

## Chapter 10.2 “Harmonics”

*Key Terms:*

**Natural Frequency**

**Node**

**Harmonic Series**

**Overtone**

**Timbre**

### Resonance at Natural Frequency: The First Harmonic

You learned in the first section of this chapter that resonance is oscillation at a natural frequency. **The natural frequency** – also referred to as the fundamental frequency – is the lowest frequency produced by an instrument. Let’s use a guitar string as an example:

As you can see, there are two parts of the wave in Figure 10.2.1 in which there is no vibration. These are called the **nodes** or “zeros” of the wave. The first harmonic has two nodes, one on each of the wave. An **harmonic series** is a series of frequencies that are integer multiples of a fundamental frequency.

## The Second and Third Harmonic

You learned in *Chapter 2* that wavelength and frequency are inversely related. Because of this, whenever a node is added the wavelength is *decreased* resulting in an *increase* of frequency at the same proportion the wavelength was decreased. Let's assume our fundamental frequency, our first harmonic, is 440 Hz. (Listen to CD Track ##) If we divide this wave into two equal waves, we are halving the wavelength while doubling the frequency. The frequency in our second harmonic is 880 Hz. (Listen to CD Track ##) In Figure 10.2.2 the second harmonic is shown.

Note that there is another node, dividing the wave into 2 times the natural frequency, or  $2f$ . The third harmonic is the fundamental frequency times three, with one third of the wavelength. In the third harmonic, the frequency is 1320 Hz, which is the fundamental frequency, 440 Hz, times 3. (Listen to CD Track ##)

Do you recognize any patterns throughout the harmonics discussed above? What if we wanted to find the seventh harmonic? With the pattern above, we would divide the wavelength of the natural frequency by 7. Because of this, we are multiplying the frequency by 7. This means that our seventh harmonic has

a frequency of 3080 Hz (which is  $440 \text{ Hz} * 7$ ). See figure 10.2.3 for a representation of the seventh harmonic.

## Musical Harmonics

When you listen to music from a guitar, you're not just hearing one frequency. Instead, you are hearing **overtones** of the natural frequency. An overtone is any harmonic greater than the first. The second harmonic is the first overtone, the third harmonic is the second overtone, etc. For example, when a guitar string is plucked, many overtones are present, and the natural frequency. The frequency, aka **pitch**, that is audible is the highest overtone present.

Recall from *Chapter 2* that the amplitude of the waves is what determines the volume of the sound being produced. For example a violin will produce waves with a lower amplitude than a guitar (you will learn everything there is to know about string instruments, such as the violin and guitar in the next chapter). Even though a violin and guitar may be playing the same frequency, the noise produced will sound different. This is due to the **timbre** of the instrument. Timbre (say: TAM-ber) is the way frequencies blend together and produce a "color" of sound. There are many words that can be used to refer to the color of sound –

timbre – such as “heavy”, “light”, “bold”, “brassy”, “clear”, “harsh”, “piercing”, and “flat”.

Different instruments of the same type can have different timbre. For example, two different guitars may play the same note but sound differently due to differences in resonance caused by the shape of the guitar (again, you will learn more about string instruments in the next chapter).

### Works Cited

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