Sound Waves and the Speed of Sound

Purpose:

1. To become familiar with the use of a function generator and oscilloscope in the production and observation of sound waves
2. To measure the speed of sound

Equipment: Oscilloscope, function generator, 1 coaxial cable, 1 coax to banana adaptor, resonant tube apparatus, microphone, speaker, movable piston

Introduction Part I: As you have learned, sound waves send energy through a medium (such as air) by rapid variations in the pressure of that medium. For example, we can send sound waves in the form of speech from one person to another by vibrations of the vocal chords in the larynx of the person doing the speaking. Studying these waves can be a bit challenging since the pressure variations occur rapidly (hundreds or even thousands of times per second for audible sound). A microphone is often used as a means of changing the mechanical energy contained in a sound wave into electrical energy. In other words, the variations in air pressure produce an identical variation in electrical voltage within the microphone. It is fairly easy to study these electrical variations with a wonderful laboratory instrument called an oscilloscope. Connected to a microphone an oscilloscope will show us a graph of air pressure versus time. Essentially, it gives us a way to see the way the air is being pushed and pulled as a sound wave passes by the microphone.

Procedure--Part I:

With the help of your instructor connect the microphone to the Channel 1 input of the oscilloscope.—See Figure 1 on the next page. You can change the settings on the oscilloscope without fear of damaging the oscilloscope. Try it! Turn the microphone on and talk, sing, or whistle into it while holding it close to your mouth. You should see a trace on the oscilloscope screen that represents the sound that you are making. Choose a particular trace that interests you and make a sketch of the observed waveform below. Remember that what you are seeing is a graph of the pressure variations in the air caused by the sound that you are making. Also, record the settings on the oscilloscope in the adjacent box. In the space below you sketch make any comments that you have regarding your observations.

Time Base Setting (ms/div): __________

Vertical Gain (mv/div): ______________

Other Settings:

Oscilloscope Trace of your Sound

Oscilloscope Settings

Comments:

Introduction Part II: By now you should have read in your text about standing waves and resonance. Standing waves occur most commonly in strings and air columns. We are going to use this important behavior of sound waves to measure the velocity of sound in a column of air. If we put a vibrating source of sound, like a speaker, at the end of a hollow tube sound waves will reflect back and forth along the tube. If the length of the tube is just right, the timing of these reflections can produce an extra intense (loud) sound wave. We say that the tube is in resonance. This is exactly what happens when you blow across the top of a soda bottle. We will adjust the length of our air column to create a resonance condition and then determine the wavelength of the sound wave. Knowing the wavelength and frequency of the waves we can then calculate the speed of sound using the equation

Speed of sound = wavelength x frequency

Procedure Part II:

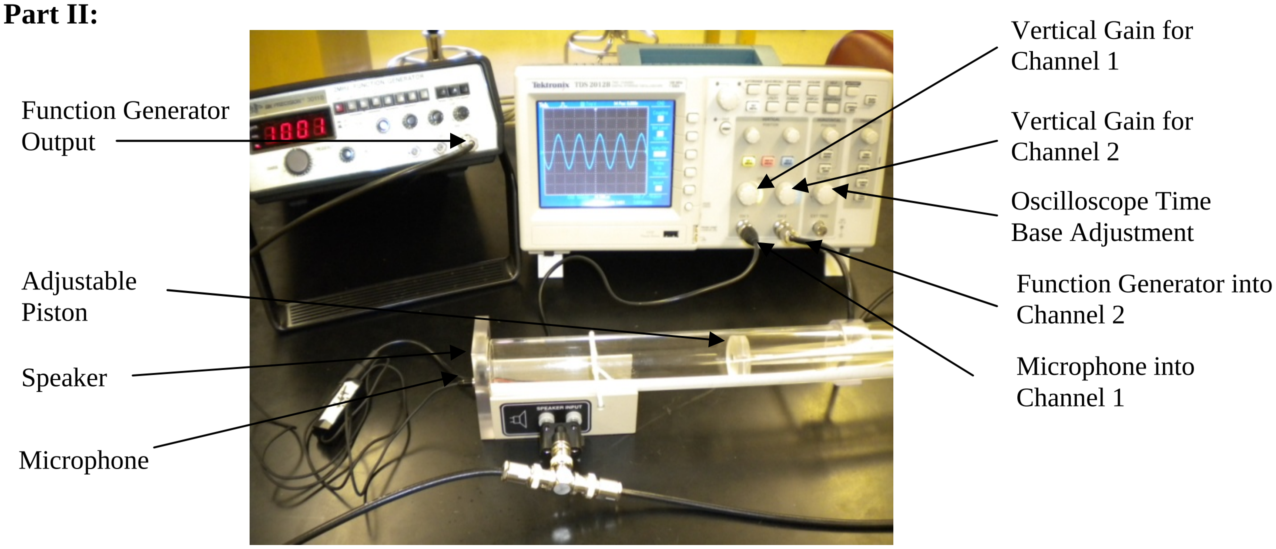

Figure 1

1. With the microphone cable still connected to Channel 1 of the oscilloscope, gently insert the microphone into the small opening below the speaker. Ask your instructor to help you connect the function generator to the speaker and (using a tee) to Channel 2 of the oscilloscope as shown in Figure 1. Adjust settings on oscilloscope if it needed. Your instructor will help you produce an oscillating voltage from your signal generator whose energy will be converted into sound waves by the speaker. Set the frequency of the generator to 1000 Hertz (cycles per second or Hz) and adjust the output of the generator so that a soft tone can be heard coming from the speaker. Observe the waveform on the oscilloscope (Don't forget to select Channel 2 instead of Channel 1). You should see a very regular (sinusoidal) wave whose height (loudness) and length (frequency) can be adjusted with the controls of the function generator. Try changing the amplitude and frequency settings and observe the changes on the oscilloscope. Make a sketch of your waveform below:

Oscilloscope Trace of your Sound

Time Base Setting (ms/div): __________

Vertical Gain (mv/div): ______________

Other Settings:

Oscilloscope Settings

2. If you have changed the frequency of the function generator, reset it to 1000 Hz. Also, on the oscilloscope, reselect Channel 1 to look at the microphone output rather than that of the function generator. By adjusting the position of the piston (see Figure 1) we can change the length of the air column in the plastic tube so that resonance occurs. Starting with the piston at the far end of the tube from the speaker, slowly move the piston toward the speaker. When the length is just right, you will know it because the height of the wave on the oscilloscope screen will be a maximum compared to other positions of the piston. The sound will also be at its loudest. When you find the maximum, record the position of the piston in cm (in the table below) using the scale attached to the tube. Now continue moving the piston slowly toward the speaker and locate and record the position for the next maximum. The distance between these two maxima is precisely one-half of the wavelength of your sound waves.
3. Continue locating and recording the locations of as many maxima as you can find (probably about five) until you reach the end of the tube nearest to the speaker. From each adjacent pair of maxima, subtract their two positions to find the half wavelength. Multiply this number by two to get the wavelength. Finish filling in the table and then find and record the average value for the wavelength of your sound waves.
4. Change the frequency of the signal generator to 2000 Hz and repeat steps 2 and 3 above. What do you notice about the distance between maxima at 2000 Hz compared to 1000 Hz? Give an explanation in the space below:

RESONANCE TUBE DATA

Frequency = 1000 Hz			Frequency = 2000 Hz		
Location of maximum (cm)	Distance between Maxima (cm)	Wavelength (cm)	Location of maximum (cm)	Distance between Maxima (cm)	Wavelength (cm)

5. When you have completed your data table, calculate the speed of sound in meters per second for the 1000 and 2000 Hz frequencies using the equation given at the top of the previous page. Be thoughtful about units! Find the average of these two speeds and record this information in the table below.

Frequency (Hz)	Speed of sound (m/s)	Average Speed of Sound (m/s)

6. Let's compare your experimental results with the theoretical value for the speed of sound. The speed sound depends on the temperature of the medium and can be calculated according to the equation

$$\text{Speed (m/s)} = 331.5 \text{ m/s} + 0.607 \times \text{Temperature } (^{0}\text{C})$$

7. Find the percent difference between the theoretical value just calculated in part 6 with your average experimental value found in part 5.

Average Speed of Sound measured (from part 5)	**m/s**	Percent Difference
Theoretical Speed of Sound (from part 6)	**m/s**	

8. Discuss in the space below any reasons that you can think of for differences between these two speeds.