AUDIO ENGINEERING 101

A Beginner's Guide to Music Production

TIM DITTMAR

2nd edition

A Focal Press Book

ROUTLEDGE

Audio Engineering 101

Audio Engineering 101, Second Edition is a real world guide for starting out in the recording industry. If you have the dream, the ideas, the music, and the creativity, but don't know where to start, then this book is for you!

Straight from an author with first-hand experience, this popular book is filled with practical advice on how to navigate the recording world that will help you succeed in the exciting, but tough and confusing, music industry. This book covers all you need to know about the recording process, from the characteristics of sound, to a guide on microphones, to analog versus digital recording. Dittmar covers all the basics: equipment, studio acoustics, the principals of EQ/compression, music examples to work from, and often overlooked topics such as internships, people skills, and insider tips on how to succeed in the industry.

This new edition offers full technology updates, an expanded section on job opportunities, plus a new section on educational programs that offer credentials. The book comes with a full suite of companion audio, video, and instructor materials. The book includes QR codes so you can upload from anywhere!

Tim Dittmar is a musician, songwriter, recording and live sound engineer, producer, and professor. Tim began his professional audio career in the late 80s at Cedar Creek Studio in Austin, TX. Tim has been a full-time faculty member at Austin Community College since 2000 where he heads up the technology side of Music Business, Performance and Technology (MBPT).

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Second Edition

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Dedication

This book is dedicated to my mom, Jane Dittmar. She encouraged me to be whatever I had passion to be, while inspiring me to pursue a back-up plan in case my rock drum fantasies never transpired.

Contents

Acknowledgments

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About the Author

When I was in high school, my mom asked me, "Tim, what do you want to do with your life?" I believe I said something like "play drums and surf." My mom was pretty cool about the whole thing, but I knew my ambitions did little to impress her. Soon after graduating high school, I enrolled at a local college. There I discovered I could obtain a degree in a field related to my interests, Radio–TV Production. I loved music, but the idea of recording and working with musicians for a living seemed to be an unattainable dream! I moved to Austin, Texas, in the late 80s to play drums and complete my Radio–TV–Film (RTF) degree at the University of Texas. I soon found myself at Cedar Creek Recording studio playing drums on a new wave demo. It was my first experience in a commercial recording studio and I was blown away. The two-inch tape machine, the array of mics, the recording console, and the reverb! Oh, the Lexicon 224 reverb on my snare. I was hooked. That first night in the studio I was so wound up and boisterous that the engineer actually asked me to be quiet. The engineer's comments taught me the first lesson in studio etiquette: Don't talk, listen! Even with this reprimand, I was given the opportunity to become an intern at CCR and spent the next ten years engineering records.

Looking back, while I had only a basic foundation in recording, I remember feeling technically inept. I had to rely on a variety of strengths to compensate for my lack of technical expertise. Some of these strengths included showing up on time and having a good attitude and willingness to listen. I was also very self-motivated and driven, had decent people skills, and was willing to struggle and work hard for little money while learning the craft. I also knew a few bands and musicians, and could bring in potential business. It took years before my technical skill level matched these intangible strengths. My point is, if you are a beginner, do not be discouraged. We all have to start somewhere.

Audio Engineering 101 YouTube channel, available at https://www.youtube.com/channel/UCOhGtYc78yzRdNrwpbj_YFQ

Preface

Audio engineering is layered with many disciplines such as acoustics, physics, technology, art, psychology, electronics, and music. Each layer provides a new set of questions, answers, theories, and concepts. You soon realize that you will never know it all. This guide encompasses many aspects of audio engineering and includes a dose of reality. This is a hard business, but if you are willing to put forth the time and effort, you may end up with a job you love.

The goal of this book is to explain audio engineering and music production in an easy-to-understand guide. I wrote the first edition after ten years of teaching Audio Engineering courses at Austin Community College, two years of lecturing at the University of Texas, and twenty-five years of engineering and producing records. I decided to create a guide that draws on the lessons and experiences that have proved to be successful with both students and clients. As a Professor, I have unique insight into a beginner's ability to retain technical information. Many audio engineering books are simply too overwhelming for those being introduced to recording and music production. This is a recurring point made by many students and is one of the inspirations for this book. *Audio Engineering 101* explains intangible concepts that can make a recording better, such as understanding body language, creating a good vibe, and people skills. Much of your business will be generated by word of mouth, so these are important skills. In addition, the book highlights what to expect with internships, how to create a productive recording space, and an overview of what jobs are available to audio engineers. You will also find a handy guide dedicated to microphones and their uses. This is a great section for a true beginner or for the hobbyist wanting to learn microphone basics. *Audio Engineering 101* includes FAQs (frequently asked questions) answered by a diverse group of professional recording engineers from around the country. Questions are answered by experienced pros: What is the first mic you should buy or how you can get your foot in the door.

You can't learn everything about music production in a semester of school or even by getting a degree in the subject. Becoming proficient in music production may take many years. Experience is one of the most valued aspects of the profession and is gained by creating thousands of mixes, both good and bad, learning from your mistakes, and continually honing the craft. This is one of the coolest jobs you could ever have, but it won't be easy becoming a true professional. Even if you decide not to become an audio engineer, this book will take some of the mystery and intimidation out of the studio and the recording process.

CHAPTER 1

What Is Sound? Seven Important Characteristics

In This Chapter:

Learning the craft of audio engineering is like learning a foreign language. A new language may be intimidating and difficult at first, but, with time and dedication, a vocabulary is built. Soon words turn into phrases and phrases turn into full sentences. This chapter will cover details of a sound wave and explore some of the language of audio. You will be fluent in no time!

WHAT IS SOUND?

Sound is a vibration or a series of vibrations that move through the air. Anything that creates the vibrations, or waves, is referred to as the source. The source can be a string, a bell, a voice, or anything that generates a vibration within our hearing range.

Imagine dropping a stone into water. The stone (source) will create a series of ripples in the water. The ripples (waves) are created by areas of dense molecules that are being pushed together, while areas with fewer expanding molecules create the flatter sections. Sound travels in a similar way to this, by compression and rarefaction. Compression is the area where dense molecules are pushed together and rarefaction is the area where fewer molecules are pulled apart, or expanded, in the wave. The compression area is higher in pressure and the rarefaction area is lower in pressure.

This chapter deals with the seven characteristics of a sound wave: amplitude, frequency, phase, velocity, wavelength, harmonics, and envelope. You will also be introduced to the various types of waveforms, analog and digital audio, and lossy/lossless formats.

Although a typical sound is more complex than a simple sine wave, the sine wave is often used to illustrate a sound wave and its seven characteristics.

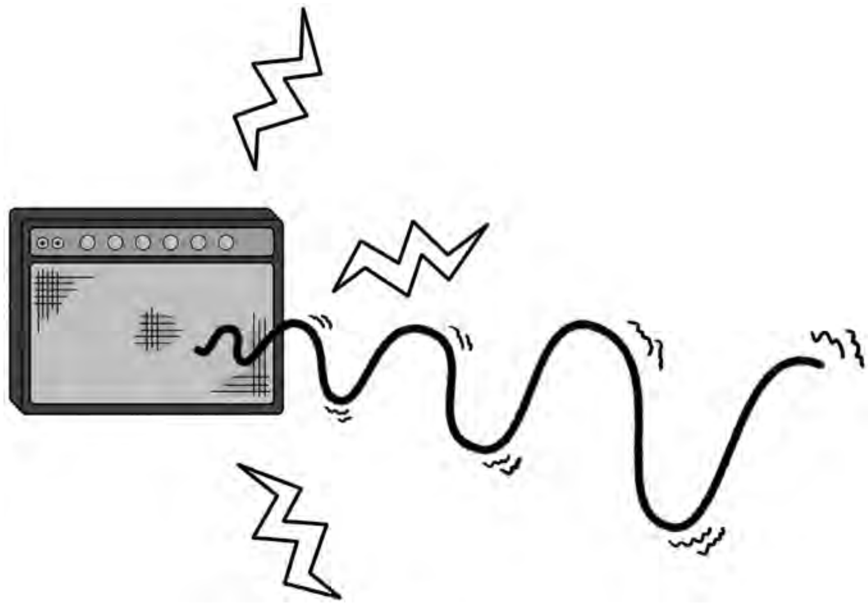

FIGURE 1.1

SEVEN CHARACTERISTICS OF SOUND

You may already know about two characteristics of sound: amplitude and frequency. If you have ever adjusted the tone on your amp or stereo, then you have turned the "amplitude" of a "frequency" or range of frequencies up or down. It is necessary to understand these two important sound wave characteristics, as they are essential building blocks in audio engineering. Two other characteristics of sound help humans identify one sound from another: harmonics and envelope. The remaining three characteristics of sound are velocity, wavelength, and phase. These characteristics identify how fast a sound wave travels, the physical length of a completed cycle, and the phase of the sound wave.

Amplitude

Amplitude is associated with the height of a sound wave and is related to volume.

When a stereo, amp, or television's volume is turned up or down, the amplitude of the sound being projected is increased or decreased. Loud sounds have higher

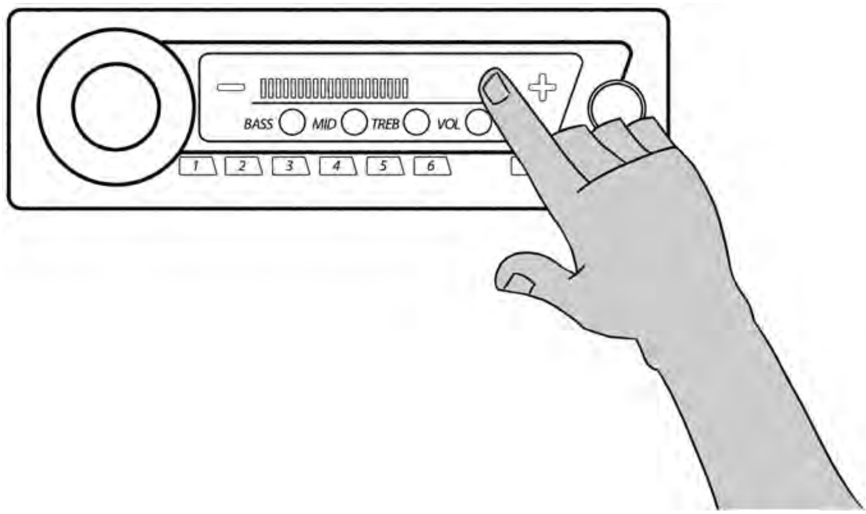

FIGURE 1.2

amplitudes while quiet sounds have lower amplitudes. The greater the amplitude of a sound the greater the sound pressure level (SPL).

Amplitude is measured in decibels (dB). Most people can recognize about a 3 dB change in amplitude. A trained ear can recognize even smaller amplitude changes. An increase in amplitude is usually expressed as a "boost" and a decrease in amplitude is often expressed as a "cut." The word "volume" is often substituted for amplitude. An audio engineer may say, "boost that 3 dB" or "cut that 3 dB." When amplitude is written out, it is expressed with a positive sign such as +3 dB or a negative sign such as −3 dB.

Here are some common activities and their corresponding decibel levels:

0 dB – near silence

40–50 dB – room ambience

50–60 dB – whisper

60–75 dB – typical conversation

80–85 dB – a blender, optimum level to monitor sound according to the *Fletcher–Munson curve*

90 dB – factory noise; regular exposure can cause hearing damage

100 dB – baby crying

110 dB – leaf blower, car horn

120 dB – threshold of pain; can cause hearing damage

140 dB – snare drum played hard from about one foot

150–160 dB – jet engine

As you can see, in our daily lives, we are typically exposed to amplitude levels between about 50 dB and 110 dB. Most people listen to music between 70 dB (on the quiet side) and 100 dB (on the loud side). To learn even more about dBs check out Appendix A.

Frequency

The amount of cycles per second (cps) created by a sound wave is commonly referred to as the frequency. If you are a musician, you may have tuned your instrument to A/440. Here, "440" is the frequency of a sound wave. It is related to pitch. Unlike amplitude, which is measured in decibels, frequency is measured in hertz (Hz), named after the German physicist, Heinrich Hertz. The average human hearing range is from 20 to 20,000 Hz. Typically, once 1000 cycles per second is reached, the frequency is referred in kilohertz (kHz), i.e., 1000 Hz = 1 kHz, 2000 Hz = 2 kHz, and 3000 Hz = 3 kHz. Frequency is related to the pitch of a sound. Figure 1.4 is a handy chart to help identify the frequency ranges of various instruments and how the keys of a piano relate to frequency.

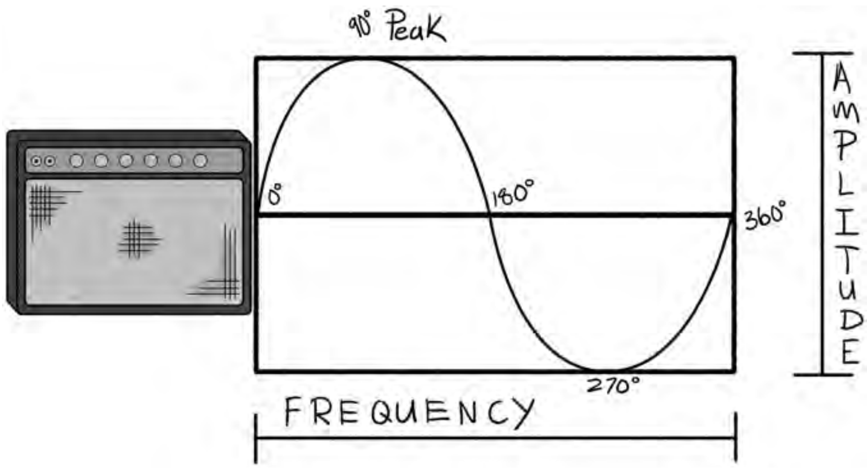

FIGURE 1.3

The first note on a piano is A, which is 27.5 Hz. Have you ever turned up the bass or treble on your car stereo? If so, you are boosting or cutting the amplitude of a frequency or range of frequencies. This is known as equalization (EQ), a vital aspect of audio production.

Each frequency range has distinct characteristics, and some common terms can help you to identify them. I will go into further detail throughout the book, but let's start here:

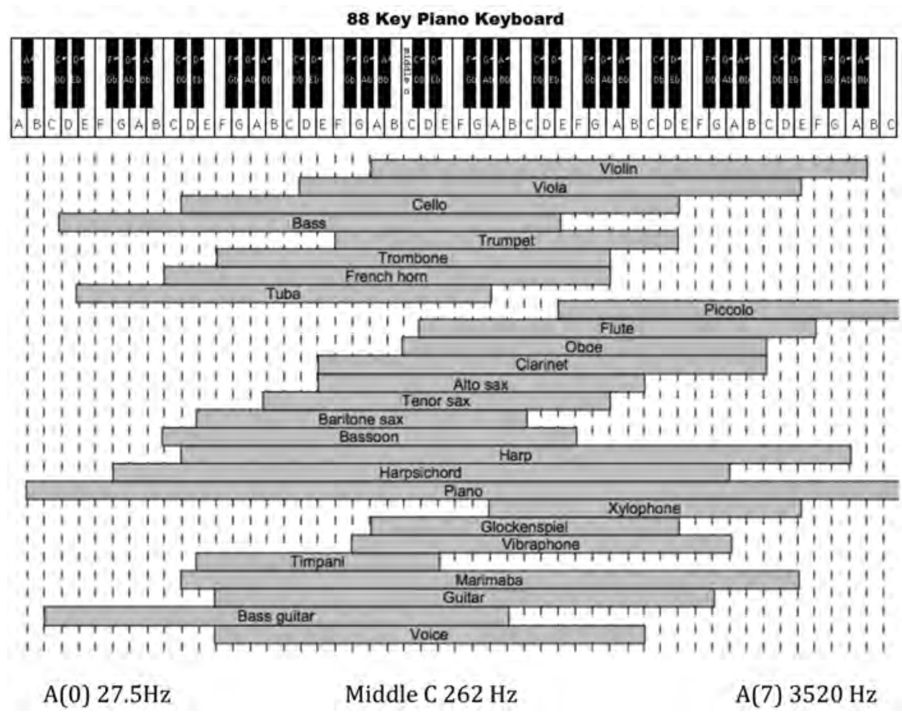

FIGURE 1.4

Frequency is often divided into three ranges:

AUDIO CLIP 1.1

https://youtu.be/J1V_Z9gfGyQ

Low or bass frequencies are generally between *20 and 200 Hz*. These frequencies are omnidirectional, provide power, make things sound bigger, and can be destructive if too much is present in a *mix*. Note that frequencies under 30 Hz produce more of a "feeling" than a sense of sound.

Mid, or midrange, frequencies are generally between *200 Hz and 5 kHz*. This is the range within which we hear the best. These frequencies are more directional than bass frequencies and can make a sound appear "in your face," or add attack and edge. Less midrange can sound mellow, dark, or distant. Too much exposure can cause ear fatigue.

High or treble frequencies are generally between *5 and 20 kHz* and are extremely directional. Boosting in this range makes sounds airy, bright, shiny, or thinner. This range contains the weakest energy of all the frequency ranges. High frequencies can add presence to a sound without the added ear fatigue. A lack of high frequencies will result in a darker, more distant, and possibly muddy mix or sound.

Midrange is the most heavily represented frequency range in music. It is often broken down into three additional areas:

Low-mids, from around 200 to 700 Hz: darker, hollow tones

Mid-mids, from 700 to 2 kHz: more aggressive "live" tones

High-mids or upper-mids, from 2 to 5 kHz: brighter, present tones

This chart in Figure 1.5 may come in handy when you are learning how to describe a particular sound or when you are mixing. These are general areas and are covered in detail in Chapter 3.

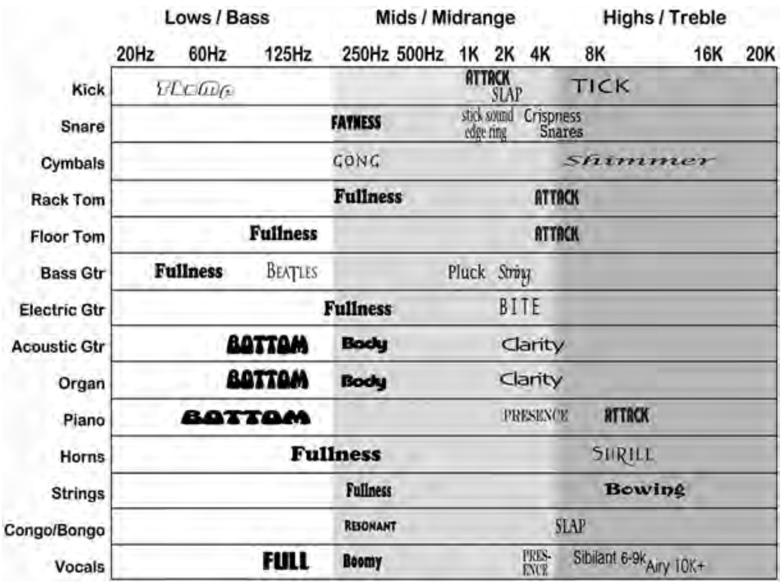

FIGURE 1.5

Phase

Phase designates a point in a sound wave's cycle and is also related to frequency (see Figure 1.3). It is measured in degrees and is used to measure the time relationship between two or more sine waves.

As you can see from Figure 1.6, when two sound waves are in phase, the result is increased amplitude. When they are 180 degrees out of phase, they can completely cancel each other out, resulting in little or no sound. This concept is used in many modern devices, such as noise-cancelling headphones or expensive car mufflers, to eliminate the outside sound or engine noise. However, sound is not

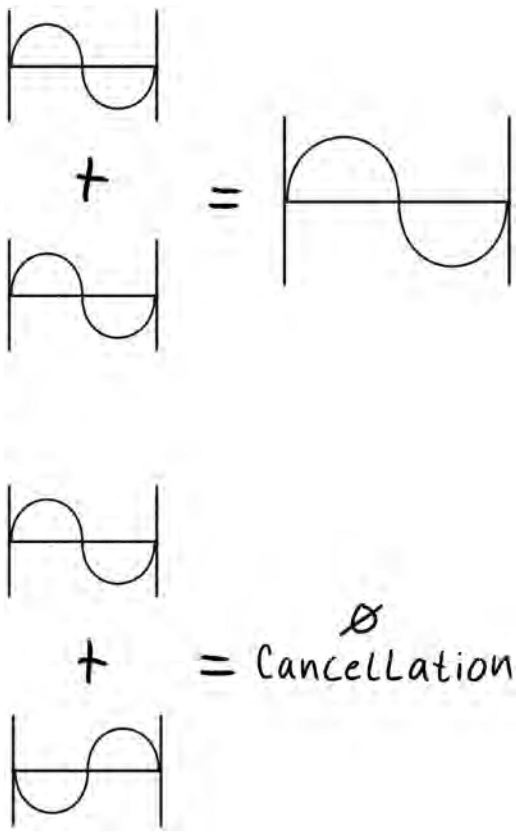

FIGURE 1.6

always completely in or out of phase. Sounds can be out of phase by any number of degrees, ranging from 1 to 359. Phase issues can make some frequencies louder and others quieter. Often a room's acoustics create these areas of cuts and boosts in the frequency spectrum. These cancellations and amplitude increases influence the way a room is going to sound. Standing waves and comb filtering are often the result of these phase interferences. Phase is also very important to keep in mind when stereo miking and when using multiple mics on an intended source. When listening in a typical stereo environment, a sound may be completely out of phase and go unnoticed unless the phase is checked.

TIP

Some tips to check phase:

- Mono button
- Phase flip (polarity)
- Phase meter

Phase issues can be exposed when a mix or a sound is checked in mono. One of the first records I mixed was a new wave record with thick delays and effects. I was mixing a particular track for a music video. The studio where I was working at that time had a small TV with a mono speaker. I would patch mixes into the TV in order to hear the mixes in mono. This would expose any existing phase issues and instrument imbalances. I patched into that TV after completing what the band and I thought was a pretty good mix, and the vocals and keyboards almost completely disappeared! Imagine if I hadn't checked the phase in mono. The video would have been aired and there would have been no vocals. I can honestly say after that experience that the mono button became one of my "go to" buttons on the recording console. Many live music venues and dance clubs' PAs and speaker systems are set up in a mono configuration to get more power. What would happen if one of your out-of-phase mixes were played in a club? It would be less than impressive. Always check your mixes in mono!

VIDEO 1.1 PHASE

https://youtu.be/tWk9EA2Y1v0

Velocity

Velocity is the speed at which sound travels. Sound travels about 1130 feet per second at 68 degrees Fahrenheit (344 m/s at 20°C). The speed at which sound travels is dependent on temperature. For example, sound will travel faster at higher temperatures and slower at lower temperatures, knowing the velocity of sound can come in handy when calculating a *standing wave* or working with live sound.

Wavelength

Wavelength is the length of the sound wave from one peak to the next. Consider the wavelength to be one compression and rarefaction of a sound wave. In determining the wavelength, use the speed of sound and divide it by the frequency. This will identify the length between these two peaks.

As seen in the figures, the lower the frequency the longer the wavelength. This demonstrates the power and energy that low end creates as a result of a longer wavelength. High frequencies are much smaller in length, resulting in a weaker form of energy that is highly directional.

TIP

The Rubens' Tube is a great visual example of compression, rarefaction, frequency, and wavelength. Look up the Rubens' Tube built by The Naked Scientists on their blog.[1]

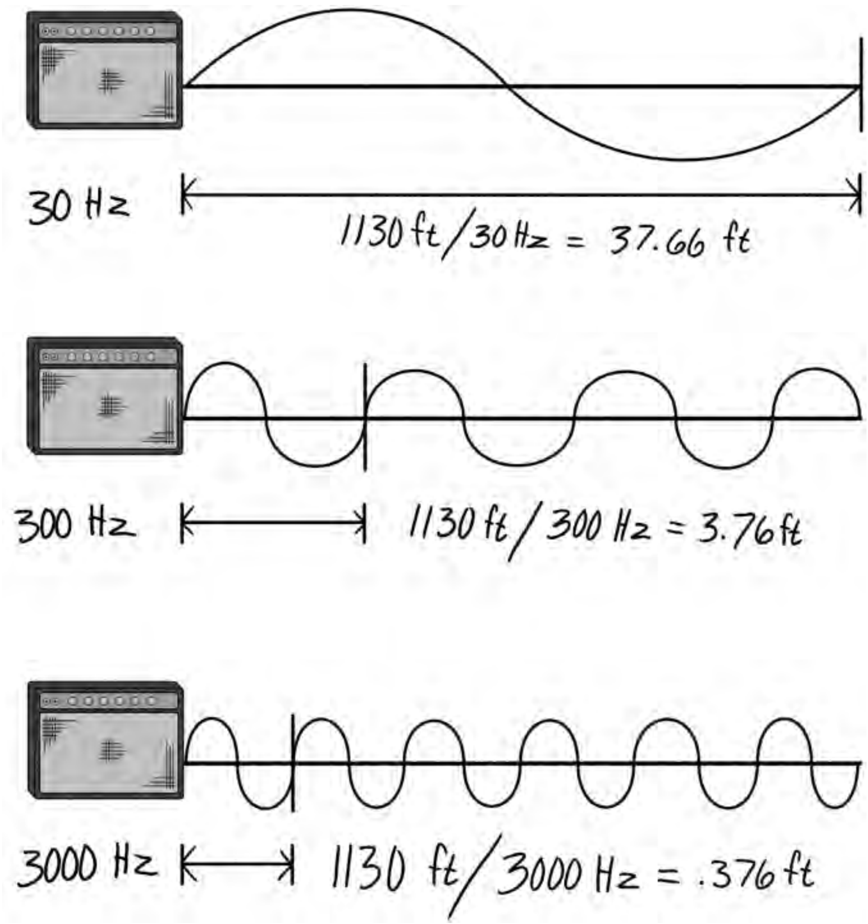

FIGURE 1.7

Unlike other sound wave characteristics previously discussed, harmonics and envelope help humans differentiate between one instrument or sound from the other.

Harmonics

The richness and character of a musical note are often found within the harmonics. Harmonics are commonly referred to as "timbre." Every instrument has a fundamental frequency, referred to as the fundamental, and harmonics associated with it. On an oscilloscope, the fundamental shows up as a pure sine wave, as seen in the Rubens' Tube video; however, sound is much more complex. Most sounds contain more information in addition to the fundamental. In music, instruments have their own musical makeup of a fundamental plus additional harmonics unique to that instrument. This is how we can distinguish a bass guitar from a tuba, a French horn from a violin, or any two sounds when the same