Interference of Sound Waves

Equipment

1	Sound Sensor	UI-5101
1	Tuning Fork Set	SE-7342
1	Mini Speaker	WA-9605
1	Banana Cords	SE-9750
Required but not included:		
1	550 Universal Interface	UI-5001

Introduction

The purpose of this activity is to measure and analyze the behavior of two sounds that combine to produce beats. This activity also examines the relationship between the beat frequency and the frequencies of the two interfering sound waves.

Confirm that two sound waves of slightly different frequency will produce beats and that the beat frequency between two sound waves of slightly different frequency is the difference in their frequencies.

Background

In situations where waves with the same frequency overlap, the principle of linear superposition describes the constructive and destructive interference experienced by the resultant wave. The resultant wave amplitude changes based on the alignment of the troughs and peaks between the two constituent waves. The same theory holds true for two waves with similar phase, but different frequencies as seen in Figure 1a. Two overlapping waves with slightly different frequencies give rise to the phenomenon of beats.

A tuning fork has the property of producing a single-frequency sound wave when struck with a sharp blow. When two tuning forks with different frequencies are struck near each other, the sound waves produced by each will interfere with each other, causing the loudness of the resulting sound to rise and fall periodically: faint, then loud, then faint, then loud, and so on. These periodic variations in loudness are called beats and are the result of the superposition of the two sound waves as they travel through air as in Figure 1b.

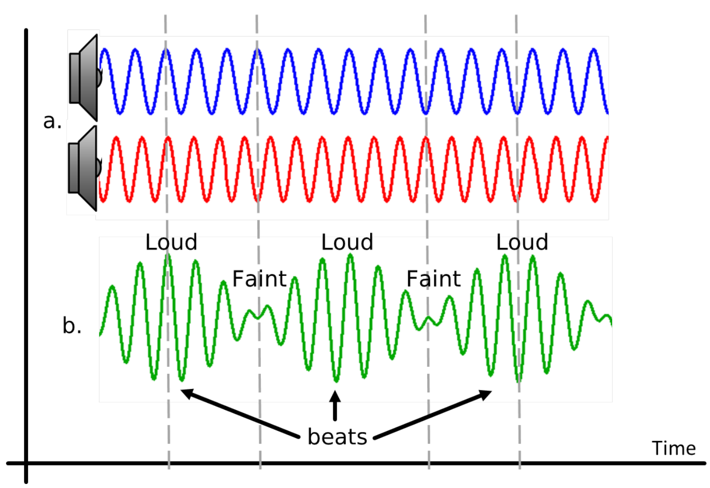

Figure 1. Interfering Sound Waves

Setup:

1. Connect the sound sensor to Analog Input A on the 550 Interface using the sensor extension cable.

2. Plug the Mini Speaker into the 550 Output using banana cables.

3. In PASCO Capstone, set the sample rate to 500 kHz. Create an oscilloscope of Sound Intensity vs. Time. Select the Monitor Mode.

4. Place the Sound Sensor on the table about 30 cm away from the speaker. Choose a tuning fork (for example, 512 Hz).

5. When creating beats, strike the tuning fork with a rubber hammer and hold the base of the tuning fork firmly against the table, about halfway between the speaker and the Sound Sensor (see Figure 2).

Figure 2: Setup

6. Open the signal generator in Capstone and set the frequency at 5 Hz below the frequency of the tuning fork (in the example, 507 Hz). Set the amplitude to 1 V. Set it on Auto.

Collect Data

1. Start monitoring. The speaker will output a sound.

2. Adjust the time axis on the oscilloscope until there is one complete wavelength. Then stop monitoring, click the Data Snapshot button at the top of the oscilloscope, and measure the time from peak-to-peak to determine the period of the wave. Use this value to calculate its frequency ($f = 1/T$). Record the frequency.

3. Turn off the Auto on the signal generator so the speaker will not sound. Repeat the two previous steps for the tuning fork. Record its frequency.

4. Turn on the Auto so the speaker will sound. Start monitoring.

5. To create beats, strike the tuning fork with a rubber hammer and hold the base of the tuning fork firmly against the table, about halfway between the speaker and the Sound Sensor (see Figure 2).

6. Adjust the time axis on the oscilloscope until you can see two complete beats (similar to Figure 1b). Then stop monitoring and click the Data Snapshot button at the top of the oscilloscope.

7. Create a graph of the oscilloscope snapshot data. Use the coordinates/delta tool in the graph display to help determine the frequency of the beats in the sound wave when both forks were struck. Record the value. What is the relationship between the beat frequency and the frequencies of the individual sound waves (f_1 and f_2)?

Conclusions

1. Describe, in complete sentences, the relationship between beat frequency in a combined sound wave and the frequencies of the two waves that are being combined.

2. Explain how the principle of beat frequency could be used to tune two musical instruments.

3. You have seen the combined waveform of two sound waves with different frequencies. Based on your data and experience, predict how a sound waveform would appear if it were the combination of three sound waves, each with a different frequency.