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Sound

This chapter is going to tell you everything you needed to know, but never got around to asking, about the very essence of music—namely, sound. Sound is little more than the movement of air in a particular formation. Even though you don't feel it, air is pressurized around you. Without it, you would explode from the inside out, which is a pretty nasty thought. Every time you make a sound, the movement that causes that sound makes vibrations in the air pressure, which results in sound waves. When you clap your hands, yell at the top of your lungs, or strum a guitar, you are making waves in the air pressure around you. These waves are very similar to the ripples and waves that you see in water. If you're standing next to a very still pool of water and dip your finger into it, ripples emanate smoothly out from that point to all edges of the pool. Think of this as a whisper.

Now, if you drop something big into the water—like a Cadillac—then the ripples become waves that slosh all over the place and create quite a pronounced effect. Think of this water-wave movement as the sound-wave equivalent of someone screaming bloody murder, or that lady you know who has the high-pitched hysterical laugh that makes you cringe whenever she's in the room. These are major air pressure disturbances resulting in major sound waves.

In the case of sound, air is what ripples and waves, not water. Interestingly, though, if you make noise in or near water, it travels a lot more clearly and faster than it does through the air. This is because water molecules are closer together than air molecules, and thus more of them move when they are disturbed.

As the sound waves move through the air because of a vibration and the resulting air pressure, they must be picked up by a sound receiver, which in our case is the ear. Our ears (and their internal workings like eardrums, cochlea, etc.) pick up the air pressure and, in conjunction with the brain, interpret them as *sounds.* No ears around? Then there are no sounds, just air pressure. Sound waves exist only as air movements until something translates the air pressure into actual sound. If a tree falls in the woods, and nobody is around to hear it, does it make a sound? No. That's right, *no.* Sorry to break this to you, but it's true. The tree makes sound waves, but unless something is there to interpret them as sound, they just move through the air until they fade out. Of course, this doesn't count if you include birds and bears, or somebody leaving a tape deck (another sound interpreter) recording all by itself in those same woods. Those animals can hear it because they have the proper ear mechanisms, and the tape deck has manmade sensors which pick up sound waves and convert them to actual sound.

Different types of hearing devices can pick up different types of sound waves. This is why dogs can hear certain high-pitched sounds, like whistles, that we can't hear. Our sound interpretation apparatus just isn't sophisticated enough to detect those types of changes in air pressure. The same is true of recording devices. Some can detect sound that we can't, and others don't pick up all the sounds that we hear. This is usually true in the high-frequency range of sound, where a recording device or microphone may not be delicate enough to capture those high sounds, leaving us with a sense of missing brightness or clarity in a recording.

Speaking of frequency, it is one of three physical attributes of sound waves, the other two being wave shape (or wave form) and amplitude. First, frequency defines the pitch of a sound, what musicians call the "high" or "low" of a sound. Second, the wave shape represents the timbre of a sound, also called its color or tone. Finally, amplitude corresponds to how loud or soft a sound is.

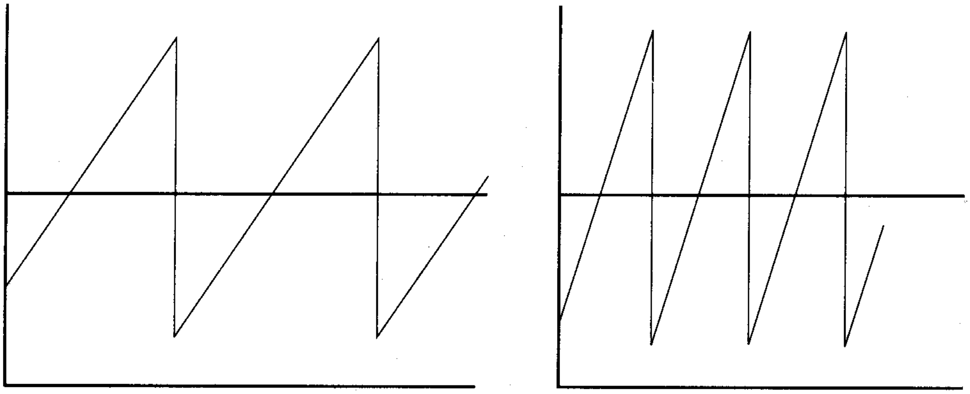
An additional and very important aspect of the physical nature of sound is not physical at all. It is time. Now before we embark on a Philosophy 101 discussion of the nature of man in relation to space and time, let's look at time practically. Sound is one of the only things that man deals with which is "time-bound," meaning time is an inextricable part of sound. You can't freeze an actual sound at a particular point in time and expect to be able to recognize that sound. You always have to view sound as a segment of time. For example, we can take a picture of an event and freeze it in time with a photograph, without regard to time. The photograph captures the specific essence of that event without any difficulty. More specifically, think of the movies. A film is actually a series of still photographs run in quick succession (24 frames per second), one after another. Each still captures an exact moment in time.

Try doing this with a sound—*any* sound. You cannot point to a frozen moment of time as you can with a photograph and say, "Oh, there's that sound." A sound has to be re-created at another point in time to be captured, and that re-creation involves making or playing that sound over a few seconds or minutes or hours of *time.* I hope all of this makes sense, because it tends to be fairly obvious. If it isn't, one method of proving this is to find a defective compact disk or CD player. On a defective disk, a segment of music only a fraction of a second long tends to loop itself continuously and very quickly. The resulting piece of music does not capture any of the essence of the song and is usually unrecognizable as a part of a particular song. This is because it requires a period of time longer than a fraction of a second for you to even recognize the resulting noise as music in the first place.

Do the same thing with a tape deck. Clip a length of tape about $^1/_8$th of an inch long and splice it onto a blank segment of tape. When playing it through the tape deck, see if you get anything other than a quick "bleep" of sound that doesn't make much sense. Even though this is a primitive example, it's almost like taking a snapshot of the sound or music. Yet you're still playing that sound through time, whether it's one second or $^1/_{100}$th of a second; you're still using time to get even a snapshot level of sound. You see the difficulty in extricating sound from time? It's impossible.

We can, however, look at representations of what a moment of sound looks like. These representations are positioned along a normal X and Y axis diagram like you might have used in grade school to measure the growth of populations per year, or how tall you grew every year. The X axis represented years (time) and the Y axis represented amounts of growth or population at each point in time—literally, the *what* that happens over time.

Here are some quick examples. In Figure 1–1, the difference between the two pictures is the number of waves created over time, or the frequency. Note that these are examples of tones which do not change over time. Although such kinds of frequencies can be generated with electronic



FREQUENCY OVER TIME

INCREASED FREQUENCY OVER TIME

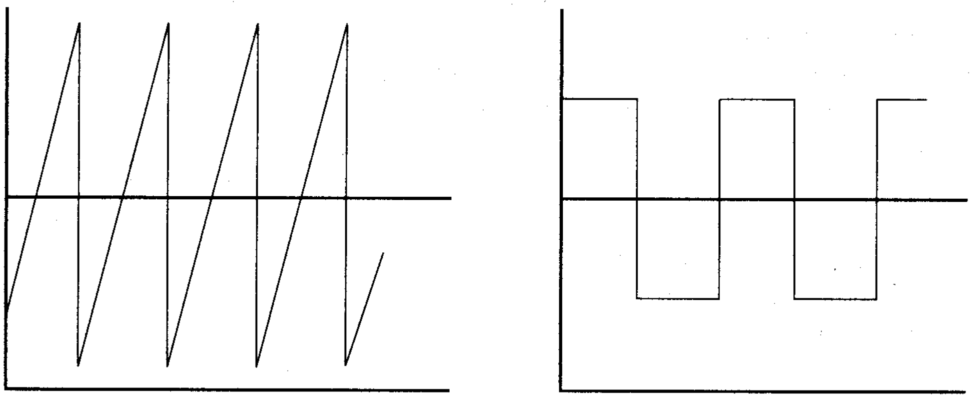
Figure 1–1. Variation in frequency (pitch) of a sound wave.

equipment, natural sounds all fade (decay) or change over time (an in-depth discussion of this occurs in Chapter Five).

In Figure 1–2, the difference is the timbre, or actual shape of the waveform over time.

The only difference in the two pictures in Figure 1–3 is the amplitude, or how loud the sound is.

Finally, the two diagrams in Figure 1–4 differ in every respect; there is no sameness in frequency, wave shape, or amplitude between the two.



SAWTOOTH WAVEFORM

SQUARE WAVEFORM

Figure 1–2. Variation in shape (timbre) of a sound wave.

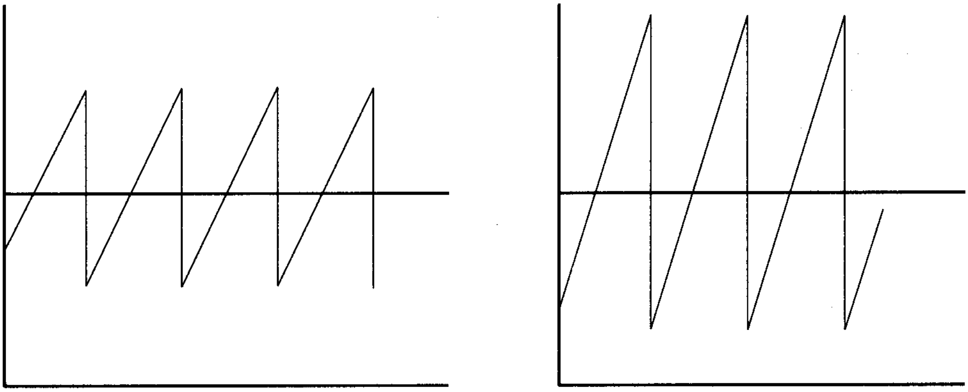


Figure 1-3. Variation in amplitude (volume) of a sound wave.

How do we get these nifty diagrams? They are really graphic representations of sound taken as electrical response to the air pressure of sound waves. When a microphone or pickup is hit with sound waves, either a diaphragm (in the case of the microphone) or a sensitive magnetic field (in the case of the pickup) is vibrated, much like the pool of water described earlier. Only instead of water ripples, these mechanisms send electrical impulses in response to the waves. The impulses are sent to an amplifier which in turn strengthens these pulses and sends them to

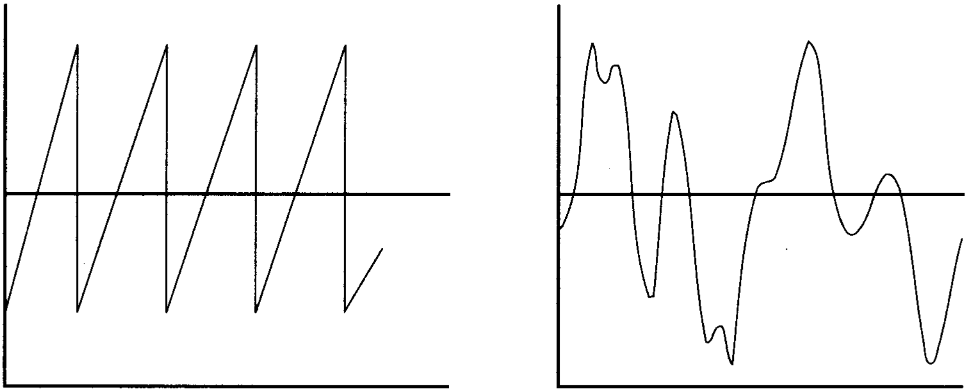
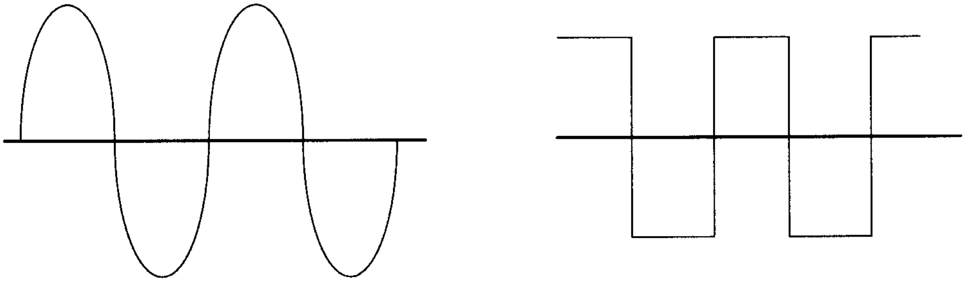


Figure 1-4. Variations in all properties (frequency, shape, and amplitude) of two sound waves.

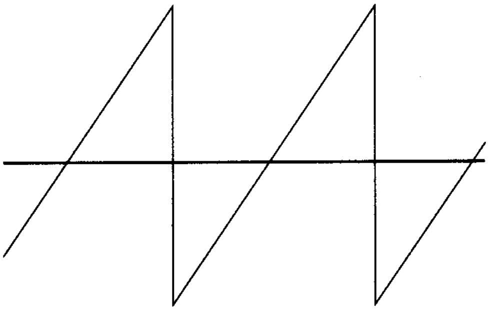
a speaker. The speaker then vibrates in sympathy with the strong electrical signal it receives and pushes that sound *back* into the air. Then—ta da—your ear picks up these speaker waves as sound. A good way to examine this is to take the front screen away from a stereo speaker, and watch how sound (especially very strong and very low bass notes, like a kick drum) will force air out of the speakers and create very noticeable air pressure.

All of this can be observed with an oscilloscope—a device that creates visual representations of waveforms, like those shown in Figure 1–4.



SINE WAVE

SQUARE (OR RECTANGULAR) WAVE



SAWTOOTH WAVE

Figure 1–5. Variations in waveform.

And the properties of sound represented on the X and Y graph can be described with very scientific-sounding terms. For instance:

- *Hertz* is a measure of frequency, one Hertz being equal to one complete cycle per second. It is called Hertz simply because it is named for the man who defined the measurement, H. R. Hertz. It's abbreviated as Hz. The lower the Hertz, the lower the frequency, the deeper the tone. Low Hz levels produce bass tones, high Hz levels produce treble tones.
- Amplitude is discussed in terms of *decibels* (dBs), or loudness units. Unfortunately, the measurement of exactly what constitutes a decibel is based on a bizarre algorithm that even most physics professors have a hard time understanding. Suffice it to say that normal conversation occurs at about 60 dBs, planes taking off create a roar of about 120 dBs, and your eardrums are in serious danger of meltdown around 160 dBs.
- Waveforms are usually defined by their shapes, or obvious and regularly occurring characteristics. Those shapes are sine waves, square waves, and sawtooth waves (Fig. 1–5).

Those are really the basics of sound. Although you didn't expect to get a crash course in the physics of wave formation and movement, don't you feel better about everything now that you've learned all this neat stuff? Everything you read from here on, though, is devoted to the whys, whats, and hows of making sound into music with modern equipment. And no more physics lessons.