RealSimPLE:

Pipes

The Tube - Laboratory Instructions

RealSimPLE lives on the web:

For high school: in Swedish and English http://www.speech.kth.se/realsimple

For college and university, in English: http://ccrma.stanford.edu/realsimple

Questions about RealSimPLE can be e-mailed
to nelsonapollolee@gmail.com or to hellmer@kth.se .

RealSimPLE - Reality and Simulations in a Pedagogical Learning Environment – is a collaborative research and development project involving KTH, Stanford University and the House of Science. It is supported through the Wallenberg Global Learning Network. www.wgln.org by the Knut and Alice Wallenberg Foundation.

Kungliga Tekniska Högskolan; School of Computer Science and Communication; Department of Speech, Music and Hearing.
www.speech.kth.se

Stanford University, California, USA - Department of Music, Center for Computer Research in Music and Acoustics (CCRMA).
http://ccrma.stanford.edu

House of Science, KTH Albanova, www.houseofscience.se

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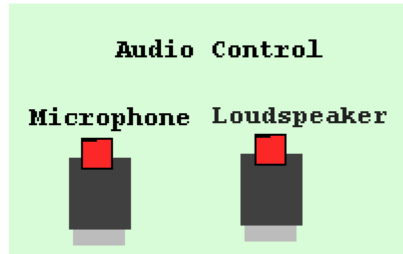
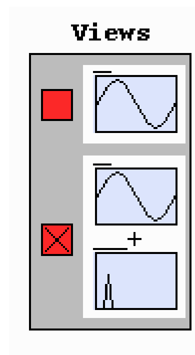
Getting Started

1. Connect the mini jack from the microphone to the pink microphone input connector on the sound card.
2. Connect the mini jack to the loudspeaker to the green line output connector on the sound card.
3. Start PD (PureData) from `Start Menu → Programs → Pure Data.`
4. In PD: Open the patch Pipe.pd by choosing `File → Open`.
5. In the patch, select the red check-boxes named Microphone and Loudspeaker to activate them.



Try whistling, talking and singing a steady tone, one at the time, and look at the oscilloscope. Look at the displayed waveforms. If the waveform is too tall or too small you can zoom in or out choosing the zoom level in the red boxes to the left of the graph.

Also try to understand the spectrum graph, or spectroscope, which can be shown by clicking the lower red box to the right of the oscilloscope.



While an oscilloscope displays the incoming signal with time on the horizontal axis, the spectroscope displays the power of the incoming signal with frequency on the horizontal axis.

Whistle and sing steady notes once again, and try to understand how the signal is displayed in the spectroscope.

Explanation

The sound that we hear is vibrations in air that our ears register and transduce to nerve impulses to our brains. In a similar way the microphone registers these vibrations and transduces them to a voltage which in this case is sent to the microphone input on the sound card.

The oscilloscope displays the incoming signal voltage as a function of time. That means that the displayed graph in the oscilloscope, which has a time window of 10 ms, is a representation of what the microphone has registered for 10 ms.

The spectroscope, on the other hand, displays the same incoming signal as a function of frequency. The higher the frequency of the incoming voltage signal, the more to the right on the horizontal axis it will be displayed. The vertical axis displays the *power* of the signal (the phase information is discarded).

Laboratory Instructions

Wavelength and frequency

Learn the relationship between frequency, speed of sound and wavelength.

1. Start Oscillator 1 and tune it to a frequency between 700 to 1000 Hz. Place the microphone near the end of the open pipe and slowly insert it into the pipe. Watch the displayed waveform in the oscilloscope while you are doing this. How can the wavelength of the sound be seen? Use the scale on the flower stake to approximate it!

Parameter	Symbol	Unit	Your result
wave length	λ	m	

2. Calculate the speed of sound, c, with the equation:

$$c = 331.5 + 0.6 * T$$

Parameter	Symbol	Unit	Your result
temperature	T	°C	

Answer

speed of sound	c	m/s	

3. Calculate the theoretical frequency with the equation:

$$f = \frac{c}{\lambda}$$

Parameter	Symbol	Unit	Your result
speed of sound	T	C	
wave length	λ	m	

Answer

theoretical frequency	f	Hz	
actual frequency in OSC 1		Hz	

Does the theoretical frequency differ from the actual frequency as set in oscillator 1? Explain why.

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Resonances of the pipe

Find the resonance frequencies of the pipe using the spectroscope.

4. Remove the shorter extension pipe if it is attached. Use Oscillator 4 to make a frequency sweep. Set start and stop to suitable values and watch for amplitude changes in the spectroscope as the frequency changes.

Parameter	**Symbol**	**Unit**	**Your result**
first resonance	f_1	Hz	
second resonance	f_2	Hz	
third resonance	f_3	Hz	
fourth resonance	f_4	Hz	

5. Make sure that the auto trigger is turned off by deselecting the red box in the top left corner by the oscillator. Use oscillator 1 to generate different tones. What happens with the waveform in the oscillator as the frequency is approaching a resonance frequency?

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6. Attach the extension tube and make the same frequency sweep as in task 4.

Parameter	Symbol	Unit	Your result
first resonance	f_1	Hz	
second resonance	f_2	Hz	
third resonance	f_3	Hz	
fourth resonance	f_4	Hz	

What does the relationship between pipe length and resonance frequency suggest?

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Tone Holes

7. Set oscillator 1 to 710 Hz. Remove the cover from hole 1 and listen to what happens. Then cover hole 1 again and remove the cover from hole 2. What happens?

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Give examples of musical instruments where this is used.

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Flute Simulation

Flutifier is a simple simulator of flute sounds, and its input are the four oscillators. The four sine waves are summed together with noise. The output of the flutifier is then sent to the miniature loudspeaker.

8. Using your knowledge about the resonance frequencies of the pipe, simulate the sound of a flute as realistically as possible using Flutifier.

    - Make sure that the speaker check box is selected and deselect the microphone check box.
    - In the To Loudspeaker section, select the check box labeled Osc for each oscillator that you want to use.
    - Adjust amplitude and frequency of each selected oscillator.
    - Click the button Flutifier to hear the result. Continue adjusting the oscillator parameters until you are satisfied with the sound.

Parameter	**Your settings**	
	Frequency	Relative amplitude
first resonance		
second resonance		
third resonance		
fourth resonance		

- Describe some features that separate the sound of the simulated flute from a real flute.

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