7.1.1: Pitch

The main component that gives us the perception of the pitch of a musical note is the ***fundamental frequency***, measured in hertz. In the modern musical scales used today the piano note middle C has a frequency of $261.63\ \mathrm{Hz}$ (we will look at how scales are constructed a bit later). This chart has the frequencies of all musical notes, based on a frequency of $440\ \mathrm{Hz}$ for the note labeled A_4 (A above middle C on the piano). As we will see in the next chapter, musical sounds are usually composed of many frequencies but the fundamental frequency gives us the basic quality we perceive as pitch.

Recall that for both sound and light, frequency times wavelength equals speed ($v = f\lambda$) but the speeds of light and sound are very different ($v = 3 \times 10^8\ \mathrm{m/s}$ for light $v = 344\ \mathrm{m/s}$ for sound). We can use the equation to find that a $440\ \mathrm{Hz}$ sound wave has a wavelength of $0.78\ \mathrm{m}$. In the case of light, frequency tells us the color of light. Green light for example lies in the frequency range $525\ \mathrm{THz}$ to $575\ \mathrm{THz}$ (T is tera or 10^{12}). A $525\ \mathrm{THz}$ electromagnetic signal has a wavelength of $571\ \mathrm{nm}$ (n is nano $= 10^{-9}$). The previous chart also has the wavelengths of notes on the musical scale in centimeters.

A person whose hearing is not damaged can hear frequencies as low as $20\ \mathrm{Hz}$ and as high as $20,000\ \mathrm{Hz}$. But very few people today can hear this range of frequencies. Exposure to normal sounds in everyday modern life tends to do at least some damage to most peoples hearing at an early age. Hearing is also affected by normal aging.

Video/audio examples:

- Article by Peter L. Tyack in *Physics Today* about Human-generated sound and marine mammals.
- Christian Huygens in 1693 noticed that the fountain at Chantilly, France produced an audible pitch. He determined this was the result of the echo of sound from the fountain being reflected off of a set of nearby steps. The steps were about half a meter in depth, causing sound to return from each subsequent step with a time delay (period) of 1m divided by $340\ \mathrm{m/s}$ ($vt = d$). A set of pulses with this period will have a frequency of $340\ \mathrm{Hz}$. This is sometimes called a ***repetition pitch***. He was one of the first scientists to connect sound with the frequency of a wave.
- Sounds reflected from the steps of the Mayan ruins at Chichenitza also produce a pitch, similar to Huygens' fountain but the pitch changes over time, due to the height of the steps. Sound from the bottom of the stairs has a repetition pitch depending on just the depth of the first step. Sound reflecting off the upper steps has a different repetition pitch because of the angle (the sound travels along a hypotenuse connecting the edge of one step to the next, rather than the shorter distance from the edge directly to the back of the step). This lower repetition pitch also takes longer to return because of the further distance to the higher steps. The result turns a hand-clap into a chirp: Sounds.