Contents

Frequency: Timbre

Sound can be quantified by three measures: *amplitude*, *frequency* and *time*. These are the three components of sound, whether captured or free. Amplitude should be a familiar term (aka volume) as should time, but timbre and frequency might be new terms for some. The frequency of a sound defines its *pitch* (musical note value), while timbre (pronounced "TAM-bur") is the overall tonal quality of a sound that allows the listener to distinguish one instrument or voice from another. Timbre cannot be quantified solely through measures of pitch or amplitude; it is the *quality* of the sound, the timbre, that lets humans differentiate a saxophone from a trumpet, even when both instruments are playing the same pitch at the same loudness.

The most basic form of sound is represented by something called the *sine wave*. Remember that sound is a 360-degree mechanical energy burst through a medium, and as such, its pushing, then pulling, behavior causes peaks and troughs in the energy wave. This is exactly the same as a familiar mathematical function called the sine wave, as seen in **Figure 1.03**. The sine wave is an even energy wave whose ridges and troughs are the same size and shape and do not change over time. Each rotation through the up and down portions of the wave is called a *cycle*. This simple one-cycle sine wave is literally the building block of sound, much like the atom is the building block of matter.

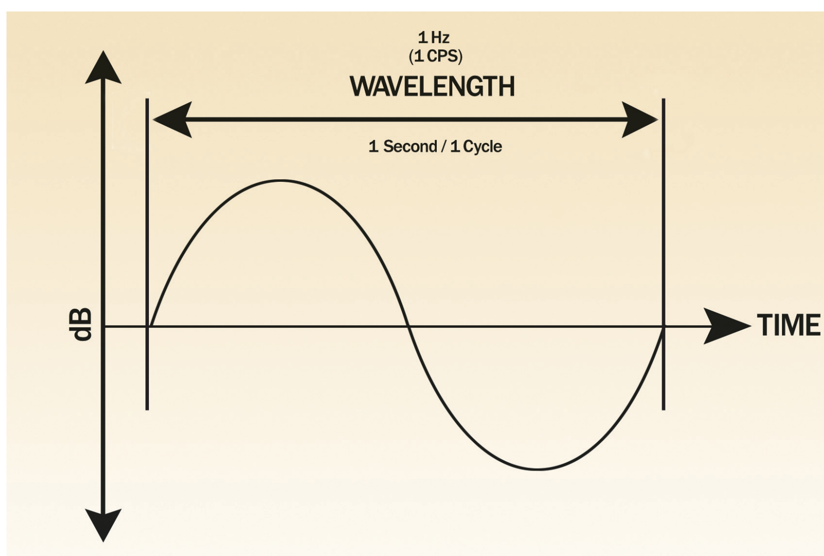

Figure. 1.03: A standard sine wave, measuring 1 Hz, meaning 1 cycle per second (cps). This is called the *wavelength*.

When drawn as a mathematical expression, a sine wave demonstrates this pushing and pulling energy, as seen in **Figure 1.04**. The curve of the wave is perfectly even and the top and bottom of the wave are exactly the same distance away from the zero line. This means that the energy starts at zero (standing still) until the burst is created, at which point the wave pushes outward, called *compression*, and then pulls back, called *rarefaction,* just as hard as it pushed out. In other words, the wave pushes and pulls repeatedly at a fixed rate, measured over the course of a second. Each repetition is called a "cycle." Frequency can thus be defined as the number of times a wave pushes and pulls in one second, which is expressed in, *Hertz* or *cycles per second*.

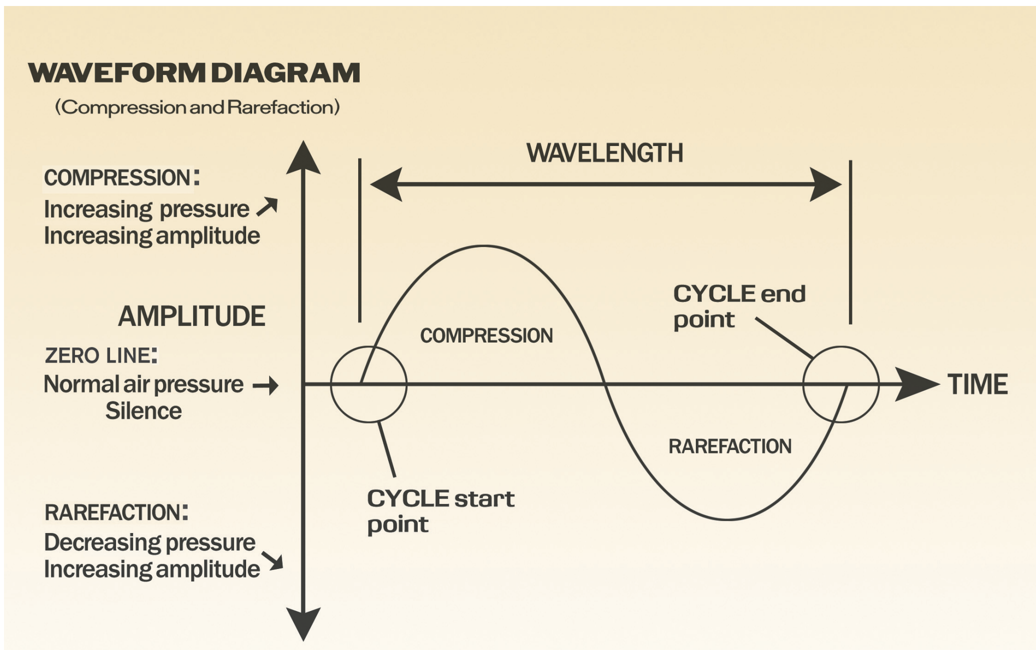

Figure 1.04: A simple sine wave showing the beginning and end of a cycle, as well as compression and rarefaction.

COACH'S CORNER

The sine wave is important to us for many reasons, but is most important mathematically because it represents a circular motion over time. Envision a world map where the world is laid out horizontally with funny curves as it tries to take the circular globe and represent it on a flat page. The math behind sound waves is called trigonometry. Trigonometry defines several functions, including cosines and tangents, but for audio purposes, we will concentrate on the sine wave.

Tech-Speak: *Octave*

An octave (8va) is a pitch at double or half the frequency of another frequency. In musical terms, it's the same note at a higher or lower level, as in from C to the next C, etc. Mathematically, it refers to a frequency that is double (or half) the original frequency as you go up (or down) in Hz.

The harmonic series is another of those "miracles" of music, in that this collection of tones provides the foundation of certain disciplines in music, instrument design, equipment manufacturing, acoustics, and synthesis. This concept is very important to understand and become familiar with, so let's refer back to the CDs, to listen to various harmonics and hear what they are.

Let's start with a simple sine wave vibrating at 110 Hz. The wave of energy is pushing (via compression) and pulling (via rarefaction) 110 times per second. Listen to the accompanying **DVD Track 4** to hear about 20 seconds of 110 Hz.

DVD Track 4: A 110 Hz sine wave being played for about 20 seconds. Can you find the note on the piano?

In this case, the fundamental is the 110 Hz tone. Multiplying 110 by 2 gives us 220 Hz—known as the first overtone or the *second harmonic* (the first fundamental is the harmonic). Now listen to it next to its fundamental and see what it sounds like.

DVD Track 5: Two sine waves played one into the other—110 Hz, then 220 Hz. Can you find the note matching 220 Hz on the piano?

Surprisingly, it's actually the same note, played an octave higher. But what happens if you do the math again, one step higher? Now, let's listen to the fundamental, 110 Hz, ×3—which is the second overtone, 330 Hz.

DVD Track 6: Three sine waves played back to back—110 Hz, 220 Hz, and then 330 Hz. Can you find all three on the piano?

Now, we have three notes, all built from the same fundamental, but not all at the same pitch. You can imagine that this can go on for a little while. So let's shortcut the process and go up to the eighth harmonic.