

Behavior and Characteristics of Sound Waves

Equipment

1	Sound Sensor w/Extension Cable	CI-6506B
1	Open Speaker	WA-9900
2	4-mm Banana Plug Patch Cord	SE-7123
1	Tuning Fork	SE-7345
Required but not included:		
1	Musical Instrument	

Introduction

In this activity you will explore the characteristics of different sounds, the waves that produce sounds, and the fundamentals of frequency and harmonics within different sounds.

Background

We can hear many different types of sounds: the impact of a falling object, the clapping of hands, the sound of traffic, and the sounds produced by singers and other musicians are several examples. Each sound has different characteristics that make them different, but most sounds are alike in that they are produced by a vibration of some sort. Some vibrations are irregular, like a rock rolling down a hill, and some vibrations are regular, like vibration of a guitar string. We know that we can tell the difference between the sounds produced by different sources just by listening to them, but how do these differences appear in the actual sound waves themselves?



Figure 1: Devices Used to Make Different Sounds

Observing Sound Waves

Set-up

1. Connect the sound sensor to Analog Input A on the 850 using the sensor extension cord.
NOTE: You must connect the sound sensor to Analog Input A.
2. In PASCO Capstone, create an Oscilloscope Display and select Sound Intensity on the vertical axis. Change the Sampling Mode to Fast Monitor and set the sample rate to 40 kHz.

Procedure

1. Click the monitor button in the controls panel at the bottom of the screen to monitor the sound measured by the sound sensor.
2. Have two group members, one at a time, each make one different vowel sound ("EE", "OH", "AY", etc.) near the sound sensor and observe the shapes of the different sound waveforms produced. Try to carry (maintain) each sound as long as possible while group members observe.
3. Click stop when finished.
4. What were the types of sounds ("EE", "OH", "AY", etc.) and what were two similar characteristics between the two different sound waveforms seen in the oscilloscope display to the right? What caused these similarities?
5. What were two differences between the two different sound waveforms seen in the oscilloscope display to the right? What caused these differences?

Pure Tone

Background

A pure tone can be produced by different types of sound sources, such as a speaker, and is relatively pleasant to the human ear. However, pure tones have distinct waveforms and specific characteristics that are difficult for some sound sources, like a singer, to produce. In this part you will produce a pure tone using a speaker and observe the differences and similarities to the waveforms observed on the previous page.



Figure 2. Speaker Setup

Setup

1. Connect the speaker to Output Channel 1 on the 850 using the banana plug patch cords.

NOTE: You must connect the speaker to Output Channel 1.

2. Set the sound sensor and speaker on the lab bench and arrange the sensor so it faces the speaker, and is about 20 cm away, as in Figure 2.

Procedure

1. Click the monitor button to activate the speaker and simultaneously monitor the sound waveform generated by the speaker in the oscilloscope display to the right.
2. How does the pure tone waveform compare to the waveforms seen on the previous page? What are two characteristics of this waveform that are different from the waveforms observed on the previous page, and what produced these differences?
3. Click stop.

Tuning Fork

Prediction

Observe the tuning fork. When you strike the tuning fork softly with the rubber mallet a sound is produced as it vibrates. Do you think that the sound produced by the tuning fork is a pure tone? Why or why not?



Figure 3: Tuning Fork and Sound Sensor

Setup

1. Set the tuning fork on the lab bench and arrange the sensor so it faces the opening in the tuning fork box, and is about 20 cm away, as in the picture to the right.
2. Adjust the slides on each fork to the highest position.
3. Click the monitor button to begin monitoring the sound measured by the sound sensor, and then strike the tuning fork softly with the rubber mallet.
4. How does the waveform produced by the tuning fork compare to the pure tone waveform seen on the previous page? Does the tuning fork produces a pure tone?
5. Click stop.

Musical Instrument

Prediction

Your musical instrument can produce several different sounds (different notes/tones) depending on how you play it. How will the waveforms differ between different notes/tones, and will the waveforms match that of a pure tone? Explain your answers?



Figure 4: Guitar and Sound Sensor

Procedure

1. Hold the sound sensor near the instrument and then click the monitor button.
2. Play a high-pitched note/tone on the instrument and observe the waveform. Then play a low-pitched tone and observe the waveform. What is the biggest difference between the two waveforms?
3. How do both of the two waveforms compare to the waveform of a pure tone? What are some similarities and differences?
4. Click stop.

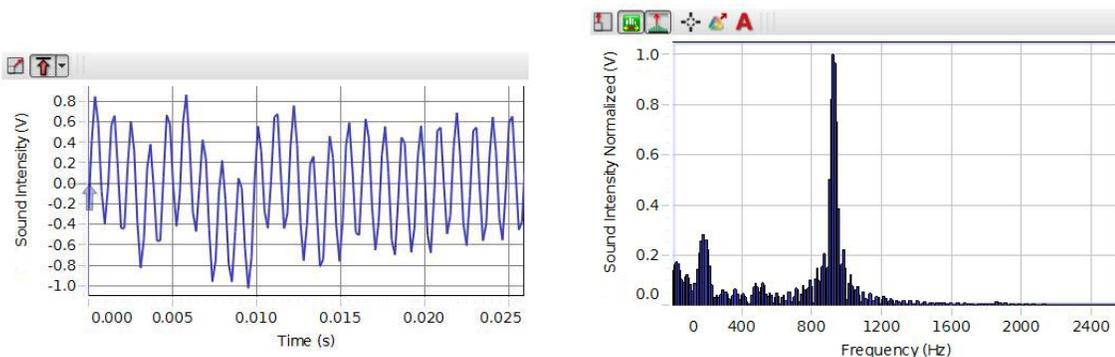
Harmonics-Instrument:

Background

Although a musical instrument can produce a sound pleasing to the human ear, it doesn't always produce a pure tone. In fact it is often the combination of different tones (different frequencies) that sounds most pleasing to the ear. Some sound sources will produce sound by vibrating at several different frequencies, all of which are an integer multiple of some fundamental (1st) frequency. This is known as harmonics.

Procedure

1. Create an FFT and select the Sound Intensity on the vertical axis.



Above are two displays: An oscilloscope that shows the sound waveform produced by the sound source, and an FFT that shows the frequency at which the sounds is emitted. When a sound is made, each spike in the graph indicates a sound being emitted at that frequency. Higher frequency means higher pitch, and lower frequency means lower pitch.

2. Set the sampling rate to 5 kHz.
3. Hold the sound sensor near the instrument and then click the monitor button.
4. Begin playing a low-pitched note/tone on the instrument and try to carry the note/tone as long as possible. Click stop while the tone is being played.
5. Observe the waveform and different frequencies that are produced by the instrument. Use the smart tool to measure the first four different frequencies and record the values.
6. Repeat the same procedure for a high-pitched tone. Use the smart tool to measure the first four different frequencies and record the value.
7. Divide each value in the High-Pitched Frequencies column by the lowest frequency in

that column. Record the results.

8. Divide each value in the Low-Pitched Frequencies column by the lowest frequency in that column. Record the results.
9. Are the calculated values approximately integer multiples of the fundamental (1st) frequency?

Harmonics-Voice

Procedure

1. Have one group member hold the sound sensor about 30 cm from her/his mouth while making the vowel sound "OH". Try to carry the sound as long as possible.
2. Click the monitor button to monitor the sound measured by the sound sensor.
3. Click stop while the sound is being carried.
4. Observe the waveform and different frequencies that are produced by the sound. Do you see harmonics within the sound? If yes, how many different harmonic frequencies do you see? If no, why do you think there aren't any harmonics?
5. What is the fundamental frequency?
6. Repeat the same procedure using the same vowel sound ("OH") but with a varying frequency from high-pitched to low-pitched. Did the number of harmonics change depending on the frequency? Explain why you think the number of harmonics did or did not change with varying frequency.
7. Using only sounds made using the mouth, repeat the same procedure and try to produce a continuous sound that has no harmonics.
8. Were you able to produce a sound without harmonics? If yes, what was the sound and why do you think it had no harmonics?

