Lab M1: A Snappy Speed of Sound Measurement

Goal: To directly determine the speed of sound in air by measuring the time for a sound pulse to echo down a plastic tube.

Aug 15, 2003

Equipment / Materials per station:

ULI interface attached to computer
Microphone
Logger Pro software
Graphical Analysis Software
clear plastic tube(s) of various lengths [fluorescent light covers work well]
metersticks
juniors partnered with seniors to proliferate knowledge of graphing calculators and Graphical Analysis software

Hardware set-up:

Be sure the ULI interface is plugged into both the computer and an electric outlet. Be sure the microphone is plugged into input channel 1 of the ULI. Lay the plastic tube flat on the tabletop near the computer. The only source of sound you will be interested in in this lab is that of a finger snap or loud clap--The tube should NOT be aimed directly toward any other significant source of sound. Extraneous noises can cause accidental triggering of the microphone/ULI and produce confusing data. Aim the end of the microphone into the end of the tube, having the microphone close to, but NOT touching or inside the tube.

Software set-up

From the START menu, select PROGRAMS and then the VERNIER SOFTWARE folder. Open the LOGGER PRO 3.1 software.
Goto FILE on the menu bar and select OPEN. Browse until you find the folder titled EXPERIMENTS. Inside this folder, open the folder named PROBES AND SENSORS, then the folder called MICROPHONE . Now open the file entitled MICROPHONE. You should then see a graph of sound level versus time on the screen.

Once the file is opened you need to check/create some settings and think about what they mean. (In later labs you might need to adjust settings on your own, so try to absorb some of the ins and outs of the Logger Pro software.)…..

- Under EXPERIMENT select SHOW SENSORS. Be certain there is a microphone icon shown connected to Channel 1. If not, click on Channel 1 and then select the microphone option from the analog sensor list.
- Again under EXPERIMENT, select DATA COLLECTION and then COLLECTION. Be certain it is set to TIME BASED, 0.05 seconds and 10000 samples/second.
- Still under DATA COLLECTION, select TRIGGERING. Be certain triggering is ENABLED, INCREASING across 3.
- Under DATA select in order: COLUMN OPTIONS, TIME, OPTIONS. Set to display every 1 point with a displayed precision of 4.

Summarizing, you have set the computer to collect sound data from the microphone attached to channel 1 of the interface box. You have told the computer to record sound data when the threshold of 3.0 is sensed by the microphone (caused by a loud noise). The computer will continue sampling for 0.05 seconds at a rate of 10000 samples per second. Then the computer will display the graph of the recorded data on screen.

Collecting the sound data

Getting the sound graph:

Click the COLLECT button near the top of the screen. This should put your computer/microphone combination into a "waiting mode". It is waiting for a loud noise to begin the data collection. You are to create a single sharp finger snap or clap at the end of the tube farthest from the microphone--this initial sound and its echo(s) are the actual sounds you want recorded in every trial you do. Once the sound is made, the data collection should commence. The collection will quickly be over and a data-filled graph of sound level versus time should appear on screen. Click the AUTOSCALE button at the top of the screen to better see the data in your graph.

Reading the sound graph:
Hopefully your displayed graph shows a rather obvious pattern with sharp "peaks" (which could actually be a couple of sharp and closely grouped up-down squiggles) separated by large relatively flat areas. The first peak should represent the initial sound you made. Subsequent peaks (one or more) represent the sound bouncing from end to end in the tube. If you do not see at least two easy to identify peaks separated in the described manner, try recollecting the data (just click collect and make the sound again). If you have difficulty a second time, please ask for assistance in finding what went wrong.

Once you have an acceptable graph, you need to read some important time values from the graph. Go to ANALYZE on the menu bar and select EXAMINE. You can then use the mouse or the left/right arrow keys to examine specific data on the graph. Your task is to record the time instant corresponding to each of the sound peaks. Be very meticulous about getting values that correspond to the same portion of the "peak" each time the pattern repeats on the graph—you should get some hints from an instructor for this part in your first trial.

The program will give you the option to repeat the measurement without going through the entire set up again. Repeat the data collection and recording several times for a single tube, carefully recording your values, until you have achieved a consistent time interval. Then move on to other tubes as told by your instructor.

report form for lab M1

my name: ____
partner name: _____________________________________
Block:____________ **Date**:________________

Speed of Sound

Data and Analysis II

1. Carefully sketch the shape of one of your good trial graphs that had more than two peaks in the box provided, so all can see the general pattern of a good trial.

2. What do each of the peaks on the sketched graph represent? Explain.

3. If, for instance, a tube is 1.00m long, what is the distance that a sound pulse travels during its round trip down the tube and back?

4. Doing trials with several tubes (of different lengths), fill in the data table below for each good round trip of the sound.

Tube identification label	Tube Length (to nearest 0.01m)	Round-trip distance traveled by sound (to nearest 0.01m)	time instant when sound is at microphone end at the beginning of the roundtrip (sec)	time instant when sound is at microphone end at the end of the roundtrip (sec)	time for one round trip of sound (sec)

5. On your calculator (see handout for instructions) or using the GRAPHICAL ANALYSIS program on the lab computer (instructions can be found at http://courses.ncssm.edu/physics/help/GRANALYS.HTM), create a plot of round-trip distance (y axis) vs. echo time (x axis). This should yield a linear graph with a slope equal to the speed of sound in the tubes. Be sure to "zoom stat" so your data fills the graph screen. Do a linear fit to the graph. Carefully sketch your fitted graph below, with all labels. Write the equation of fit beside the graph. [Seniors are expected to teach their junior partners how to do this. Be certain juniors do the data entry and necessary steps to obtain the graph fit under the instruction of the senior. Then everyone will be equipped for future graph making!]

Equation of fit in math symbols:

Y = ______________ X + ________________

Equation of fit in physics symbols/words:

Round trip distance = ____________m/s * round trip time + ____________m

6. According to the best linear fit to my graph, the speed of sound is ______________________ which is represented by the __________ of the graph.

7. What does the y-intercept of the graph represent physically? Explain what the value should ideally (theoretically) be and why.

8. Explain why the value in question 6 is considered "better" than the value you would get from <u>any one</u> of your trials.