Lab 15: Sound Waves and Beats

**Equipment:** Verneir LabPro, microphone, LoggerPro, electronic keyboard, tuning fork and banger, musical instruments

In this experiment we will measure the frequency and wavelength of sound waves from several different sources, and observe beats between sound waves of different frequencies and determine the beat frequency.

**Background**

Sound waves consist of a series of air pressure variations. A microphone diaphragm records these variations by moving in response to the pressure changes. The diaphragm motion is then converted to an electrical signal. Using a microphone and a computer interface, one can explore the properties of common sounds.

We can study this phenomenon with a microphone, lab interface, and computer. You are going to measure is the period (T) and frequency (f) of a tuning fork from both the number of cycles, from a sinusoidal curve fit, and also by using Fourier’s transformation technique, which gives power spectrum from frequency data. Recall that T is defined as the time for one complete cycle of repetition. Since period is a time measurement, it is usually written as T. The reciprocal of the period (1/T) is called the frequency, f, and the number of complete cycles per second. Frequency is measured in hertz (Hz). 1 Hz = 1/sec

When two sound waves overlap, their air pressure variations will combine. For sound waves, this combination is additive. We say that sound follows the principle of linear superposition. Beats are an example of superposition. Two sound waves of nearly the same frequency will create a distinctive variation of sound amplitude (loud and faint), which we call beats. The beat frequency is the difference between the two wave frequencies.

You will also determine the periods and frequencies of flute sounds/tones produced on the lab electronic keyboard’s keys: lowest C, C-sharp (C♯), and D.

Note: Your keyboard may not have the lowest C at the same key. That’s ok, you can either find the low C if you're musically inclined or use whatever note you get when playing the fifth white key from the left.
Part 1: Tuning Fork

1. Connect the Vernier microphone to Channel 1 of the LabPro, and connect to the computer.
2. Open the Logger Pro file “Sound”. The program will display a graph of sound wave pressure (in arbitrary units) versus time. It will only collect data for a short period of time to display the rapid pressure variations in sound waves.
3. Strike a tuning fork with the banger and collect the sound. Keep trying until you get a nice waveform with at least 10 periods in your graph. Find the time for 10 cycles, and use this to calculate the period and frequency of the sound wave generated by the tuning fork. Copy and paste your waveform into the lab report.
4. Use the “f(x)” button to do a sine curve fit to the waveform. The coefficient B is equal to $2\pi f$. Use B to find the frequency based on your fit.

Part 2: Keyboard

1. Select the flute sound on the keyboard, and capture the wave pattern on the screen for the lowest C (fifth white key from the left end on the keyboard). Hold the keyboard close to the microphone, and click “Collect”. The data should be sinusoidal in form. Count and record the total time for ten complete cycles and determine the period and fundamental frequency for the sound wave. Calculate the frequency in hertz (Hz) and record it in your data table. Copy and paste your wave form into your lab report.
2. Repeat the above procedure for the C-sharp - C# (the black key to the right of the lowest C – it is often called C-sharp.) on the keyboard and for the lowest D (the white key to the right of the lowest C, which is then 5th white key from the left end of the keyboard). Copy and paste your waveform into your lab report.
3. Adjust the maximum time on the horizontal axis to 0.2 s and change the data collection length (under menu item Experiment) to 0.2 s. Capture the wave pattern on the screen when the lowest C and C# are played together on the keyboard, and copy and paste it into your lab report. Determine the time for one beat and the beat frequency using $f = \frac{1}{T}$. Compare (% difference) with the expected beat frequency using the values of frequencies found in the previous steps.
4. Repeat the above procedures for the lowest C and D played together on the keyboard.

Part 3: Other Sounds

1. Now digitize 5 more sounds of your choosing such as jangling your keys, humming, singing, playing a sound from your phone, etc.
2. Copy and paste the waveforms for each sound into your lab report, and label them in your report with any comments you have on the shape of the waveform (was it expected or unexpected? Etc.)
3. Try to determine the frequency of each sound wave, and write a brief explanation of how you did so for each sound.
Analysis/Conclusions
1. Based on the graphs you collected using LoggerPro, what is your uncertainty in the
time periods and frequencies you measured for the various sound waves?
2. Look closely at the tuning fork: it should have the frequency stamped on it. What is the
percent error between this frequency and the measured frequency from LoggerPro?
3. What is the percent error between the printed frequency and the frequency you
measured from the sine curve fit in LoggerPro?
4. Which do you think is more the more accurate measurement method: finding the
frequency by counting oscillations, or doing the curve fit? Explain your reasoning.
5. Considering the other sounds you measured (not the keyboard or the tuning fork), for
which one was it easiest to measure the period and frequency? Which one was the
most difficult? Why do you think this is so?