

Section: _____ Name: _____ BU ID: _____

Partner: _____ Name: _____ BU ID: _____

Lab 6: Sound

This laboratory assignment is composed of three independent exercises. Students whose table has a microphone and a set of various sound sources should start from Part I and then switch with students who started from Part II. Students whose table has an oscilloscope should start from Part II and then switch with students who started from Part I. For all students Part III should be the last part of the lab.

Part I: SOUND: MICROCOMPUTER-BASED LAB: A

In this experiment a microphone is used to measure the intensity of a standing sound wave (at the location of the microphone) and a computer is used to help analyze the waves.

The software needed for this experiment is the “Sound” file in PY106 folder. Double-clicking on the file should start the Logger Pro program. In Logger Pro you should see a sound versus time graph at the top of the screen and a graph of the frequency spectrum at the bottom of the screen. The frequency spectrum tells you which frequencies make up the sound, and shows the dominant frequency or frequencies.

When the program starts (by clicking ), it is set to record and display data for 0.03 seconds, at a rate of 10000 Hz, and then it will repeat the process again and again until you turn off the data collection (by clicking STOP). These settings are excellent for investigating repeating sounds such as those made by a tuning fork, a musical instrument playing a single note, or you whistling or singing a single note.

If you want to change the repeat time or the rate at which data is recorded, hit “Ctrl-D” to bring up the Data Collection box. Select the “Sampling” tab, and enter a new Experiment Length and/or use the slider to adjust the Sampling Speed. NOTE: if you change any setting, please, do NOT save the file!

Hit the  button and start recording sounds – hit the “Stop” button when you want to stop recording and/or when you want to take measurements from the data. First, familiarize yourself with what you can do with the graphs.

1. Generate a pure tone by whistling or singing a single music note or use a musical instrument to play a single note. Record the data. What do you observe on the top graph? What do you observe on the frequency spectrum?

2. Record the data for several different pure tones (be creative, try making sound using different sources). As you increase or decrease the frequency what do you observe on the frequency spectrum? Play several notes at the same time and observe the spectrum.

A bloogle is a corrugated tube which, when rotated over your head, generates sound.

3. How do we call a pipe like a bloogle (“open” or “closed”)? A(n) _____ pipe.

4. When you rotate the bloogle faster, how does the frequency of the sound change?

5. Measure the length of the bloogle and estimate the fundamental wavelength of the bloogle. Assume the speed of sound is 330 m/s and estimate the fundamental frequency of the bloogle.

6. Measure the values of several consecutive frequencies of the bloogle.

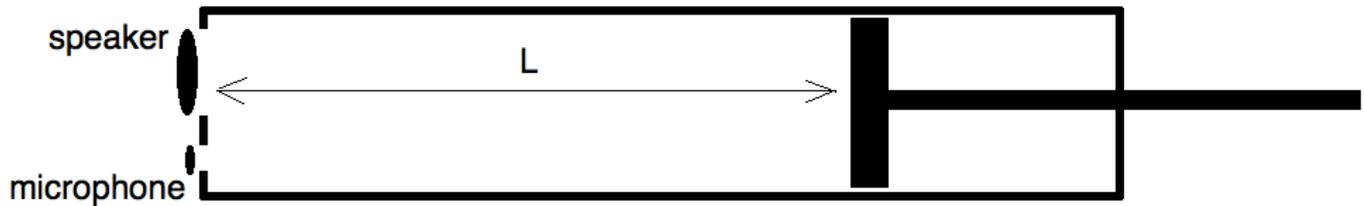
7. Now use values of the frequencies measured in part 6 and estimate the fundamental frequency of your bloogle and compare with the one in part 5.

8. Switch from a bloogle to a plastic pipe. Use available data and estimate the values for several harmonics of the pipe when one of its ends is closed. Use the microphone and the software to check if you can generate those harmonics.

9. Use some of the sound sources provided to you and try to generate beats. Try to measure (using a PC or your ears) the frequencies for each pure tone and calculate the beat frequency.

Part II: MICROCOMPUTER-BASED LAB: B

In this experiment a microphone is used to collect sound waves and an oscilloscope is used to help with the analysis of the standing sound waves.



The speaker (connected to a Pasco interface used as a generator governed by a computer) generates a sound wave in the pipe, and the microphone measures the intensity of the sound at the opening on the left. A movable piston is used to change the length of the air column L .

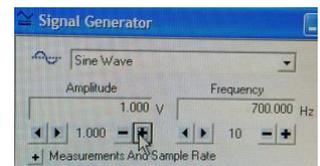
1. What kind of a pipe is it (to answer this question imagine that the speaker and the microphone are removed)?

an open pipe a closed pipe

2. Write a general expression which relates the length of the pipe L and the wave length λ_n of the n -th overtone (mode, harmonics) for standing waves resonating in the pipe.

3. Write the relationship between the speed, the frequency, and the wavelength of the sound waves in the pipe.

Start file resonance.ds (in PY106 folder). Turn on the microphone (there is a switch connected to the microphone). Turn on the oscilloscope (use the power button). To generate the sound set the amplitude to 1 V (see Pic. On the right). Set the frequency of the sound to 660 Hz. On the screen of the oscilloscope you will see two graphs (not photographs!). One graph shows the signal generated by the speaker and will not change if you move the piston. Another graph represents the air pressure *at the location of the microphone* as the function of time (the amplitude of that signal is related to the loudness of the sound).



4. Move the piston about 90 cm away from the microphone. Slowly move the piston back and forth for about 15 cm in each direction and observe what happens to the graphs, what happens to the loudness of the sound. Comment.

5. Bring the piston at its initial position (about 90 cm away from the microphone) and start moving it slowly toward the microphone. When the amplitude of the sound intensity measured by the microphone reaches its maximum value (the graph provided by the oscilloscope shows the maximum possible amplitude), measure and write down the distance between the microphone and the piston (i.e. the length of the air column with an excited standing wave). Keep moving the piston closer to the microphone. You should observe at least two events when the intensity of the sound at the location of the microphone reaches its maximum.

a) $L_1 =$

b) $L_2 =$

6. You do not know for sure which specific overtones (modes, harmonics) you have observed, but you do know that those are two consecutive harmonics! For each harmonic, write the relationship between the wavelength of the sound and the length of the pipe. Explain (clearly indicate) how you used the fact that the harmonics are the two *consecutive* ones. What should the difference $|L_1 - L_2|$ be equal to, if measured in terms of the wavelength of the sound wave generated in the tube?

7. Use your expressions above to calculate the wavelength of the sound wave generated in the pipe.

8. Calculate the speed of sound in the pipe (remember, you set the frequency to a certain value). Does it agree with an average value of the speed of sound in the air? If not, explain why there is a difference.

9. Set the frequency to 330 Hz. By moving the piston find one location providing the maximum of the loudness of the sound wave in the tube. Predict the next location and check your prediction.

7. Click on the equation in the applet, change the equation to $\sin(2\pi \cdot 300 \cdot t) + \sin(2\pi \cdot 305 \cdot t)$, and click on the New button. What kind of sound do you hear? Was your prediction correct? The top graph (the blue one) shows the intensity of the sound as a function of time. Copy the graph. Which two periods do you see in the graph?

Equipment

Lab 6

Part I (6 tables, or more): **Sound – MBL apparatus**

Part II (6 tables, or more): **PASCO resonance tube apparatus**

Part III (12 tables, or more): **Computer with speakers**

Unit layout

L6: 120 min;

PI: 40 min;

PII: 40 min;

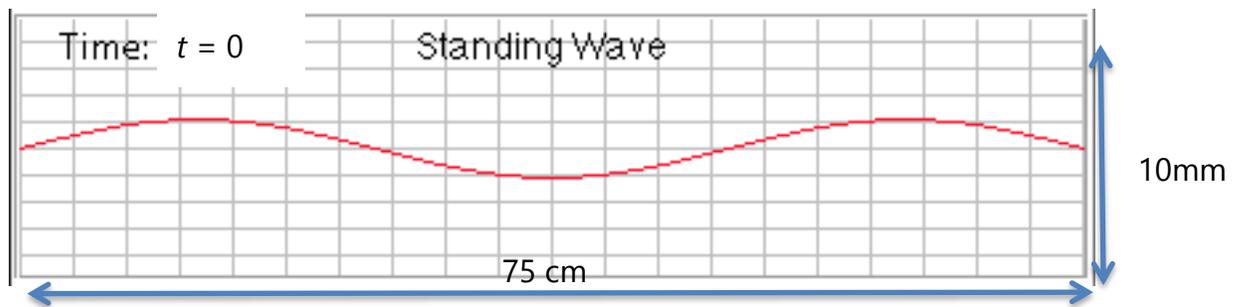
PIII: 40 min;

PE6: 80 min;

Breaks when needed.

Practice Exercise 6

Part I



The picture above shows a vibrating string. The grid you see is 75 cm m long and 10 mm wide.

(NOTE: you can see this wave “live” at

http://webphysics.davidson.edu/physlet_resources/bu_semester1/index.html

if you scroll down to **Interference of Waves** and click • [Sample problem](#))

1. Find the amplitude of the wave.
2. Find the wavelength and the wave number of the wave.
3. Assume the frequency of the wave motion is 1200 s^{-1} and find the speed of the wave in the string.
4. Find the period, the angular frequency of the oscillations, and the maximum speed of the motion for any part of a wave (i.e. for *a single point on the string*).

5. What is the fundamental frequency for the string shown in the picture?

6. The picture on page 7 shows the snapshot a standing wave which is the result of the interference between two waves traveling in opposite directions. Assume that at $t = 0$ all points on the string are at the maximum displacement from the equilibrium, and the first anti-node is displaced up. Draw below the profile of the string at different instances (T is the period):

$$t = 0.125 T$$

$$t = 0.25 T$$

$$t = 0.5 T$$

$$t = 0.625 T$$

$$t = 0.75 T$$

$$t = T$$

7. Write the equation for the standing wave you observe in the picture which you can use to calculate the displacement of any point of the string at any time and location.
8. Write the wave equation for the wave traveling to the right and to the left which together should provide the standing wave in the picture.
9. Write the motion equation for the second node of the wave.
10. Write the motion equation for the first anti-node of the wave.
11. The string has a mass of 3 gram. Find the tension in the string.

Part II:

Two identical speakers (see the picture below) are generating sound waves which are in phase and with frequency 660 Hz. The speed of the sound in the air is 330 m/s. Find how many sound minima and maxima are between the speakers. Find the location of each minima and maxima.

Note: this a *driven* standing wave; what will any driven standing wave (similar to the one described above) generate right in the middle between the speakers?

