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TEACHER INFORMATION

Stay Tuned: Sound Waveform Models

1. When using a Microphone, it must be connected to a CBL 2 or LabPro and not directly to the calculator using an EasyLink. The use of the Microphone, requires data be collected at a rate that surpasses the EasyLink's 200 pts/sec capability.

2. A tuning fork of relatively low frequency works best. Use tuning forks with frequencies between 256 and 300 Hz for best results.

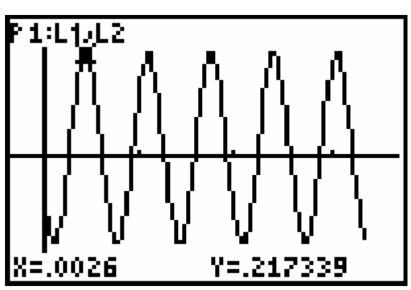
3. You may want to introduce the term *sinusoidal curve* to your students as a curve which has an equation of the form $y = A\cos(B(x - C))$. Many books use the form $y = A\cos(Bx + C)$. Written the latter way the parameter C is an angular offset, while in the first form C is a time offset. The time offset is easily determined from the graph, so the first form is used in the activity. The latter form is more difficult for most students to understand, but could be used if you prefer it.

4. Data collection is very brief; the fork or keyboard must be sounding when data collection begins.

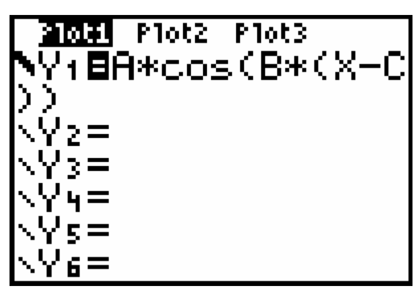
5. Use a rubber mallet (or the sole of a rubber shoe) to strike the tuning fork to obtain a clean sinusoidal curve. If the fork is struck on a hard surface there will be overtones, which will yield a rough waveform. Note that the fork must be loud enough to hear. If you can't hear the fork over the room noise, neither can the microphone.

6. An inexpensive electronic keyboard is an excellent substitute for the tuning fork. The flute setting will give a sine waveform. Turn off any vibrato to obtain clear frequency measurements. It is easier to obtain consistently good waveforms with a keyboard than a tuning fork. Middle C will produce a frequency of about 263 Hz, appropriate for this exercise.

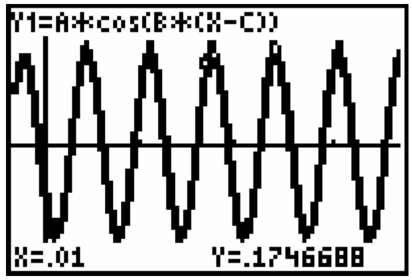
SAMPLE RESULTS



Raw data



Model equation



Waveform with model

DATA TABLE

period (s)	0.00390
amplitude A	0.22
time offset C	0.026
frequency (measured)	256 Hz
frequency (marked)	256 Hz

ANSWERS TO QUESTIONS

1. The model fits the sound waveform data quite well. The model equation is $y = 0.22\cos(1607(x - 0.026))$.

2. Frequency and period are inversely related.

3. The waveform would be taller if plotted on the same scale, if the sound produced were louder. This could be accomplished by making the fork sound louder or moving the microphone closer to the fork.

4. A higher frequency would create a shorter period, so there would be more cycles on displayed on the screen if the axis settings were the same.

5. Multiple values of C could create a good fit of the model. Since the graph repeats every time the period of time passes, additional values of C could be obtained from $C = C_0 + K$ (*Period*), where K is any integer and C_0 the original value. Using this formula and the sample data, a C of $0.010 + 0.0039 \cong 0.014$ would produce a plot looking just like the one shown above.

6. The amplitude A and the frequency parameter B are unchanged by the sine function substitution. Since the sine function is ¼ period behind the cosine function, we need to subtract ¼ of the period from the original C to adjust C for the sine function, or $0.010 - 0.0039/4 \cong 0.009$.

7. Graphing the sine function with the reduced value for C shows the discussion in question 6 to be correct; the fit is excellent and indistinguishable from the cosine fit.