

## Standing Waves on a Stretched String

In this lab you will measure the frequencies of the “normal modes” of a string under tension, and compare your results to what you predict.

In class we saw how to relate the normal mode frequencies to the length of the string and the speed  $v$  of wave propagation. We also saw how to relate  $v$  to the tension and mass density of the string, which you will measure independently. This will allow you to make a comparison between prediction and measurement. As always, you should observe whether or not your prediction and measurement agree to within uncertainty.

Your “string” is actually a wire which conducts an electric current. This allows us to set the string in motion using some simple artifacts of electricity and magnetism.

The string is set horizontally, through a fixture off a spool at one end, and around a pulley on the other end. It hangs off the pulley, and a weight hanger is hooked to the end. Weights are added to the hanger, and that applies the tension. You should measure the total weight hanging off the end in order to determine the tension in the string.

To get the mass density of the string, use one or more of the samples left out for you. Measure the length of a long piece, and weigh it on the sensitive digital scale. This will give you the mass per unit length of the string.

Then, measure the length of the string. This should be the distance between the fixed end, and the spot where it is up against the pulley. All of this information is now enough for you to predict the normal mode frequencies. Which of these measurements do you think dominates the uncertainty in your prediction? (That is, which has the greatest fractional uncertainty?)

In order to measure the normal mode frequencies, you put an alternating current through the string, i.e. the wire. An alternating current (AC) generator is attached through connectors on either end of the wire. Make sure the AC generator is on the setting that produces a sine wave output. You can adjust the frequency of the sinusoidal current by using the knobs and range switches on the front of the AC generator. Note that there are fine and coarse frequency adjustment knobs. It will take a little effort to tune the frequency and set the wire in motion.

A small C-magnet, located somewhere along the wire, will give a force to the wire that varies at the same frequency as the current. That will set the wire in motion at that frequency, and when you are tuned to a normal mode, you will see it clearly in the behavior of the wire. (The wire is in “resonance.”) The number of nodes (i.e. stationary points along the wire) will tell you which mode you are in.

Tuning the wire to the first two or three normal modes is not very hard, but they get harder as you get higher in frequency. Identify as many normal mode frequencies as you can, and check that they are integer multiples of a “fundamental” frequency. Use this to determine (with an uncertainty) the fundamental frequency, and compare this to your prediction from the length of the wire and the speed of wave propagation in the wire.

You may want to repeat this experiment for different values of the tension.