Sound

Olympic College, Phys 256

# Introduction

In this lab you will investigate and analyze various sounds, and relationships between different sounds.

## Lab report

You will not write a full report for this lab. Instead, you will present your work as a thorough record of your data collection and some analysis. Think of yourself as an “acoustic explorer” recording your observations in an uncharted territory. Some of your report will be qualitative, and some will be quantitative.

## Software

You will use the program *Audacity*. You can download it for free from [audacityteam.org](https://www.audacityteam.org/).

### Generating a tone

To generate a tone in Audacity, click on “Generate” menu and choose “tone.” You can select different waveforms; unless otherwise specified, use a sine wave. You should set a duration of at least a couple of seconds so you can really get the sound in your head.

### Multiple sounds

* To add two tones sequentially, click at the very end of the first tone’s waveform, and then generate the next tone. It should be added to the same track as the first tone.
* To listen to two tones at the same time, click on the empty space (so you’re “clicking out” of the first track) before generating the other tone. It will begin where the vertical line on the existing track is, so you should click the “skip to home” button first if you want them to start at the same time. You can also go to the Tracks menu and select Add New > Mono Track before generating the new tone.
* When there are multiple tracks, you can mute each one individually if you want to hear a tone by itself.

### Investigating and analyzing

* Clicking on the zoom in and zoom out buttons will allow you adjust the scale of the time axis. Zooming in will be particularly helpful; when zoomed out, there are too many oscillations for your eye (or computer screen!) to distinguish between.
* You can click and drag over a section of the wave form, then go to the Analyze menu and select Plot Spectrum. This will give you a graph showing the relative loudness of each frequency that contributes to the sound, similar to the FFT mentioned on the *Instruments* page in the Week 7 Canvas module, and shown on the *Superposition of harmonics* page.
  + For our purposes, 1024 is a good resolution to use. You can choose to use either a log or linear frequency axis. Use the default algorithm (spectrum).
  + The *fundamental* frequency has the largest peak. *Overtones* are represented by other peaks higher than the fundamental.
  + When you click and drag to select a segment of the tone, timestamps for the start and end of your selection are displayed at the bottom of the window.

# Investigations

## Frequency and Period

* Generate a 220 Hz sine wave.
* Calculate the period using the frequency you input for the wave.
* Zoom in so that you can only see one or a few oscillations, and measure the period directly.
* Compare the calculation to the direct measurement.

## Muiscal intervals

* Without changing your 220 Hz tone, add a 440 Hz tone so that you will hear the two played sequentially.
* Listen to the tones in sequence. Subjectively evaluate and describe how the two tones sound when played one after the other. Do not compare then notes to each other (e.g. do not say “the second one was higher in pitch”), or disucss the quality of individual tones: the focus here is on the experience of hearing the two tones in sequence.

This is a frequency ratio of 2:1 and is called an *octave.* Both of these tones are the note A.

* Repeat for the following pairs of frequencies:
  + *Perfect fifth:* 3:2 ratio of frequencies
  + *Major third:* 5:4 ratio of frequencies
  + *Tritone* (also known as an augmented fourth, diminished fifth, or the Devil’s interval): √2:1 ratio of frequencies
  + *Half step*: 21/12:1 ratio of frequencies

You may choose which frequencies you use, within the range of 100 Hz to 500 Hz. Report the frequencies that you chose in your writeup. Play the tones in sequence such that the higher tone is after the lower tone.

In Western music, the octave, perfect fifth, and major third are considered to be harmonic and sound pleasant. The tritone and half step are considered to be discordant and sound unpleasant. In your subjective evaluation, feel free to agree or disagree with either sentiment.

## Beats

* Clear your workspace by deleting any existing tracks, or opening a new Audacity window.
* Generate a 220 Hz sine wave that lasts for 10 seconds.
* Add another track with a 221 Hz sine wave lasting for 10 seconds. Set this up so that it plays at the same time as the 220 Hz tone (i.e., *not* sequentially)

When the two tracks are played at the same time, you will hear an oscillation in the volume. These oscillations are called *beats*.

* Pause the playback when the sound is loud. Zoom in on the waveforms and compare them.
* Pause the playback when the sound is soft. Compare the two waveforms.

## Instruments & overtones

* From Canvas, save the files “trombone.ogg,” “trumpet.ogg,” and “tenor-sax.ogg”
* Open each in Audacity, and give them a listen
* For each, select a large portion of the wave and analyze its spectrum
  + Determine the fundamental frequency; record the frequency and its sound intensity level
  + Report at least five overtones
  + Determine the ratio of the overtone to the fundamental; make a plot with this ratio on the vertical axis, and the harmonic number on the horizontal axis (the fundamental is the first harmonic, the first overtone is the second harmonic, and so on). Find a line of best fit and discuss the trend.
* Save the file “drum.ogg.” Open it in Audacity, listen, and analyze the spectrum.
  + Qualitatively compare its spectrum and waveform to those of the tonal instruments. You may discuss in generalities–you do not need to compare the drum directly to each individual instrument.

## Have fun

There’s lots of cool stuff you can do in Audactiy. Try comparing sawtooth waves, square waves, and sine waves (from the tone generator), or analyze white noise and pink noise. Neither of these are required for the lab report, but feel free to include it if you do!