Speed of Sound Activity

The fact that the speed of sound does not vary with frequency and wavelength is a critical principle in understanding the physics of music. However, it is also important that students understand that the speed *can* vary with factors such as temperature. If you collect student results at the end of the lab and display them for the whole class to see, you have the opportunity to discuss measurement variance as well.

Introduction

When you snap your fingers, the sudden motion of the air getting out of way launches a pressure pulse that travels away from your hand in all directions. The pulse travels at the speed of sound. This speed is sensitive to the temperature of the air. In today's lab, you will attempt to measure the speed of sound and verify its dependence on temperature.

Materials

Vernier LabQuest (fully charged)
Plastic Tube
Meter Stick

Procedure and Analysis

1. Verify that the power supply for charging your LabQuest is plugged in. This is how you should leave the LabQuest at the end of the session today.
2. Using the plastic stylus, go to the Sensors/Sensor Setup menu. Check the box for Internal Microphone. This will activate the microphone in the LabQuest which sits under the small hole in the upper right corner of the device. Click OK.
3. Select Sensors/Data Collection. Click on Triggering and check the box for Enable Triggering. Set the trigger to start collection when the internal microphone is "increasing" across 3.0. Also set the device to collect 100 points before trigger. Click OK. Verify that the data rate is set for 8000 samples/s and the Length is set to 0.03 s.
4. Click on the collect button (green triangle) in the lower left of the screen to start taking data. The LabQuest will wait for a large enough noise and then will collect data. Try snapping your fingers or your fingernails to take a trace. Practice this a few times until you can generate a nice sharp pressure pulse at t=0.
5. Hold your plastic tube vertically with one end firmly on the hard floor. Hold the microphone of the LabQuest near the top end and click the collect button. Snap your fingernails close by the top end of the tube. With a little practice, you should be able to see both the initial pressure pulse and the reflection after the pulse has travelled down the tube, bounced off the floor, and returned to the top end.
6. Carefully measure the time delay between the start of your pressure pulse and the start of the reflection pulse. Record the time for 10 trials. Average these values and check in with your instructor with this value. Use this value along with the length of your tube to estimate the speed of sound.
7. Put on your coat, and bring the LabQuest, temperature probe, and plastic tube outside.
8. Repeat steps 2-6 outside. Make sure the air in the tube and the temperature probe come to thermal equilibrium with the outside air before taking any measurements. Record the average value of the speed of sound outside.
9. Theory tells us that the speed of sound should be $v = 331\sqrt{1 + T_c/273}$ where v is in m/s and T is in degrees C. Is your data consistent with this?

Follow-up discussion questions

1. Why might the speed of sound vary among the different measurements made by the different groups?
2. How does the speed of sound vary with temperature (increase or decrease) and why is this the case?
3. How does this all relate to music?

Source: Wheaton College PHYS221 lab