Sound Waves and Beats

Objectives

In this lab you will

- measure the amplitudes and periods of sound waves emitted from tuning forks using the Vernier Microphone.
- observe the phenomenon of beats and measure the beat frequency.
- plot your data and analyze it using the Vernier Logger Pro™ software.

Equipment

Vernier Microphone, cable adaptor, Vernier LabPro™ system (includes computer and Logger Pro™), set of tuning forks (notes B, C, E), and a rubber mallet.

Theory

Waves are shapes that transfer energy and momentum without transferring mass. Specifically, sound waves are pressure waves that travel through a medium, such as air. A pure musical note is a sound wave of a single frequency represented by a sine or cosine:

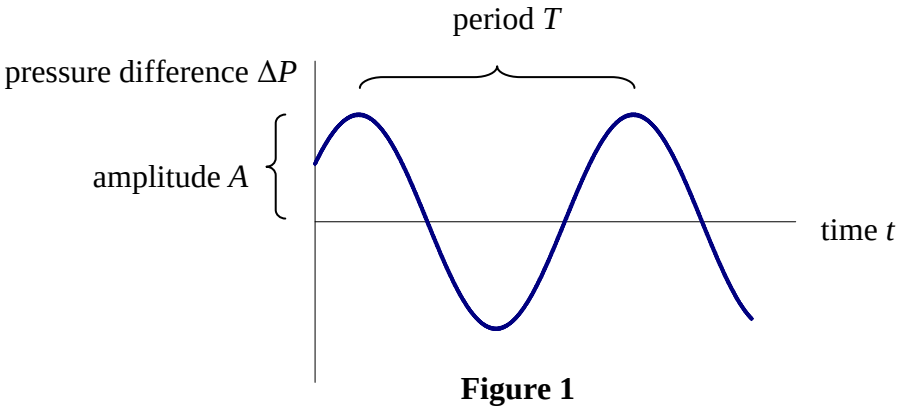


Figure 1

The equation describing this shape is

$$\Delta P = A\sin(2\pi ft + \varphi) \qquad \textbf{Equation 1}$$

where $f = 1/T$ is the frequency and φ is the phase shift. When two sound waves of similar frequencies f_1 and f_2 combine, the phenomenon of *beats* occurs: a distinctive "wa-wa" sound is heard with a frequency

$$f_{beat} = |f_1 - f_2| \qquad \textbf{Equation 2}$$

Procedure

1) Connect the microphone with the cable adaptor to Channel 1 of the Vernier interface. Open the "21 Sound Waves" file from the "Physics with Computer" file. You ought to see a Pressure-Time graph. Click on the ZERO button to center the waveforms.

2) Use the rubber mallet to strike the C tuning fork and hold it close to the microphone (see Photo 1). Click the Collect ▷ button and you should see a sinusoidal function. Do not strike the tuning fork too hard – you may generate overtones (*i.e.* higher-frequency waves on top of your fundamental wave). Save your graph for the C fork and print it.

3) Use the X button to explore your graph. Click and drag between two consecutive crests. The period T is the time interval between these two crests. Record T in Data Table 1 and calculate $f = 1/T$.

4) Click and drag between the first crest and last crest shown on your graph. Find the time interval Δt. Count the number N of complete cycles that you have in this interval. Calculate the period as $T = \Delta t/N$ and record your result in Data Table 2.

5) Click and drag from a crest to an adjacent trough on your graph. The pressure difference equals $2A$. Divide your measurement in half and record A in Data Table 3.

6) Repeat the experiment for the E fork (f = 320 Hz) and save your graph for the E fork.

7) Open the file for the C fork and highlight a large section of your graph. Use the Curve Fit button and choose the sine function: A*sin(Bt+C)+D (see Graph 1). Record A in Data Table 3 and B in Data Table 4. Repeat for the E fork.

8) Now strike the B and C forks simultaneously and collect data. You have to strike them equally hard and hold them at the same distance from the microphone. You should see the variation of pressure amplitude (see Graph 2). Save your data and print the graph of the beats.

9) Use the X button to find the time interval for one complete cycle. Record the beat period and the corresponding beat frequency in Data Table 5.

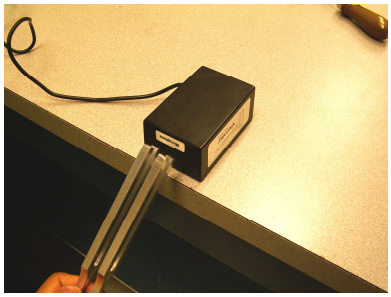
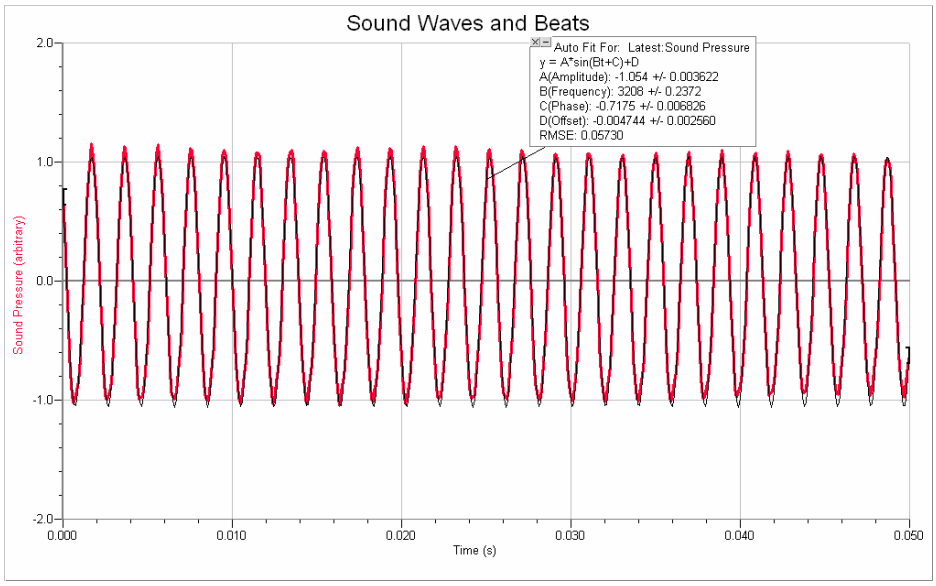
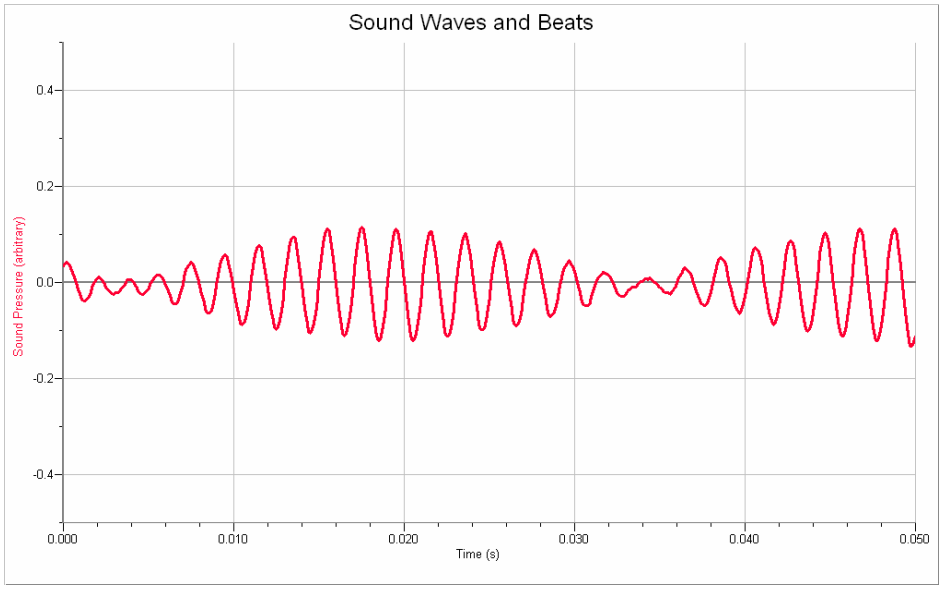


Photo 1

Each student is required to submit a completed data sheet in order to receive full credit. Your lab group needs to submit only two Pressure-Time graphs. These graphs are to be stapled to the data sheet of one of your lab partners – Each lab partner does not need to submit his/her own set of graphs.



Graph 1



Graph 2

Data Sheet – Sound Waves and Beats

Name _____ Date _____

Partners' Names _____

Accepted Values for Frequency:
B fork 480 Hz C fork 512 Hz E fork 320 Hz

Data Table 1 Using X button Calculated

Fork	Period [sec]	Frequency [Hz]	% error in freq.
C			
E			

Data Table 2 Using $T = \Delta t/N$ Calculated

Fork	Period [sec]	Frequency [Hz]	% error in freq.
C			
E			

Data Table 3 Using X button From Curve Fit

Fork	Amplitude [arb]	A value [arb]	% error in *A*
C			
E			
	"Measured *A*"	"Accepted *A*"	

Data Table 4 From Curve Fit Calculated

Fork	B value [rad/s]	Frequency [Hz]	% error in freq.
C			
E			

Data Table 5 Using X button Calculated

Forks B and C	Beat Period [sec]	Beat Freq. [Hz]	% error in f_{beat}
Trial 1			
Trial 2			