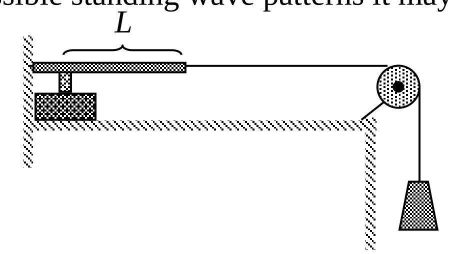
String, Spring, and Sound Waves

Introduction: In this laboratory you will investigate some aspects of string/spring waves and sound.

1. Consider two strings, one of density much greater than the other, that are attached as shown in the figure.

a) If the string of greater density has length *L* and tension *F* describe the possible standing wave patterns it may support. Sketch the wave patterns corresponding to the first three modes.



b) By measuring a segment of white string of known length, determine its density. Attach a piece of thread to the white cord that is two to three times its length. Using the density of the white cord and assuming a mass of 200g is hung over the pulley determine the allowed resonant frequencies of the system. Obtain numerical answers for the frequencies corresponding to the first four modes.

c) Set the system into oscillation with a mechanical vibrator and determine the first four resonant frequencies. How do these compare with your predictions of part (b)? To what extent does the string behave the way you assumed in your predictions?

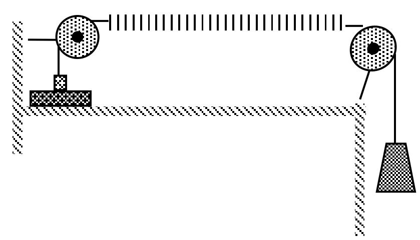
d) Obtain a microphone from the front of the room and plug it into the ULI. Go to Logger Pro – Experiment 21. Set the string into its lowest mode of vibration and record the sound emitted from it. Describe the sound waveform you observe on the screen.

e) Go to the Window/New Wide Window/ FFT. This analyses the wave into its different frequency components. You will see many frequencies present, however, among the different frequencies can you identify those around where you expect the string to resonate? Make a rough sketch of the FFT graph and indicate the spikes corresponding to the string resonances.

f) Repeat part (e) for the first overtone.

2. Obtain a spring from the front of the room and hook it up to a vibrator and mass as shown in the figure. Please have me come to your bench when you are ready for this part.

a) Attach a mass around 80g over the pulley and adjust the vibrator to set up longitudinal waves in the spring. Assuming the ends are "fixed" describe the possible standing wave configurations of the spring. Make sketches of the first three modes. Set the spring into oscillation and describe what you see.

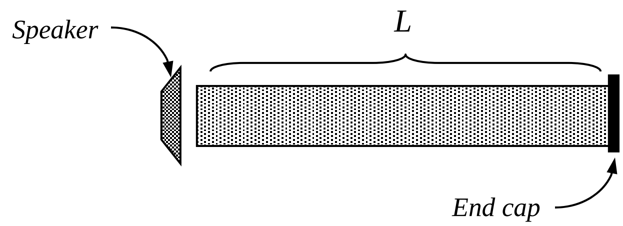


b) Locate the frequencies of two adjacent modes and use them to estimate the fundamental frequency of the system. Measure the mass *M* of the spring and its spring constant *k*.

c) It can be shown that the speed of waves on a spring of constant *k*, length *L*, and density μ is $v = \sqrt{kL/\mu}$. According to this why might one expect the fundamental frequency of the spring to coincide with $f_1 = 0.5\sqrt{k/M}$? How does this result compare with your estimate of the fundamental frequency?

3. Obtain a speaker and small resonance tube from the front of the room. Measure its length L and radius R.

a) If one end of the tube is kept open and the other covered describe the standing waves that will occur in the tube. Make sketches of the displacement patterns corresponding to the first three modes. Determine the general form of the resonant frequencies and express your result in terms of L, and the speed of sound v. *Estimate* the frequencies corresponding to the first three modes.



b) Measure the first three resonant frequencies of the tube. What speed of sound does each of these frequencies imply?

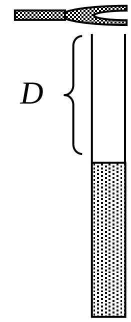
c) It happens that the antinode of the wave does not terminate abruptly at the open edge of the tube but instead extends out roughly $0.6R$ from the tube's end. Using this result and the observed value for the fundamental frequency revise your estimate for the speed of sound. How does it now compare with the excepted value?

d) Now uncover the other end of the tube opposite the speaker so that both ends of the tube are open. Describe the standing waves patterns that are now possible in the tube and make sketches corresponding to the first three modes. Determine the general from of the frequencies in terms of L and v.

e) Using the speed of sound you found from part (c) and the end correction, predict the frequencies of the two lowest modes of the tube. Observe the resonant frequencies and compare with your predictions.

4. Obtain a long tube from the front of the room and fill it partially with water.

a) If a tuning fork vibrating at frequency f is held over the tube describe the possible standing wave patterns that may result in the tube. How is the wavelength of each mode related to the distance D of the water from the tube edge? Make sketches corresponding to the first three resonant depths.



b) As you might have observed in the previous activity **3** the wave antinode extends out of the open end of the tube. Assume this distance the wave extends from the tube is unknown. Explain how one may bypass this unknown feature and utilize the observed frequencies of the tube to estimate the speed of sound.

c) Strike a tuning fork of frequency 427Hz and place it over the top of the tube and vary the water height until there is resonance. Record the first three resonant distances D. Does the depth of the second and third resonances corroborate your answer to part (b)? Using the observed resonance depths and your answer to part (b) estimate the speed of sound. How does it compare with the accepted value?

d) Using the observed resonance depths you found in part (c) estimate the amount d that the wave extends from the open end of the tube. How does the ratio d/R compare with 0.6?