Applet Exercise 2: One Dimensional Open-Open Tube

Objectives:

1. Find the resonant frequencies of an open-open tube.
2. Explore the shape of the mode and how this affects the intensity of the sound at the microphone and the placement of finger holes.

Background:

Woodwind and brass instruments are all based on resonances in long narrow tubes. The tube essentially restricts the sound waves to one dimension. The resonances of these tubes produce clear tones or notes. In this lab, you will find the resonances of an open-open tube by changing the frequency of the waves until you find a maximum in the amplitude of the wave in the tube at a particular frequency. Remember, the resonant frequency of an open-open tube is given by:

$$f_n = n\frac{v}{2L},$$

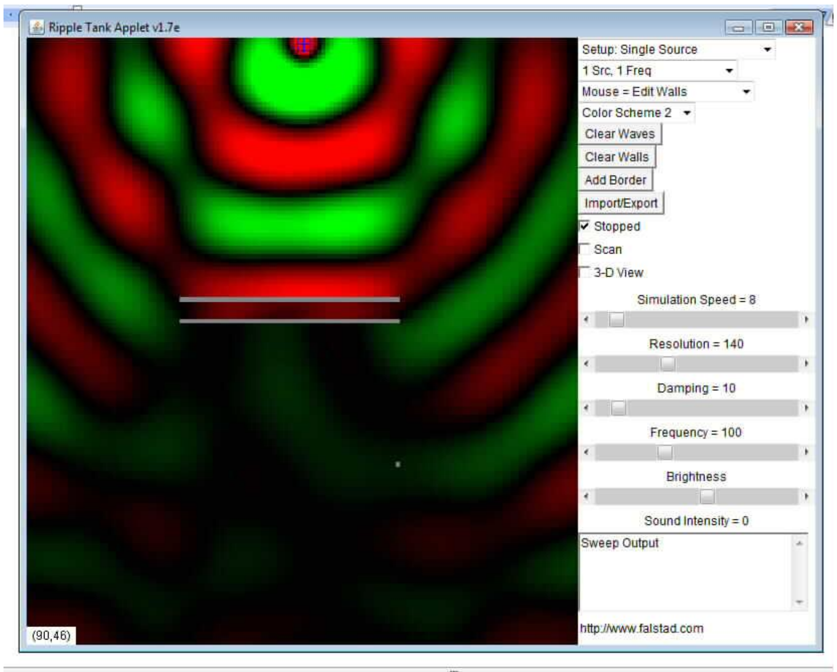
where f_n is the frequency of the n^{th} mode, c is the velocity of the wave, and L is the length of the tube

In a real tube, you can find the resonances by varying the frequency and listening for when the sound is the loudest. In the Virtual Lab, there are two indicators that you have a resonance: the waves within the tube stop moving, and simply oscillate between high and low amplitudes (red and green coloration) and the amplitude of the wave will grow dramatically. You will look for resonances by finding standing waves and by maximizing the intensity of the waves in the tubes.

Once we find a mode of the tube, we can look at its shape. The shape is characterized by nodes and antinodes. Again, it is sometimes hard to know where the nodes and antinodes are in a real tube, but in the Virtual Lab, it should become very clear. You might think that the shape of the mode does not matter so much, when it is the frequency or pitch of a mode is what we care about. However, there is a strong interaction between the shape of the modes and the location of finger holes (as in a woodwind instrument).

Instructions:

1. Initial settings: Simulation speed = 8, Resolution = 140, Damping = 2, Frequency = 100.
2. In the upper right part of the Applet, there is a Mouse selection drop-down menu. Choose Mouse = edit Walls. Draw two horizontal parallel lines. The lines should be around 50 cm long and separated by about 4 or 5 cm. Note, you can draw lines by clicking and dragging. If you start the line on a spot that has no wall, you will add a wall wherever you go. If you start on a spot with a wall, you will erase the wall wherever you go. This allows you to fix errors. Finally, make sure the source is not positioned exactly above the middle of the tube – move it off to one side. You're screen will look something like this:



3. Change the mouse menu to Mouse = Place Mic and place the microphone in the middle of the tube.
4. We will now find the first resonant mode of this open-open tube. Estimate the frequency of the lowest mode based on the length of the tube you drew and the velocity of the waves that you found in VLab#1 (somewhere around 3000 cm/s). Record this estimate in Table 1.
5. Set the frequency slider to a value 10 less than the frequency you found in step 4, above. Clear the waves, let the simulation run, and watch the microphone readout. The microphone intensity will drift around before settling down – just wait a few seconds and watch it. To speed up the process, you can increase the simulation speed. Record the frequency and intensity in Table 1.
6. Repeat step 5 increasing frequency by 1 each time until you notice that the maximum intensity within the tube starts first increase and then decrease. The frequency that gives the highest microphone intensity produces the first resonant mode - circle this frequency and intensity.
7. Now that you have the fundamental frequency, estimate the frequency of the second mode. Move the microphone to a point ¼ of the way into the tube. Repeat the procedure above to get the exact frequency of the mode. You only have to record enough points to convince yourself you found the maximum intensity.

8. Continue this process until you have found the frequencies of the first 4 modes of the tube. Note, you will have to keep repositioning the microphone.
9. Now that you have found the frequencies of the modes, we will examine the shape of the modes. Set the frequency to the resonance producing the 2^{nd} mode. Place the microphone at the end of the tube and record the intensity in Table 2. Then move the microphone to the other positions listed in Table 2 and record the intensity at each position.
10. Place the microphone at a spot in the tube that gives the highest intensity for this (2^{nd}) mode. Open a hole in the side of the tube at the same locations listed in Table 2. This time, you are not moving the microphone – just record the intensity of the microphone as it is affected by the open hole. Then, close the hole and open a new hole at the next location.

Table 1:

Mode #1: Estimated frequency:	

Frequency (Hz)	Intensity

Mode #2: Estimated frequency:	

Frequency (Hz)	Intensity

Mode #3: Estimated frequency:	

Frequency (Hz)	Intensity

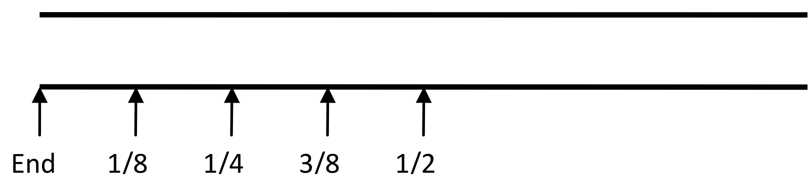
Mode #4: Estimated frequency:	

Frequency (Hz)	Intensity

Table 2

Mode #2:					
Microphone position	End	1/8	1/4	3/8	1/2
Sound Intensity					

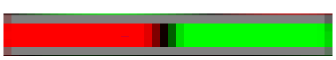
Finger hole position	End	1/8	1/4	3/8	1/2
Intensity at antinode					



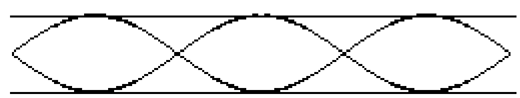
Questions:

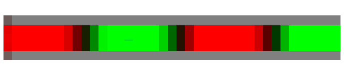
A. What is the overtone series for this open-open tube? Is it harmonic, partial harmonic, or neither? What is the fundamental frequency?

B. Based on what you have seen, match the mode number with the corresponding picture of the tube and with the correct graph of the waves:

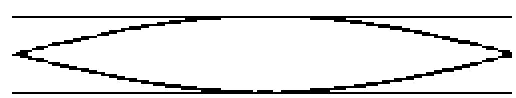


First Mode

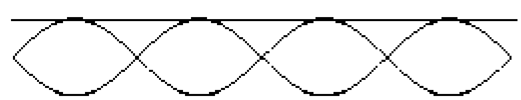




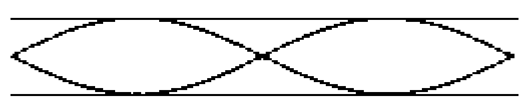
Second Mode



Third Mode



Fourth Mode



C. How can you connect the sound intensity at different places in the tube with the position of the nodes and antinodes?

D. Do the finger holes affect the sound intensity within the tube? What positions affect the intensity the most? How do you explain this?

E. Fill in the following table:

Velocity of wave from Lab#2 (cm/s): Length of tube (cm):

Mode number	Expected frequency	Measured frequency	Measured/Expected frequency
1			
2			
3			
4			
		Average	

What are some of the reasons that the expected and actual frequencies are not the same?