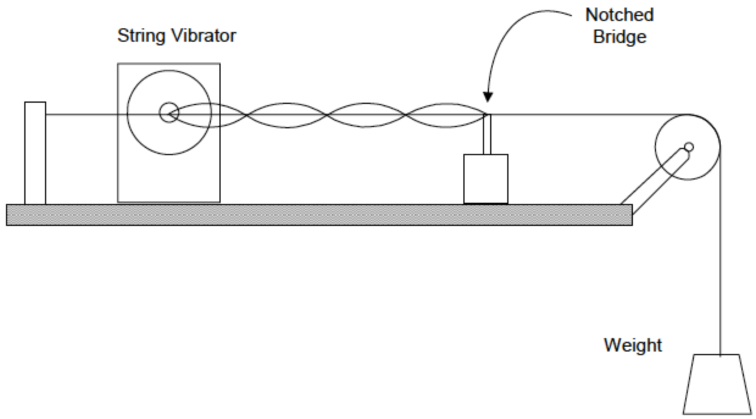
Standing Waves

In this lab activity, you will examine standing waves in two forms: on a string and in a column of air. In each case, we will use the standing wave pattern to determine the speed of the waves (on the string or in the air) and then compare those experimental values to the theoretical value of the wave speed. Keep in mind that the speed of a wave depends solely on the *properties of the medium* in which it is traveling.

I. Standing waves on a string

Set up a string under tension, as shown in the figure below. The string is attached to a rod on one end, and then hangs over a pulley on the other end, with weights used to apply tension to the string. The vibrator and the notched bridge form the "fixed endpoints" for the standing wave patterns (*i.e*. these constitute the points "tied" to the wall, in the conventional pictures).



1. Your objective is to measure the wave speed on the string under different conditions (*i.e*. different string tensions). You will be varying the frequency of the vibrator (driven by a function generator) in order to establish standing waves on the string (various harmonics). Before starting, make sure that you know what parameters enter into this calculation, so that you will know exactly what quantities you need to measure.

2. Choose a reasonable mass (in the range 100-400 g) to hang on the string and then begin to scan the frequencies for standing wave resonances. Identify as many as you can possibly generate and record the relevant parameters for each case. You should be able to observe up to (at least) the $n = 5$ standing wave pattern (frequencies are $f < 100$ Hz).

3. From each measured harmonic, calculate the wave speed. You should present your results (including *frequency* and *wavelength* for each harmonic) in a neatly organized data table. Obtain an overall average for the wave speed.

4. Determine the "theoretical" value for the wave speed based on the relevant physical parameters of the string.

5. Compare the "theoretical" value to your experimental average for this configuration.

6. Now change the hanging mass to a different value and repeat steps 1-5 for this new case.

II. Standing waves on a torsional spring

The apparatus with the long black rods with white painted ends is a torsional spring. It is a pretty good analog for sounds transmission is solids, where the elasticity of the solid is related to the spring constant of the individual atoms that make up the solids crystal lattice. It will also allow you to vary the fixed end vs. free end condition).

1. You objective is to excite several resonant modes of the spring system (first and as many higher order harmonics as possible), and then measure the wave speed. You will also measure with the last rod fixed and unfixed (this will allow you to excite a fixed end and a free end condition).
2. There is only one apparatus, so you should space yourselves throughout the lab period to give each group a turn. You should also work together in pairs of groups (6 students). We will use video analysis, so the goal is to make a good video of each of the modes that you excite.

3. Take turns exciting the various modes by gently wiggling the end rod of the assembly, at different frequencies. You will find that there is a sweet spot where the oscillations build up without too much effort.

4. Stop and brainstorm with your group an experimental approach to the measuring the wavelength, frequency, and velocity from the videos that you will make. From your experience with what right or wrong on the first lab, discuss what you need to take into account (length scales, camera position, lighting, how many videos). Discuss this with one of the instructors before moving forward.

5. Go ahead and take a picture of your brainstorming activity and post to FB.

6. Now go ahead and make your videos, be sure to label them in some way and then post them to FB for analysis by your group. We will finish this on Tuesday, if needed.

7. While waiting to use the apparatus, clean up to other lab setup and move it to the cart in the lab. You can also start to analyze your data from part 1 of the lab.