

13.3 Music

Music is a combination of sound and rhythm that we find pleasant. The kinds of sounds and rhythms can be very different for different styles of music. Some people like music with a heavy beat and strong rhythm. Other people like music where the notes rise and fall in beautiful melodies. Music can be slow or fast, loud or soft, happy or sad, comforting or scary. In this chapter we will learn what kinds of sounds music is made from.

Pitch and rhythm

Pitch The pitch of a sound is how high or low we hear its frequency. Pitch and frequency usually mean the same thing. However, because pitch depends on the human ear and brain, sometimes pitch and frequency can be different. The way we hear a pitch can be affected by the sounds we heard before and after.

Rhythm Rhythm is a regular time pattern in a sound. Rhythm can be loud and soft, tap-tap-TAP-tap-tap-TAP-tap-tap-TAP. Rhythm can be made with sound and silence or with different pitches. People respond naturally to rhythm. Cultures of people are distinguished by their music and the special rhythms used in the music.

The musical scale Most of the music you listen to is made from a set of frequencies called a **musical scale**. The scale that starts on the note C is show in the diagram below.

C major scale								
Note	C	D	E	F	G	A	B	C
Frequency (Hz)	264	297	330	352	396	440	495	528
Ratio to C=264	$1/1$	$9/8$	$5/4$	$4/3$	$3/2$	$5/3$	$15/8$	$2/1$
	$\left(\frac{264}{264}\right)$	$\left(\frac{297}{264}\right)$	$\left(\frac{330}{264}\right)$	$\left(\frac{352}{264}\right)$	$\left(\frac{396}{264}\right)$	$\left(\frac{440}{264}\right)$	$\left(\frac{495}{264}\right)$	$\left(\frac{528}{264}\right)$

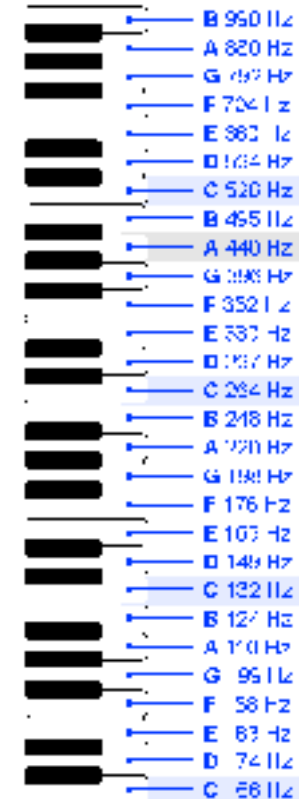


Figure 13.15: A portion of a piano keyboard showing the frequencies of the notes*. Four octaves are shown. A grand piano has 88 keys and covers seven octaves. (*tuned to perfect C major scale)



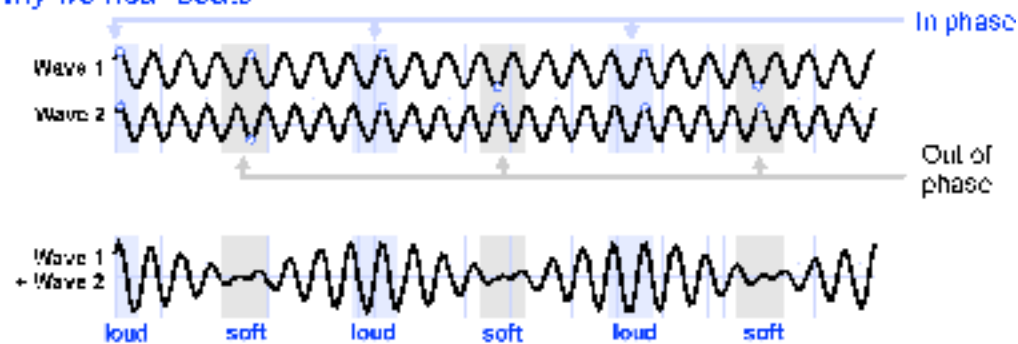
Consonance, dissonance, and beats

Harmony Music can have a profound effect on people's mood. The tense, dramatic soundtrack of a horror movie is a vital part of the audience's experience. Harmony is the study of how sounds work together to create effects desired by the composer. Harmony is based on the frequency relationships of the musical scale.

Beats An interesting thing happens when two frequencies of sound are close, but not exactly the same. The phase of the two waves changes in a way that makes the loudness of the sound seem to oscillate or **beat**. Sometimes the two waves are in phase, and the total is louder than either wave separately. Other times the waves are out of phase and they cancel each other out, leaving periods of silence. The rapid alternations between loudness and silence are referred to as beats. Most people find beats very unpleasant to listen to. Out-of-tune instruments make beats. The frequencies in the musical scale are chosen to reduce the occurrence of beats.

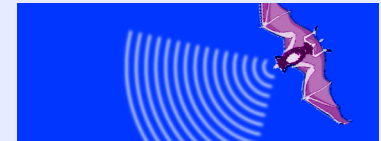
Why we hear beats

Beats come from adding two waves that are only slightly different in frequency



Consonance and dissonance When we hear more than one frequency of sound and the combination sounds good, we call it **consonance**. When the combination sounds bad or unsettling, we call it **dissonance**. Consonance and dissonance are related to beats. When frequencies are far enough apart that there are no beats, we get consonance. When frequencies are too close together, we hear beats that are the cause of dissonance. Dissonance is often used to create tension or drama. Consonance can be used to create feelings of balance and comfort.

Echolocation and beats



Bats “see” at night using ultrasound waves instead of light. A bat’s voice is like a “sonic flashlight” shining a beam of sound. A bat emits bursts of sound that rise in frequency, called “chirps.” When the sound reflects from a bug, the bat’s ears receive the echo. Since the frequency of the chirp is always changing, the echo comes back with a slightly different frequency. The difference between the echo and the chirp makes *beats* that the bat can hear. The beat frequency is proportional to how far the bug is from the bat. A bat triangulates the bug’s position by comparing the echo from the left ear with that of the right ear.

Harmonics and the “color” of sound

The same note can sound different

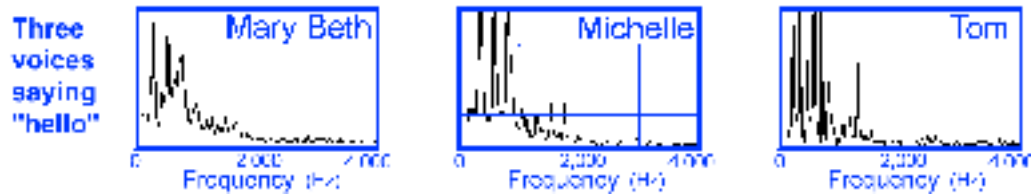
The same note sounds different when played on different instruments. As an example, suppose you listen to the note C-264 Hz played on a guitar and the same C-264 Hz played on a piano. A musician would recognize both notes as being C because they have the same frequency and pitch. But the guitar sounds like a guitar and the piano sounds like a piano. If the frequency of the note is the same, what gives each instrument its characteristic sound?

Instruments make mixtures of frequencies

The answer is that the sound we hear is not a single pure frequency. If the piano and the guitar both made a pure 264 Hz sound, we could not tell the difference. We can tell because real instruments make sounds with many frequencies. The most important one is still the fundamental note (for example, C-264 Hz). The variation comes from the **harmonics**. Remember, harmonics are frequencies that are multiples of the fundamental note. We have already learned that a string can vibrate at many harmonics. The same is true for all instruments. A single C from a grand piano might include 20 or more different harmonics.

Recipes for sound

A good analogy is that each instrument has its own *recipe* for sound. The “guitar” sound shown in figure 13.16 has a mix of many harmonics. For this guitar, the fundamental is twice as big as the 2nd harmonic. There are strong 3rd, 4th and 5th harmonics. The piano recipe would have a different mix.



Human voices

The human voice also has harmonics. We recognize different people’s voices by the patterns in frequency. The diagrams above show the frequencies of male and female voices saying the word “hello.” The frequencies range from 100 Hz to about 4,000 Hz. The peaks in the diagrams indicate the harmonics in the voices. Each voice has a unique set of harmonics. This is why it is possible to identify someone by their voice even if you only hear that person say “hello.”



Frequencies in a Guitar’s E

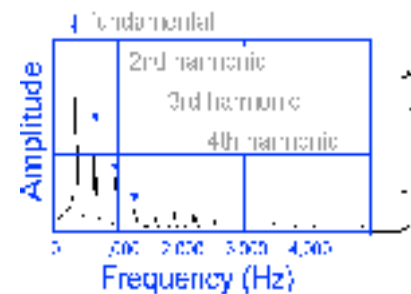


Figure 13.16: This graph shows the frequencies in a guitar playing an E note. Notice how many harmonics there are!