# Lab 2: Sound Interference and Frequencies

## *Part A – Beats*

1. Two pure tones with different frequencies sounded at once will create the phenomenon known as beats. Sometimes the waves will reinforce one another and other times they will combine to a reduced intensity. This happens on a regular basis because of the fixed frequency of each tone.

   You may observe the beat phenomenon both by using two tuning forks and by using a tone generator program. To listen to beats with a tone generator, open the program "Audacity". Open the "*Generate" pull-down menu*, then click on "*tone"* and choose the frequency you would like to hear. Create a new track (*Tracks -> Add New -> Audio* Track). Generate a second tone in your new track; this time selecting a different frequency than before. Pick two frequencies about 10 Hz apart from one another. If the beats are slow enough, you should be able to hear a variation in intensity. When the beats are too rapid to be audible as intensity variations, a single rough-sounding tone is heard. At even greater frequency differences, two separate tones may be heard, as well as various difference tones.

2. To capture the beats it is necessary to collect data for a long enough period of time.
   a. In LoggerPro, Go to "*Experiment"*, then "*Data Collection"*. Change the data-collection rate to 2500 samples/second and the data-collection length to 0.2 seconds.
   b. Select "*Done"*.

3a. First, strike two tuning forks at the same time, put them both next to the microphone and start the LabPro data acquisition.

3b. After you've acquired data from the tuning forks, start the two tones playing in Audacity, then start the LabPro data collection.

4. For each part (3a and 3b), note the shape of your waveform graph. You should see a time variation of the sound amplitude. The pattern will be complex, with a slower variation of amplitude on top of a more rapid variation. Ignoring the more rapid variation and concentrating on the overall pattern, count the number of amplitude minima after the first minima and record it in the data table.

5. Record the times for the first and last amplitude maxima, found in the spreadsheet on the left. Divide the difference, $\Delta t$, by the number of cycles to determine the period of beats (in s). Calculate the *beat frequency* in Hz from the beat period. Record these values in your data table.

| Number of cycles | Time of first min (s) | Time of last min (s) | $\Delta t$ (s) | Beat Period (s) | Calculated beat frequency (Hz) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

## ANALYSIS

1. How is the frequency of the beats related to the frequencies of the tones that you generated in Audacity? Compare your conclusion with information given in your textbook.

2. Attempt the experiment again with different tones and see if you get the same result. Finally, try three or more tones at a time to see if you obtain an understandable pattern.

## PART B - TONES, VOWELS AND TELEPHONES

In this experiment, you will analyze various common sounds. You will use a Microphone connected to a computer. Logger *Pro* will display the waveform of each sound, and will perform a Fast Fourier Transform (or FFT) of the waveform. The FFT tells you the amplitudes and frequencies of a collection of sine waves that, when added together, would sound the same as the original waveform.

In the first part of the experiment, you will study the sound of a tuning fork which produces a tone composed mainly of a single frequency. Next, you will observe the production of *overtones* on a tuning fork. Overtones whose frequencies are multiples of the fundamental are called harmonic; other overtones are called inharmonic. You will also analyze the sound produced when you say two vowels. An FFT graph will reveal that your voice is composed of a large number of individual frequencies.

In the last part of the experiment, you will be given a problem to solve. How does the telephone company know what numbers you dial on touch tone phones? Do those tones that you hear when you press the buttons on the telephone contain some kind of code? You can solve this problem and crack the code using the Microphone, the FFT analysis, and an inexpensive tone dialer.

## OBJECTIVES

- Use a Microphone to analyze the frequency components of a tuning fork and your voice.
- Record overtones produced with a tuning fork.
- Examine how a touch-tone phone works.

## PRELIMINARY QUESTIONS

1. Strike one of the tuning forks with a rubber mallet or the bottom of a rubber-soled shoe. Do not hit the tuning fork on a hard surface; doing so may damage the tuning fork. Listen to the sound. Now press a single number on the number keypad of your cell phone. Which sound do you think is more complex? Explain your answer.

2. Compared to the tuning fork and the tone dialer, is the sound of a person humming a simple or a complex sound?

### *PROCEDURE*

**Part I Pure Tone**

1. Connect the Vernier Microphone to Channel 1 of the interface.

2. Open the file "34 Tones Vowels Telephone" in the *Physics with Vernier* folder. The display will include both a graph and an FFT.

3. Gently strike a tuning fork with a rubber mallet and hold it near the Microphone. Click Collect to begin data collection. If you strike the fork too hard, it will create overtones, or a blend of higher frequencies in addition to the main frequency.

4. Click the Examine button, , and scan across your data to determine the average time interval between adjacent peaks, or one complete cycle. Record this value in your data table.

5. Calculate the frequency and record it in the data table.

6. As you move the mouse across the FFT graph, record the predominant frequency as displayed.

7. Repeat Steps 3–6 with the second tuning fork.

**Part II Overtones on a Tuning Fork**

8. All tones generated by vibrations will have overtones present. However, in "good" oscillators, the overtones will damp out relatively quickly, leaving only the fundamental frequency. To catch the overtones in the tuning forks, you'll need to record the data before the overtones die out.

9. Go to Experiment, then *Store Latest* Run. Strike the tuning fork repeatedly with the rubber mallet until the tone is rather loud and hold it near the Microphone. Click Collect to begin data collection as soon as possible after your last strike.

10. Compare the waveform and the FFT to the ones produced in Part I. Click the Examine button, . Move the mouse cursor across the FFT graph and determine the fundamental frequency and the first overtone. Record these values in the data table. ***Challenge: How many overtones can you record?***

**Part III FFT of Two Vowels**

11. Hold the Microphone near your mouth, say the vowel "e" and hold it while you click the Collect button. Print a copy of the graph and FFT graph and glue it into your notebook.

12. Go to Experiment, then *Store Latest* Run. Repeat Step 11 and this time say "o".

**Part IV Telephone Dialer Frequencies**

13. In this part of the experiment, you will analyze the sound made by a telephone tone dialer. You will use a Java applet that generates telephone tones.

Go to the website: http://faculty.bennington.edu/~hcrowl/phonedialer.html

You will need to set up LoggerPro to collect data data upon triggering. Go to "*Experiment"*, then "*Data Collection"* Turn triggering ON, then set the trigger to sound pressure increasing past 2.7. You may need to try several trigger levels to get it to collect the data properly.

Hold the microphone near the computer speaker, click Collect to begin data collection, then press the "1" button. Use the FFT display to find and record the two predominant frequencies for this sound.

14. Repeat Step 14 for numbers "2" through "9".

## DATA TABLES

**Part I Pure Tone**

| | | Tuning fork 1 | Tuning fork 2 |
|---|---|---|---|
| Frequency stamped on tuning fork | (Hz) | | |
| Period from waveform | (s) | | |
| Frequency from waveform | (Hz) | | |
| Frequency from FFT graph | (Hz) | | |

**Part II Overtones on a Tuning Fork**

| | | |
|---|---|---|
| Frequency stamped on tuning fork | (Hz) | |
| Fundamental frequency | (Hz) | |
| Overtone frequency | (Hz) | |

**Part IV Telephone Dialer Frequencies**

| 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) | | | |

## ANALYSIS

1. For each tuning fork, compare the frequency calculated from the waveform and the FFT to the value stamped on the tuning fork.
2. Describe the difference in the frequency structure between the two vowels examined in Part III.
3. Examine the data for the tone dialer. What pattern do you observe?
4. Which frequency is higher, the row frequency or the column frequency?
5. What is the row frequency for the 4, 5, and 6 buttons?
6. What is the column frequency for the 2, 5, and 8 buttons?
7. Summarize how old school touch tone phones knew what numbers you pressed.