Learning Intentions

- Learn how sounds with similar frequencies interfere to create beats.

Procedures

1. Download the free, open source software (FOSS) program Audacity from

   www.audacityteam.org and install it. Have Mr. Renwick authorize the installation.

2. Under the "Generate" menu, click "Tone…"

3. For each of the 4 waveforms (sine, square, sawtooth, square no alias)

   a. Set the frequency to 440 Hz, also known as A440

      (en.wikipedia.org/wiki/A440_(pitch_standard)), which is the musical note A above

      middle C.

   b. Set the amplitude to 0.8, and the duration to 10 seconds, and click "OK".

   c. Zoom in on the graph of the waveform, until the line becomes a series of

      individual points.

   d. Play the tone, and listen to its characteristics.

   e. Delete the tone by clicking the "x" in the top-left corner.

4. Generate a sine wave tone with a frequency of 440 Hz, amplitude of 0.8, and duration of

   10 seconds.

5. Click outside the waveform that was just generated to de-select the tone.

6. Generate a sine wave tone with a frequency of 442 Hz, amplitude of 0.8, and duration of

   10 seconds. You should now have two waveforms in the program window.

7. Play the tones together. Watch the elapsed time, as well as the "Playback Level" toolbar

   (which shows the current volume in decibels).

8. Delete the second waveform, and then click outside the first waveform to ensure it is

   de-selected.

9. Generate a sine wave tone with a frequency of 438 Hz, amplitude of 0.8, and duration of

   10 seconds. You should now have two waveforms in the program window.

10. Play the tones together. Watch the elapsed time, as well as the "Playback Level" toolbar (which shows the current volume in decibels).

11. Generate beats with a 440.5 Hz tone and a 440 Hz tone.

12. Generate a 60-second long 440 Hz tone and another tone, such that the resulting beats has a period of 60 seconds.

13. Generate a 440 Hz tone, and another tone, such that the resulting beats have the highest possible frequency.

14. Select a section of one of the waveforms, and click the "Analyze" menu, then "Plot Spectrum...". There should be a huge spike at the fundamental frequency of the waveform (and no other spikes).

15. For fun: Try to create a square wave. This can be done by creating an infinite sum of sine wave tones.

    a. The first tone should have the same frequency as the square wave you want to create. It should also have an ampitude of 0.8.

    b. The second tone should have 3 times the frequency of the first tone, and 1/3 the amplitude of the first tone.

    c. The third tone should have 5 times the frequency of the first tone, and 1/5 the amplitude of the first tone.

    d. Continue for at least 7 overtones.

16. For fun: Try to sing a perfect note. Using Audacity, record yourself singing (ideally a single note). Select a section of the recorded waveform where you were singing well, and click the "Analyze" menu, then "Plot Spectrum...".

    a. You should be able to see a large peak at the fundamental frequency (first harmonic), and smaller peaks at other frequencies.

    b. If the smaller peaks are at exact multiples of the fundamental frequency, they are probably overtones.

    c. If the smaller peaks are not at exact multiples of the fundamental frequency, it is

    probably noise in the recording.

Questions

1. For the four different waveforms (sine, square, sawtooth, square no alias), what similarities and differences do you notice:

   1. in the graphs of the waveform?

   2. in the sounds of the waveform?

2. You generated a tone using 440 Hz and 442 Hz.

   1. What was the frequency of the generated beats?

   2. What was the period of the generated beats?

   3. If it is 24 °C in the classroom, what is the wavelength of the generated beats?

3. You generated a tone using 440 Hz and 438 Hz.

   1. What was the frequency of the generated beats?

   2. What was the period of the generated beats?

4. You generated a tone using 440 Hz and 440.5 Hz.

   1. What was the frequency of the generated beats?

   2. What was the period of the generated beats?

5. What frequency tone, paired with a 440 Hz tone, generated beats with a period of 60 seconds?

6. What other frequency tone would have generated beats with the same period?

7. What frequency, pair with a 440 Hz tone, generated beats with the highest frequency? What was the frequency of the beats??

8. Why do beats occur?