time. Sound typically has four elements in its envelope. The four elements of an envelope in order are:

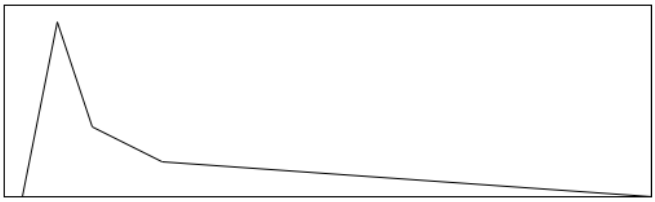
Attack
Decay
Sustain
Release

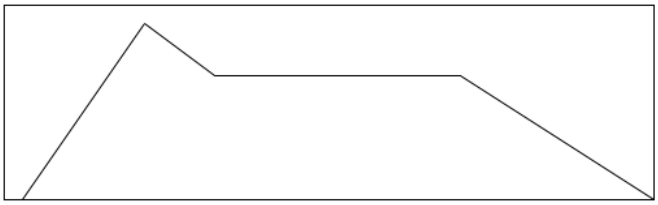
Envelope is typically most associated with amplitude.



From the list below, which is the amplitude envelope for strings, organ, and snare?



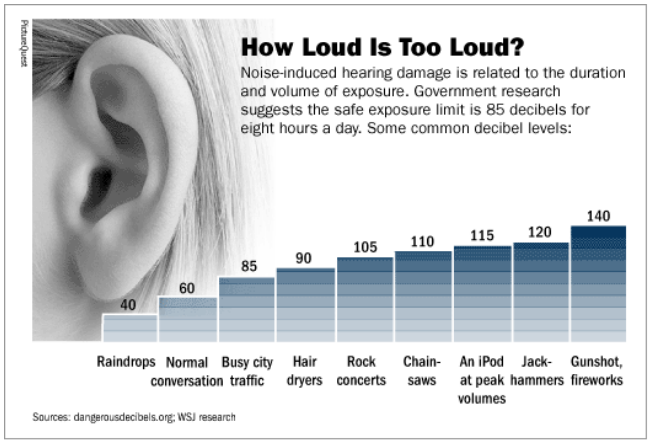




Protect your hearing!

How to set your headphone volume

Set the volume just to the point where vocals become intelligible on commercially released songs.



When mixing, there are three monitoring levels: Loud, Moderate, and Low. Everything seems to sound good when it is loud. Avoid mixing or doing audio related work at loud volumes! Do your work at moderate levels where background lab voices or the television are still audible but the sound is not intelligible. Check your work for short periods of time at higher than normal volume and at low volume, just at the point of intelligible.

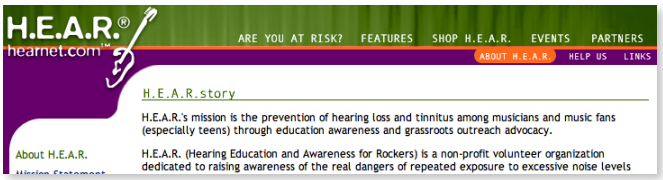
The louder your headphones are, the more likely it is that you will get fatigued from listening. From experience, I can tell you that **listening fatigue** can be nauseating, painful, and unproductive. As a generalization, your job is not to enjoy the listening experience of mixing, recording, editing et cetera; it is to provide a product that is intelligible and enjoyable to consumers at all listening levels.

YOUR EARS ARE YOUR CAREER! PROTECT THEM!

Tinnitus is the ringing in the ears caused from long exposure to loud sounds, like after a concert. This can be temporary or permanent. Former Music Industry Arts' technician Lee Mashinter suffered from tinnitus. This meant that he had a constant ringing in his ears day and night! He warned students and professionals to turn down the volume!

I also suffer from ear fatigue where my ears, after years of listening loudly, will go into compression quickly if I listen too loudly for even a short period of time. When this happens, it takes a few hours for my hearing to return to normal.

For more info on hearing protection and the prevention of hearing loss, check out: **www.hearnet.com**



Interesting little-know fact: Most people have worse hearing in their left ear from exposure to wind noise from driving with the window open.

Headphones

Headphones are a great way to monitor sound. Most audiences today will listen back on headphones. So why not mix and work on projects on the format that listeners will be using.

Headphones also represent a great value. For way less than the cost of studio monitors, full-range professional quality headphones can be had and can easily be taken anywhere!

Headphone Types:

- Open-back
- Semi-open
- Closed-back
- In-ear

Open-back headphones allow sound both into the ear and out to your surroundings. These headphones tend to be the most transparent and natural sounding and give the least amount of listening fatigue. Open-back headphones also allow the sound of the environment to still be heard. So, you can listen to music and still hear conversations or noises around you. The main drawback of open back is that the sound also can be heard by others and hence can be picked up by a microphone. Open-back headphones tend to be more expensive, but are well worth the price. Grado is a respected headphone maker that makes open-back headphones.

Semi-open headphones combine the best of both open and closed designs. Semi-open headphones are a great place to start for headphones. They provide a nice open sound while still minimizing headphone bleed. Probably the most iconic open-back headphone is the AKG 240 series headphone. They are light, durable, self adjusting, sound good and represent good value. Users have been known to use their 240s for years with the pads wearing off and still drag them around.

Closed-back headphones are the most common headphone type, particularly among inexpensive headphones. Closed-back seal your ear with little to no sound coming in from the outside world.

Closed-back headphones work great for recording. The sealed back stops click and instrument bleed from getting into vocal tracks.

Closed-back headphones can quickly cause listening fatigue, where your ears exhaust from listening. This occurs more frequently with closed-back headphones then other types of headphones because your ear is sealed and the headphone driver acts as a plunger on your ear drum giving it little reprieve from the constant pulling and pushing.

Beats headphones tend to be closed-back and as such can exaggerate the bass.

A few iconic studio closed-back headphones are the Sony MDR-7506 and Fostex T40.

If you want to get hit by a bus or car while walking or riding down the street, wear closed-back headphones. They remove you from your environment and stop you from hearing things around you, which is great if you have roommates but not so great if you zone out while on the street.

In-ear headphones are great for stage work, but typically of little use in the studio environment.

What to look for in a pair of headphones for professional audio:

- Comfort
- Build quality
- Durability
- Frequency response
- Transient response
- Driver size (larger is better)

The most important quality is probably comfort as you will be wearing headphones for extended periods of time.

If you wear glasses, try a few different types of headphones. Avoid a headphone that puts pressure on your glass arms and squeezes your head all day.

For professional audio, avoid Bluetooth and noise cancelling headphones, both of which compromise audio quality.

Main Headphone Driver Types:

- Dynamic / Coil
- Planar Magnetic
- Electrostatic

By far, the most popular headphone type is Dynamic / Moving Coil. These headphones are inexpensive, durable and require little power to drive them.

Planar magnetic and electrostatic headphones are mainly marketed to hi-fi customers and are priced accordingly.

Planar magnetic and electrostatic headphones offer a more natural sound with faster transient response, but are more expensive, heavier and require an additional amplifier.

WARNING!!! Many professional engineers will warn against only mixing on headphones for reasons such as stereo imaging and so on. Make sure you listen to your work on a few different systems to ensure that your audio intentions translate well onto other systems (cars, radio, speakers etc.).

Chapter Summary:

Sound is made of waveforms.

The natural harmonic series (the physics of sound) influences all sound and correspondingly all music.

Every sound has an envelope: ADSR

Protect your hearing!