VELOCITY OF ONE DIMENSIONAL WAVES

In this lab, a mechanical driver will shake a stretched string. You will adjust the frequency of the driver's oscillations.

The velocity of the waves on that string is determined by the linear mass density of the string and the force of tension on the string:

$$v = \sqrt{\frac{F_{\mathrm{T}}}{\mu}}\ .$$

You will have two different strings to use, and you will be able to adjust the tension by the addition or removal of hanging masses.

The wavelength of the waves will be determined by these two parameters:

$$v = \lambda f.$$

When the wavelength is such that a half-integral number of wavelengths appear on the string, the interference between the waves generated by the driver and those that reflect from the other end of the string will produce large-amplitude standing waves through constructive interference:

$$\frac{n\lambda}{2} = L.$$

For these special cases, the wavelength can easily be directly measured from the appearance of the string. This is what you will be measuring.

1. There are samples of the white cotton string and green wire string by the scales. Do not cut them. Use them to determine the values of the linear mass density for each type of string.

2. The sample of white cotton string is already set up for your system. Use about 150 grams to stretch the string.

The function generator allows you to choose the frequency for the driver. The multimeter allows you to get a more precise reading from the generator's dial setting. Turn on the function generator. Adjust the amplitude to a value in the lower middle of the range. Start changing the frequency with the dial until you observe one of the large-amplitude standing waves. (You may need to make further adjustments to the amplitude.)

What frequency have you found?

Which mode is it? (What value of n?)

Measure the wavelength. (Remember, there's only ½ a wavelength between adjacent nodes.)

From the frequency and the wavelength, calculate the velocity of this wave. (Call this "experimental.")

From the tension force and the linear mass density, calculate the velocity of this wave. (Call this "theoretical.")

3. Predict the frequency for the next higher standing wave mode (the next higher value of n). I don't mean turn the knob until you find it, and I don't mean guess at it. Calculate it.

OK, now go looking for it experimentally. Where did you actually find it?

What "experimental" velocity do you obtain for this setting?

4. Variation with tension.

You can change the tension by changing the hanging mass. This will change the velocity of the waves traveling in the string. Determine the same information for four different tension values (all using masses greater than 150 g). For each tension, use two different standing wave frequencies, so that you'll be able to get two different velocity data points for each.

Tension force	***n***	**Frequency**	**Wavelength**

You're going to use this data to obtain "experimental" values of the wave velocity as a function of the tension force. We will want to make a graph of that data (wave velocity and tension) that is theoretically expected to be a straight line.

What should we plot on the vertical and horizontal axes of that graph? What does theory say the slope of that straight line should be?

Once you've got a plan, put both "experimental" values of velocity for each value of tension in Excel (including the data from parts 2 and 3). Make the graph that you theoretically expect to be a straight line. Fit the data to a straight line. Print that graph.

Does the slope of the fit line agree with its theoretically expected value?

5. Variation with linear mass density.

Switch to the green wire string. You will again use the same 150 g mass to produce tension as you did in parts 2 and 3. Based on your measured linear mass densities and your data from parts 2 and 3, predict the frequencies for which you will find the same standing wave modes as you observed in parts 2 and 3 for this new string.

Now do the experiment. What frequencies did you obtain for those same modes?