Tones, Vowels, and Telephones

Purpose: To use a microphone and computer to observe and analyze the waveforms of several common sounds
To study the sounds made by a touch tone phone dialer

Equipment: 256 Hz tuning fork attached to resonance box, rubber hammer, microphone, computer with Logger Pro software, lab pro interface, cell phone (supplied by student)

Introduction:

The frequency of a vibration is the number of times the vibration occurs each second. The period of vibration is the length of time it takes to complete a vibration. The two are related in the following way:

$$1) \qquad \textbf{frequency} = \frac{\textbf{1}}{\textbf{period}}$$

When an object vibrates, it disturbs the surrounding air with the same time variation as the vibrations of the object itself. For example, if a tuning fork vibrates at a frequency of 256 Hz, the nearby molecules of air are shaken at this same frequency. As these molecules vibrate, they disturb their nearby neighbors who pass on the disturbance to their neighbors, etc. In this way, the energy of the original disturbance can travel rapidly through the air and contain the same frequency as the tuning fork that originated the "sound wave." When the wave arrives at our ears, the eardrum is vibrated (at this same frequency) and the energy associated with this vibration is converted into nerve impulses that are interpreted by our brain as sound. If instead, the sound wave enters a microphone, a small crystal is vibrated which in turn produces an electrical voltage with the same time variation as the vibrating tuning fork. Obtaining such a voltage is often desirable since it is then easy to amplify (to make a louder sound) or analyze the wave in other ways. In this experiment we will do the latter by studying the shape, frequency, and amplitude of a sound wave using the computer to analyze the electrical signal produced by such a microphone.

Procedure:

1. Gently strike the tuning fork with the rubber hammer and listen to the tone. Does it sound similar to any musical instrument that you are familiar with? With the microphone connected to the LabPro Interface, Channel 1, start up the Logger Pro software on the computer. (Double click on the **Logger Pro** icon located in the **Physics Apps** folder.)
   Click on **File/Open/Sound/Sound Analysis** to open the experimental file that you will use in this experiment. You should see a window containing two graphs. One labeled "Sound Waveform" and the other "FFT." Take a minute and examine the axis labels and units on each graph. This should give you an idea of what these graphs are designed to display.
2. With the microphone placed near the opening of the resonance box, strike the tuning fork again. Click on the [Collect] icon allowing the computer to begin collecting data. Observe the wave form. It should have a smooth, wavelike (sinusoidal) appearance with very little clutter. There should be about twelve cycles of the wave visible. Now, click on the "x=" icon, , (on the menu bar at the top of the window) and using the mouse, move the cursor along the wave form. Point the cursor at the crest of the first cycle and record the time when this occurred. Move the cursor down the wave ten cycles and as before, find the time when the wave reaches this (11^{th}) crest. If you subtract the two times, you have the time interval for ten cycles. Now, divide this time by the number of complete cycles (ten) between the two crests and you have the time for one cycle (called the period of the wave). Calculate the frequency of the wave using equation 1 above and record your data in the table.

Time at 1st crest T_1 (s)	Time at 11^{th} crest T_2 (s)	time interval $\Delta T = T_2 - T_1$ (s)	period $T = \Delta T/10$ (s)	frequency $f = 1/T$ (Hz)	FFT frequency (Hz)

3. Take a look at the FFT graph displayed on the computer monitor. This shows the frequencies and amplitudes of the individual waves that a complex waveform may contain. In the case of the simple wave produced by our tuning fork, there should only be one frequency. Record this "fundamental" frequency (calculated by the computer) and see how it compares to your calculated frequency found in step 2. Obtain a printout of the two graphs by clicking on the printer icon at the top of the window. Include these graphs in your lab report.
4. Hold the microphone near your mouth and say the vowel "eeeeeeeee….", extending the sound while you click the Collect button. Look at the waveform displayed and click on **stop** when you have a good display. Examine both the waveform and the FFT graph. How does each differ from what you saw for the tuning fork? Obtain a printout of these graphs.

5. Repeat step 4 while saying the letter "o" in a similar manner.

6. In this part of the experiment you will analyze the sound made by a telephone tone dialer. Hold the speaker of the dialer near the microphone and press the "1" button on the dialer. Collect sound data with the computer as you have done before. If you look at the FFT graph you should see two dominant frequencies present. Record these frequencies in the data table below. Also obtain a printout of the graphs.
7. Repeat step 6 for each of the digits 2-9 on the phone dialer. No printouts are necessary, but do record your frequencies in the data table.

Button	1	2	3
Low frequency (Hz)			
High frequency (Hz)			
Button	4	5	6
Low frequency (Hz)			
High frequency (Hz)			
Button	7	8	9
Low frequency (Hz)			
High frequency (Hz)			

Questions:

1. Examine the data for the phone dialer. Do you observe a pattern? Explain.

2. Which frequency is higher, the row frequency or the column frequency?

3. Summarize how the telephone company tells what numbers you have pressed when you make a phone call.