Modern Physics	name_____
Lab: "Oh Snap!" or "Measuring the Speed of Sound"	hour_____

Objective

The objective of this lab is to learn one method to accurately measure the speed of sound in air. We'll use a microphone, the LabQuest lab interface, and a computer to record a sound pulse and its echo in a cardboard tube and use this recording to find the speed of the pulse as it travels down the tube and back.

Background

Compared to most objects, sound waves travel very fast – fast enough that measuring the speed of sound accurately is a technical challenge. One method is to time an echo. For example, if you were in an open field with a large building 100 meters away, you could start a stopwatch when a loud noise was made and stop it when you heard the echo. You could then calculate the speed of sound using $v = d/t$. Although this would work, it is not very practical and is subject to random errors due to reaction time and interference from other sounds.

To use an echo to measure the speed of sound over short distances in the lab we need a more precise timing system. We'll use a microphone connected to the LabQuest to record sound during a short time interval. The microphone will be placed next to the opening of a hollow cardboard tube 1-2 meters long. When you make a sound by snapping your fingers next to the opening, the LabQuest will begin collecting data. After the sound reflects off the opposite end of the tube, the microphone will record the echo. We'll use LoggerPro graph the amplitude of the sound to determine the time interval between. From this graph, you will then be able to determine the round trip time and use this along with the length of the tube to calculate the speed of sound.

Procedure Part One: Setting up the LabQuest and LoggerPro

First you must use LoggerPro to set the LabQuest to begin recording sound when it senses your finger snap and to record for a short time interval until the reflection returns.

1. Open the LoggerPro.

2. Connect the microphone to input 1 of the LabQuest and connect the LabQuest to the computer.

3. Click the data collection button 🕓 to open the data collection window shown at right.

4. Change the *Length* to *.05 seconds*.

5. Change the **Sampling Rate** to **50,000 samples/second**

6. Click on the *Triggering* tab and check the *Triggering* box.

7. Choose **On Sensor Value,** select **Increasing** across **0.05**

8. Close the *Data Collection* window. You are now ready to begin measuring.

9. Press **APPLE 0** to zero the microphone.
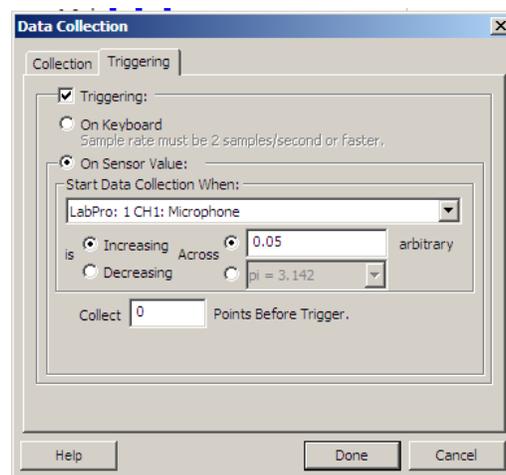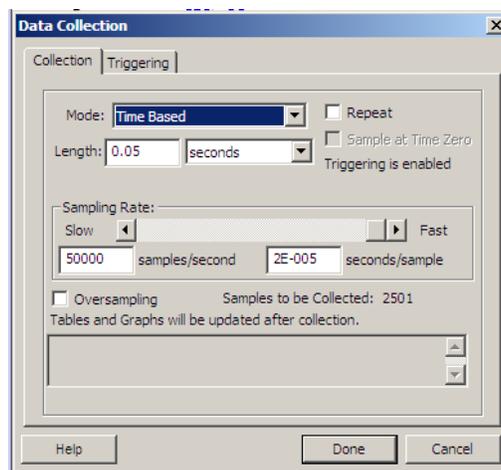
The LabQuest is now set for you to begin measuring the time it takes for a sound pulse to travel down the tube and back. Your lab apparatus should look like the picture below.
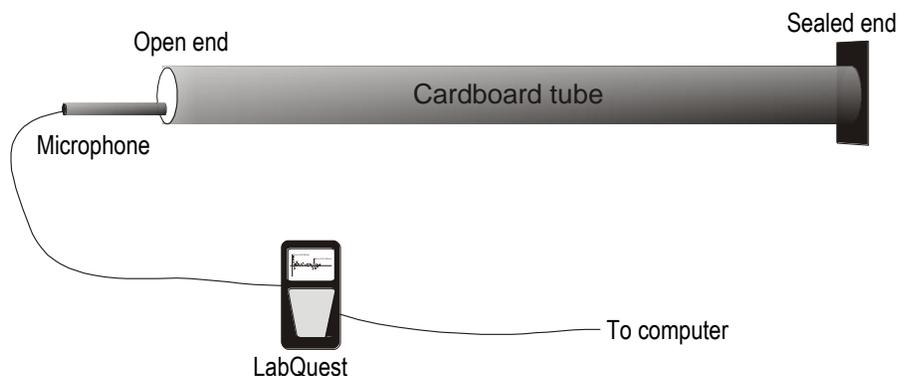
Here's how to collect data:

1. Measure the length of the tube in meters and record below. Include an estimate of the uncertainty of your measurement.

2. Set the microphone directly in front of the opening of the tube.

3. Have one person operate LoggerPro while the other person holds the microphone.

4. Press the collect button [▶] to begin recording data.

5. Snap your fingers near the microphone. Notice that LoggerPro immediately records and graphs the sound wave. The graph should show a distinct pulse from the finger snap and a distinct echo. It takes some practice to get the snap just right. Keep trying until you get a graph that looks like the one at right.

6. Use the *Examine* tool to find the elapsed time between the initial sound and the reflected sound. Click on the graph at the beginning of the initial pulse and drag right to the beginning of the echo pulse. The elapsed time shows in the lower left of the graph.

7. Record this time in the table below. Repeat 10 times and complete the calculations in the next section.
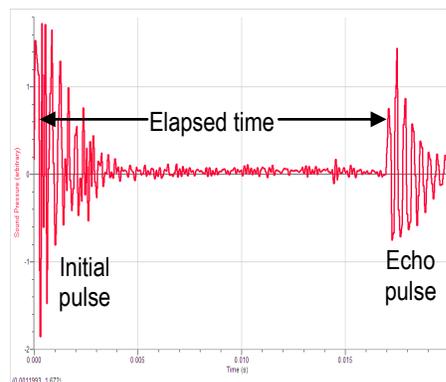
Data

Length of tube: _____ ± _____ meters

Air temperature in the lab: _____ ± _____ °C

Estimate the uncertainty of your time measurements caused by your inability to select the exact beginning of the initial pulse and the echo: ±_____ s

Trial	Time I (s)	Deviation (s)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Avg		±

Calculations

1. Calculate the speed of sound

Total distance sound travels: _____ ± _____ meters

Average time for sound to make round-trip: _____ ± _____seconds

Use the formula $v = \dfrac{d}{t}$ to calculate the speed of sound in the pipe. Show uncertainty calculations here:

Average speed: _____ ± _____m/s

2. Compare your average with the accepted value for the speed of sound.

Use this formula to find the accepted value for speed of sound $V_{sound\ in\ air} = 331\ \text{m/s} + 0.60T_{Celsius}$
Show uncertainty calculations:

Accepted speed of sound at that temperature: _____

Calculate percent difference between your value
and the accepted value: _____ $\%difference = \dfrac{(Accepted\ value - Measured\ value)}{Accepted\ Value} \times 100$

Questions

1. Why did you multiply the length of the tube by 2?

2. What do the spikes on the LoggerPro graph represent? Why does the graph show two distinct sets of spikes?

3. Why do we use a sharp short sound instead of a tone?

4. What is the greatest contributor to uncertainty of your time measurement?

5. Identify at least three realistically plausible systematic errors that might have affected your results.

6. Does your measured value match the accepted value within your range of certainty?

7. Comment on your answer to the previous question. What conclusions can you reach based on this answer?