Spectral Analysis of Sliding Whistles

EQUIPMENT

- Microphones + Preamps + cables and associated connectors, adaptors and cables. It should be possible to record sound into the computer using Audition, Microphone stands
- Clean Sliding whistles (metal ones as they are easily washed)
- Rulers
- Antiseptic mouthwash in spray bottles for sanitizing the whistles. Alcohol.
- Alcohol. Clean and dirty sign!
- Digital Tuners

Health Warning: We wash the whistles before *every* lab. However if you share the whistles, please sanitize them first with alcohol or by washing them in the bathroom sink before you blow into them. We don't need to contribute to the flu season!

Tis/TAs: If the whistles have a ***clean*** sign on them they are ready for the lab. If not, please wash them before the lab. There is a gallon of alcohol to sterilize after washing them.

INTRODUCTION

The whistle appears to be a simple instrument: a tube, open at one end, which resonates at many frequencies. Yet the whistle is a complex instrument. For the moment, we will only explore the simplest quality of the sliding whistle: the relationship between the position of the stopper and the tone produced. You probably are already familiar with this relationship, as you have seen a trombone player extend the length of his resonance tube by moving his slide, in order to produce a lower tone. The relationship between length (L) and frequency (f) is given by the following formula:

$$L \propto \frac{1}{f} \qquad \text{(Equation 1)}$$

The symbol in the center denotes proportionality. By this we mean

$$L = \frac{A}{f} \qquad \text{(Equation 2)}$$

where A is a constant. This relation predicts that shorter tubes will resonate at higher frequencies and so play higher notes.

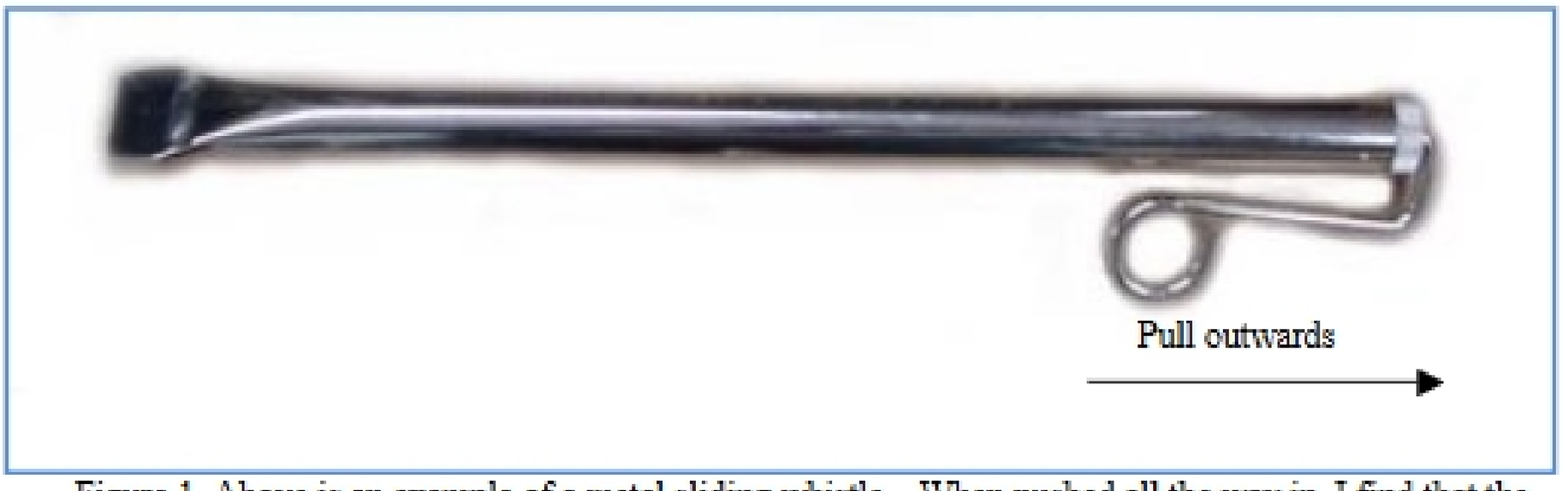


Figure 1. Above is an example of a metal sliding whistle. When pushed all the way in, I find that the distance between the end of the inner stopper inside the tube and the edge of the hole in the mouth piece is about 3.8 cm. As the stopper is pulled outwards this distance increases. When you blow into the whistle you get a high note if the stopper is nearly all the way in. As you pull out the stopper the note becomes lower and lower.

PURPOSE

The purpose of this lab is to use software to analyze the waveforms and frequency spectra produced from a sliding whistle and your own voice. You will adjust the stopper of a sliding whistle and establish a relationship between the length of the resonating air pipe and the frequency or note produced. In addition, you will look at the spectrum of the human voice and compare its overtones to that of the sliding whistle. The length, *L*, that we want to measure is the length of the air pipe that is in vibration. The length of this column of air is the **distance between the edge of the hole in the mouthpiece and the flat face of the stopper that is inside the pipe**. See Figure 2.

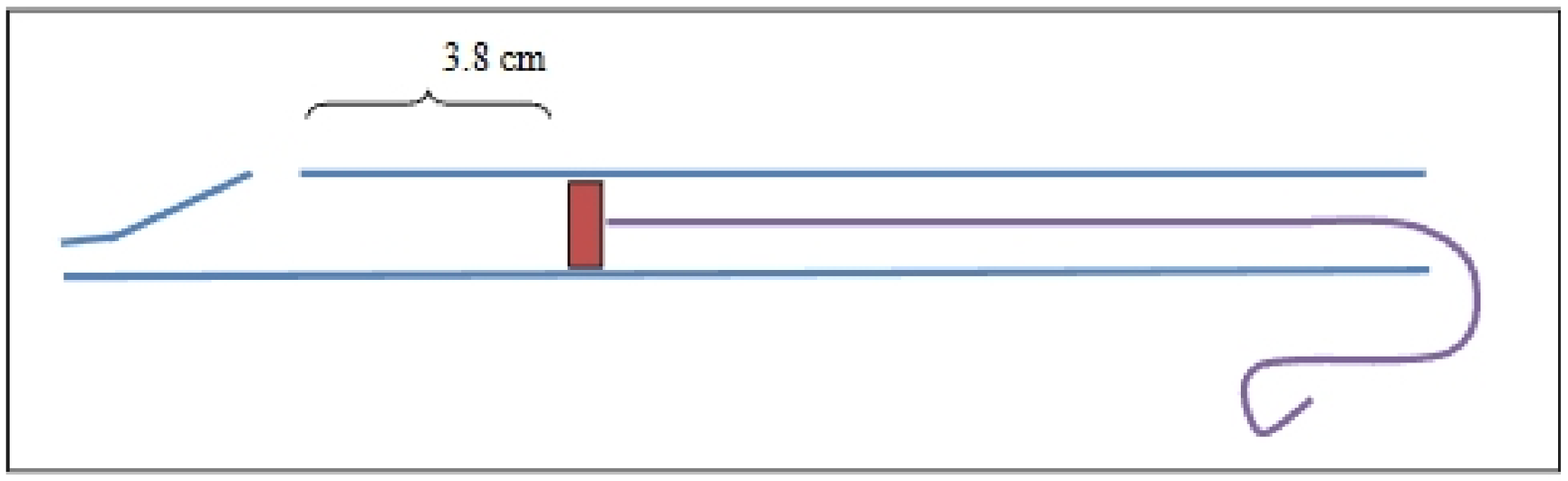


Figure 2. When the stopper is pushed all the way in the length of the air column is *about* 3.8cm. You can measure this by pushing a wire into the hole of the whistle until it touches the plunger. Mark or hold the part of the wire just sticking out. Pull out the wire and measure the length between the end and your mark. Note the location of the air column that is shown with the } symbol! This length is the distance between the edge of the hole and the stopper. This is the length we want to measure!

To measure the length of the air column when the stopper is pulled out: Measure the length of the whistle (or the length of the wire sticking out past the end) when the stopper is in. Measure the same length for the whistle when pulled out. Subtract the two lengths and add 3.8cm (or what you have measured for this length). This will give you the length of the air column between the edge of the hole in the mouthpiece and the stopper.

Health Warning #2: If you share the whistles, please sanitize them first with mouthwash or alcohol or by washing them in the bathroom sink before you blow into them. We don't want to contribute to the flu season!

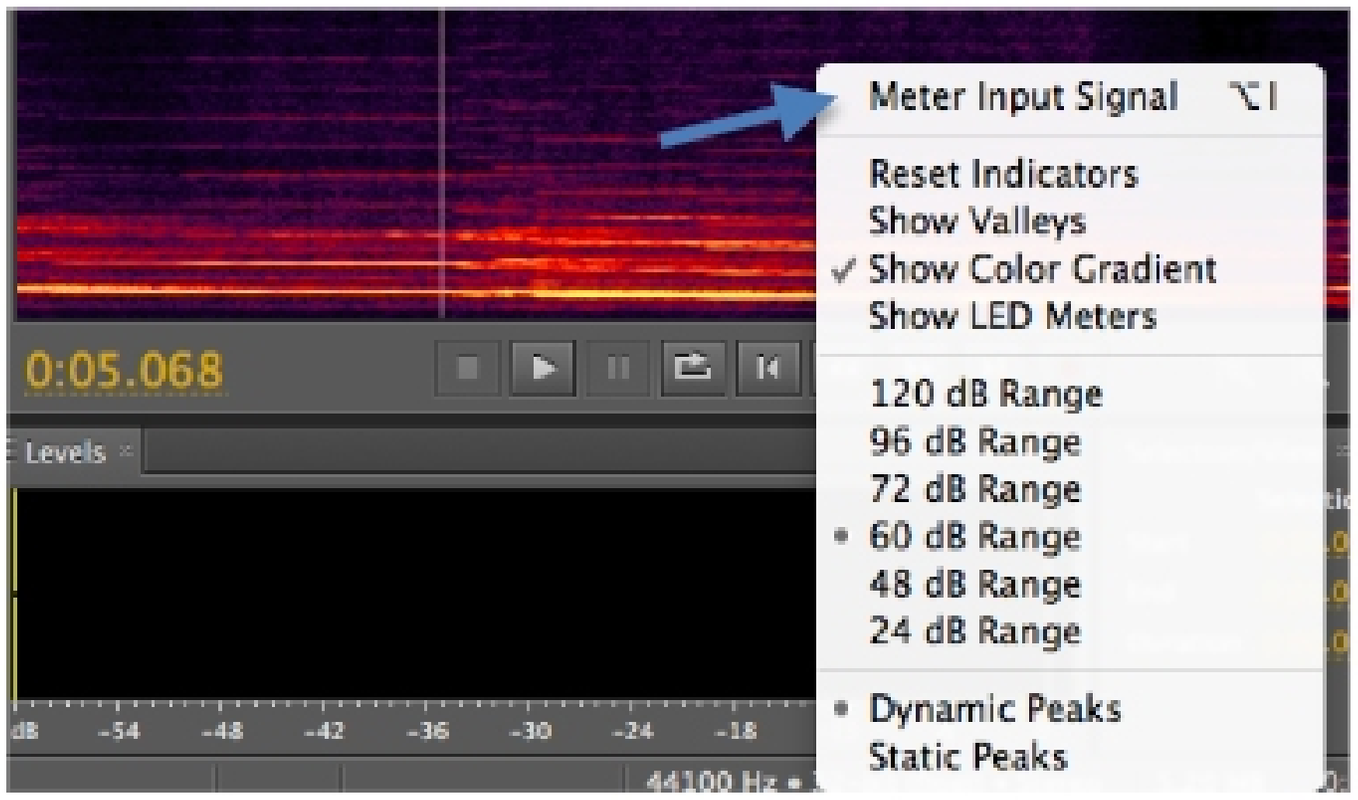
PROCEDURE

Part I – Setup for Recording Sounds

- If there is a lot of noise in the room, you can use headphones by unplugging the speakers and connecting the headphones into the speaker jack. When you are using speakers, make sure they are turned on (turn the knob on one of the small speakers).
- Make sure that your microphone is connected to the preamp and that the preamp is plugged in. The green power indicator should light up. The +48V button should be pushed in. This is to power the microphone.
- Make sure that the preamp is connected to the computer through the preamp's output jack and the computer's input microphone jack.
- Load the application Audition on the computer by double clicking the AU icon. We are currently using Audition CS 5.5, see http://help.adobe.com/en_US/audition/cs/using/index.html
- Create a new file by clicking File -> New -> Audio File, then choose Mono as you only have one microphone set up.

- To record you need to click on the red dot (record button). Do a sound check by recording yourself talking, whistling or singing. Play it back to check the sound quality.

- Ensure that the volume input and outputs on the preamp are at a good level so that the signal is not heavily clipped or extremely faint. You can check the volume level before you record by right clicking on the Levels box and choosing **Meter Input Signal.** You can adjust your distance to the microphone and the input and output volumes on the preamp. To minimize the effect of noise in the room, you would like to record with your noise source (e.g., mouth) close to the microphone. With a couple of recording trials adjust the preamp knobs so that this is possible.



Part II – Sliding Whistle and Measuring Frequencies of overtones

- Inspecting the whistle: Note that when you blow the air is forced to hit a narrow wedge. The air stream becomes unstable and oscillates as it crosses the wedge setting the air column inside the whistle in motion. The end part can be adjusted so that the air column inside the whistle is either short or long. We want to measure the length of the air column inside the whistle. You can do this using the ruler, measuring the length of the instrument and comparing this to the length when the stopper is all the way in. As shown in Figure 1 the distance between the end of the stopper and the end of the mouth hole is about 3.8 cm. This should be enough information to allow you to calculate the distance between the edge of the mouth hole and stopper inside the tube (see Figure 1 and Figure 2).
- You can use the tuner to adjust the length of the whistle to play particular musical notes.
- For each note you blow and record measure the length of the instrument so you can calculate the length of the air column inside the instrument (see Figure 2 caption).
- Blow a steady stream of air into the whistle while recording. Start with the whistle pulled out.
- Bring up the Frequency Analysis Window. Click on Window->Frequency Analysis.