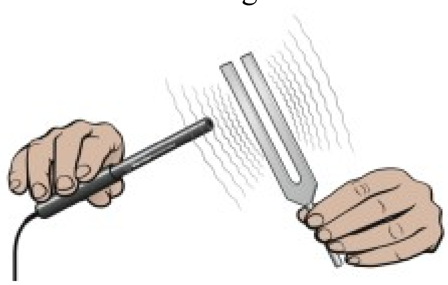
#31 Tones and Vowels

Purpose: The object of this experiment is to analyze various common sounds.

Introduction
In Part A of this experiment, you will study the sound of a tuning fork, which produces a pure tone composed mainly of a single frequency. Next, you will observe the production of overtones on a tuning fork (Part B). Overtones whose frequencies are multiples of the fundamental are called harmonic; other overtones are called inharmonic. Finally, you will analyze the sound produced when you say two vowels (Part C).

Apparatus:
To analyze various common sounds (like a tuning fork and your voice), you will use a Microphone connected to a computer. The data-collection program will display the waveform of each sound, and will perform a Fast Fourier Transform (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.



Procedure
Part A: Using a Tuning Fork to Produce a Pure Tone

1. Connect the Microphone to LabQuest and choose New from the File menu.

2. Choose Data Collection from the Sensors menu and extend the duration to 0.2 s

3. Gently strike a 256 Hz tuning fork against the bottom of a rubber-soled shoe or a rubber mallet and hold it near the Microphone. Start 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. Tap and drag across a region of the graph to highlight it.

5. Choose Zoom In from the Graph menu.

6. Sketch the wave that you observe.

7. To examine the displayed graph, tap any data point. As you tap each data point, sound pressure and time values will be displayed to the right of the graph. Scan across your data to determine the average time interval between adjacent peaks, or one complete cycle. Record this value (period from waveform) in the data table.

8. Calculate the frequency (in Hz or s^{-1}) and record it in the data table.
Frequency = 1/period from waveform

9. Determine the predominant frequency using the FFT.

a. Choose Advanced from the Analyze Menu, then choose FFT.

b. Tap and drag your stylus across the region that contains the predominant frequency and zoom in on the region.

c. As you move across the graph, magnitude and frequency values are displayed below the graph. Record the predominant frequency from FFT graph in the data table.

d. Select OK.

10. Repeat Steps 3-9 using a 512 Hz tuning fork.

<u>Part B: Overtones on a Tuning Fork</u>

1. In this part, you will make the 256 Hz tuning fork produce an overtone. This time strike the tuning fork on your knuckle and listen to the sound. Describe the difference.

2. Strike the 256 Hz tuning fork on your knuckle and hold it near the Microphone. Start data collection.

3. Follow the method described in Step 9 of Part A for generating the FFT.

4. Compare the waveform and the FFT to the ones produced in Part A. Use the Part A procedure to determine the fundamental frequency and the first overtone frequency. Record these values in the data table.

<u>Part C: Fast Fourier Transform (FFT) of Two Vowels</u>

1. Hold the Microphone near your mouth, say the vowel "e" and hold it while you start data collection.

2. Follow the method described in Step 9 of Part A for generating the FFT.

3. Sketch copies of the graph and FFT graph.

4. Hold the Microphone near your mouth, say the vowel "o" and hold it while you start data collection.

5. Follow the method described in Step 9 of Part A for generating the FFT.

6. Sketch copies of the graph and FFT graph.

Data and Results (Tones and Vowels)

Name(s) ____

Part A: Using a Tuning Fork to Produce a Pure Tone

Sketch of wave observed:

	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 B: Overtones on a Tuning Fork

Sketch of wave observed:

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

Part C: Fast Fourier Transform (FFT) of Two Vowels

Sketch of wave observed for the vowel “e”:

Sketch of wave observed for the vowel “o”:

Questions:

1. For each tuning fork, compare the frequency calculated from the waveform and the FFT to the value stamped on the tuning fork.

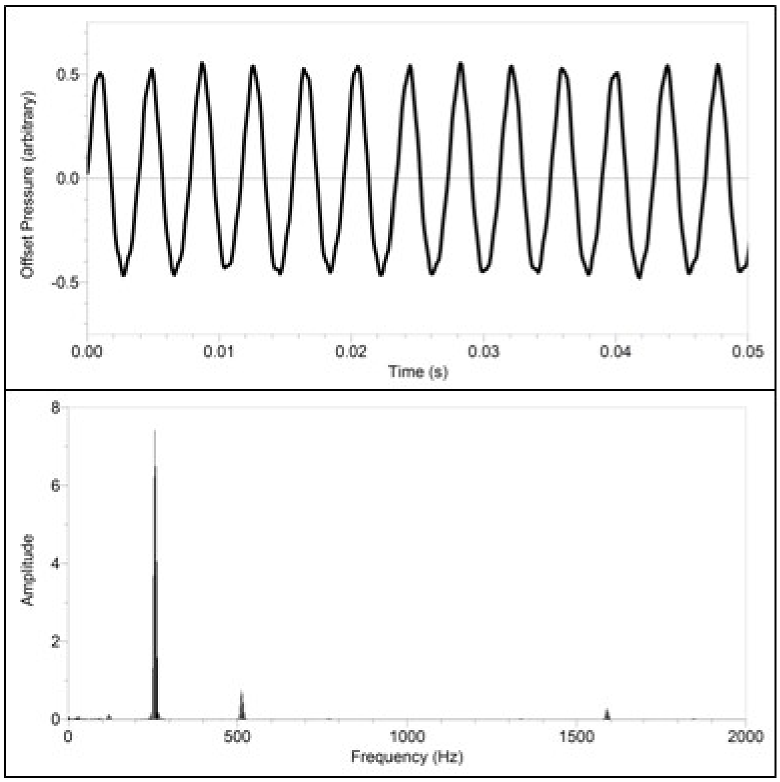
2. Describe the difference in the frequency structure between the two vowels examined in Part C.

Instructor's Guide
Tones and Vowels

(**Data and Results**)

Part A: Using a Tuning Fork to Produce a Pure Tone

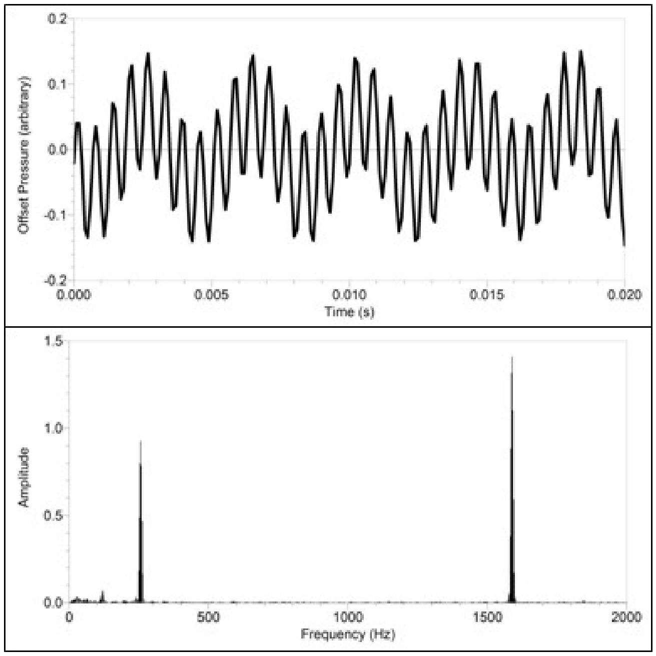
Sketch of wave observed:



	Tuning Fork 1	Tuning Fork 2
Frequency stamped on tuning fork (Hz)	**256**	**512**
Period from waveform (s)	**0.00387**	**0.00175**
Frequency from waveform (Hz)	**258**	**571**
Frequency from FFT graph (Hz)	**250**	**516**

Part B: Overtones on a Tuning Fork

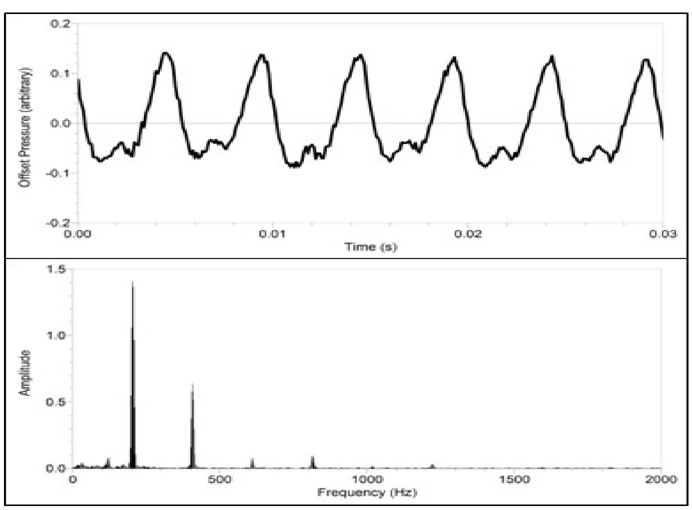
Sketch of wave observed:



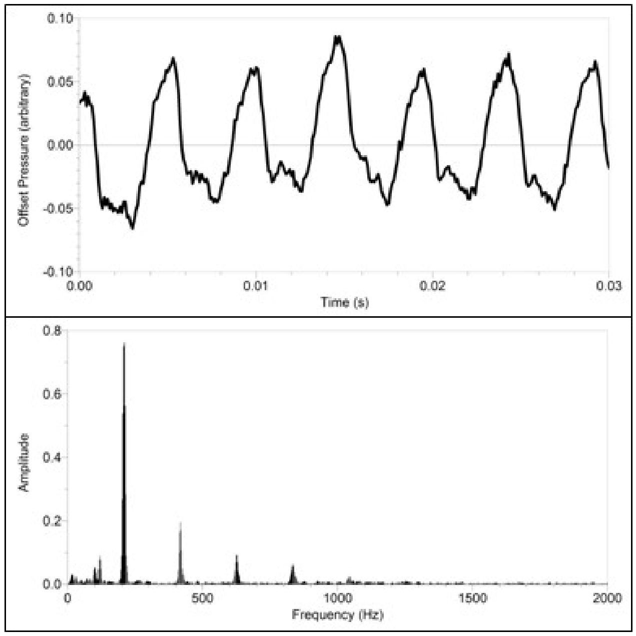
Frequency stamped on tuning fork (Hz)	**256**
Fundamental frequency (Hz)	**250**
Overtone frequency (Hz)	**1578**

Part C: Fast Fourier Transform (FFT) of Two Vowels

Sketch of wave observed for the vowel "e":



Sketch of wave observed for the vowel "o":



Questions:
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 C.

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1. *The frequencies should be close to the same.*

2. *The "o" sound is brighter, with stronger high-frequency components, then the "e" sound (see sample graphs in Part C of the sample results).*

Instructor's Guide
Tones and Vowels (cont'd)

Time: 45 minutes This includes data collection and analysis for this experiment.

Equipment and Materials: Per group:

Items	**Number**	**Comment**
LabQuest	1	Vernier
Vernier Microphone	1	
Tuning forks	2	suggested: 256 Hz and 512 Hz
Rubber mallet	1	optional

Ideas/ Information

1. When using a tuning fork to produce a pure tone, it is important to strike the tuning fork softly. Use a soft rubber mallet, the rubber heel of a shoe, or the fleshy part of the hand. Students should not strike hard objects like the tabletop, since that produces overtones and can damage the tuning fork.

2. Use tuning forks in the range of 256 to 512 Hz. Overtones are easy to produce on lower frequency tuning forks. Overtones on a 512 Hz tuning fork die out quickly.

3. Most tuning forks, when struck on a slightly harder object, produce the fundamental tone and one strong overtone.