THE SPEED OF SOUND

Objectives: • To measure the speed of sound in three different ways.
• To compare and reflect on your results, taking into account the uncertainties in your measurements.

To Do Before Lab: • Read this lab

Apparatus: Speakers, digital oscilloscope, Al rods, speaker, signal generator, cables, Excel.

Introduction:
In this lab we measure the speed of sound c_S three ways. The first method is a direct measurement of the propagation of a sharp pulse of sound over a known distance. This is a crude but direct method. In the second method we find the speed of sound by observations of travelling waves. The third method uses properties and observations of standing waves. Finally in the last part we compare and reflect on the results of the three methods.

Enjoy!

Part I: Measuring c_S with Time Delay
In this method we measure the speed of sound by directly measuring the time required for sound to travel over a known distance. Two microphones are connected to the inputs of the digital scope. Set them about 1.5 meters apart facing in the same direction. You can monitor the voltage output from the two microphones with the digital scope.

(1) Try out the apparatus making a sharp sound in front of the first microphone by hitting the two metal rods together. Try this a few times. Do you see evidence for a time delay between the signals from the two microphones? If so, move the two cursors to the beginning of the two signals (if you can't find the right knob ask your instructor). The box labeled "Delta" on the right hand side of the screen gives the time difference between the two cursor lines. Repeat this measurement a few times and estimate the uncertainty in the measured time delay.

(2) What else do you need to measure to find the speed of sound? Measure it and estimate the uncertainty. Determine the speed of sound and use a propagation of error analysis to find the uncertainty in the speed. After writing your result in standard form, celebrate your first measurement of the speed of sound by drawing a box around this result.

Part II: Measuring c_S via Wavelength, Period, and Frequency
In this second method we find the speed of sound with measurements of wavelength and frequency.

(1) Set up the optical bench with the ultrasound transmitter- receiver pair, marked with a "T" and "R" on the back.

(2) Set the signal generator to about 25kHz then adjust until you see the receiver respond. Move the transmitter forward or backward slightly until the trace from the receiver is in phase with the trace from the signal generator. Adjust the volts/div settings to make this determination as easy as possible. Record the position of the transmitter with uncertainty.

(3) Now move the transmitter away from the receiver noting at what position the two signals are in phase again. How far did you move the transmitter? How far did you move it in terms of the wavelength of the sound waves coming from the transmitter? (This is a KEY point!)

(4) Carefully move the receiver away from the transmitter, counting the number of wavelengths that you have moved the transmitter. Think about and explain why it makes sense to move the transmitter many wavelengths. From your data determine the wavelength and estimate the uncertainty. Determine the frequency of the sound waves and estimate the uncertainty. Calculate the speed of sound with uncertainty. This is it! Finish this part by flourishing a pen to box this result.

Part III: Measuring with the Wavelength, Period and Frequency of Standing Waves

The last method uses not just a single sound, nor a traveling wave but a standing wave in a glass tube. It is similar to the standing wave on a string lab.

(1) Place the loudspeaker near one end of the long glass tube, so sound waves can enter the tube. Place the microphone near the other end of the tube to measure the intensity of the sound coming from the tube. Set the signal generator to around 1000 Hz. Adjust the frequency of the signal generator until a standing wave resonance is detected. Listen and you will know when you've got one. Find at least 5 others.

(2) Determine the speed of sound with uncertainty. Celebrate your last speed of sound measurement with a box.

Part IV: Summary and final results

(1) State your three results. Do they agree?

(2) Discuss the variation in values for the speed of sound in each method. Can the discrepancies be explained in terms of random errors? Is there evidence for systematic errors in one or more of the methods?