Name: ______________________________
Partner(s): ____________________________
1101 Section: __________
Desk # _______________
Date: ________________

Standing Waves on a String

Purpose: to find the speed of a wave on a string.

Introduction and Theory:

A standing wave pattern can be created on a string that is fixed at both ends by vibrating the string near one end. Waves travel along the string and are reflected at the fixed ends of the string. At certain frequencies, the waves and their reflections interfere constructively, giving rise to large stationary amplitudes. These are called standing waves.

The frequencies of the standing waves are called resonance frequencies f_n. For a string fixed at both ends, the resonance frequencies are:

$$f_n = \frac{n v_{\exp}}{2L} \qquad (1)$$

where $n = 1, 2, 3, 4\ldots$ is the harmonic number (or the number of antinodes)
v is the speed of the wave on the string
L is the length of the string between the fixed ends (see Fig. 1)

The smallest resonance frequency f_1 is called the "fundamental frequency".

In this lab, you will measure the first 6 resonance frequencies $f_1, f_2, \ldots, f_6$, and find the wave speed v_{exp}, using Eq. (1).

In order to find a reference speed of the wave on the string, we note that the material that the wave is moving in (the wave medium) will affect how the wave moves. The speed is determined by the tension F_T in the string and its linear mass density μ (mass per unit length), so the reference speed v_{ref} is:

$$v_{ref} = \sqrt{\frac{F_T}{\mu}} \qquad (2)$$

Standing Waves on a String 1101 Prelab

Instructor initials:

1. From Eq. (1):

$$f_n = \frac{n v_{\exp}}{2L} \qquad (1)$$

Rearrange this equation to find the experimental speed v_{exp} of the wave on the string:

Find the relative uncertainty equation for the experimental v_{exp} :

2. From Eq. (2):

$$v_{ref} = \sqrt{\frac{F_T}{\mu}} \qquad (2)$$

Write an equation for linear mass density μ :

Find the relative uncertainty equation for the reference speed v_{ref} of the wave on the string:

The Experiment The Speed of a Wave on a String

Apparatus:

See Fig. 1 for the setup. List and identify all apparatus required. Obtain wire leads (BNC/coax cables), a 4-arm balance and a function generator.

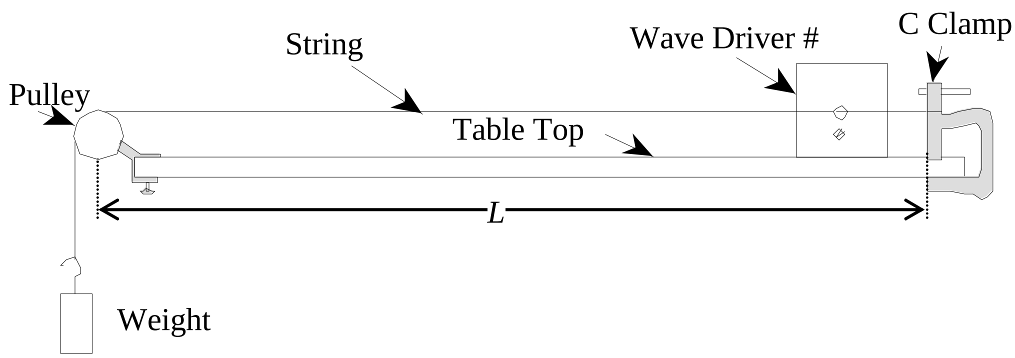

Fig 1

Data:

Before you make any knots on the string, measure the appropriate quantities to determine the linear mass density of the string, using the 4-beam balance and metre sticks.

Measurements for linear mass density of string		uncert
Total mass of string (g)		
Total length of string (m)		

Set up the apparatus as shown in Fig 1. The string must be threaded through the *small* hole (not the larger hole) in the shaft of the wave driver and attached to the C clamp.

Attach a total weight of 2.10 N (± 0.02 N) to the end of the string.

Connect the main output of the function generator to the wave driver. Set the function generator to output a sine wave of maximum amplitude.

Find and record the resonance frequencies of the first 6 harmonics, f_1 through f_6. While making the measurement, determine the uncertainty for both f_n and n.

Measure the length L of the vibrating string. See Fig 1.

Harmonic number	Frequency (Hz)	uncert

Length of vibrating string (m)	uncert

Calculations: (Show your work and DO NOT ROUND ANYTHING IN THIS SECTION)

For each of your resonance frequencies f_n, calculate the corresponding wave speed v_n , using Eq. (1):

Calculate the average wave speed v_{avg} from your previous calculations:

Calculate the linear mass density of the string μ: (do unit conversion(s) first)

Calculate the reference value for the wave speed v_{ref}, using Eq. (2):

Uncertainty Analysis: (Show your work and DO NOT ROUND ANYTHING DURING THIS SECTION)

Find the uncertainty of your average speed of the wave on the string v_{avg}, using the scatter of your v_n values:

Write the relative uncertainty equation for the experimental v_{exp} from your prelab:

This will have a term of $\delta f_n / f_n$. Find the average relative uncertainty of your resonance frequencies:

Calculate the relative uncertainty for the experimental v_{exp}:

Calculate the absolute uncertainty for v_{exp}:

Which of these two absolute uncertainties is largest? THAT is what you will use for the uncertainty of your experimental speed of the wave on the string:

Write the relative uncertainty equation for the reference speed v_{ref} from your prelab:

Calculate the relative and absolute uncertainties for v_{ref}:

Conclusions:

In complete sentences, state your experimental and reference speeds of the wave on the string. Use proper format, with proper rounding, with proper units, etc.

Discussion: (Do these on the back of this page)

Do your two speed values agree within their uncertainties? Do NOT just say "yes/no". Compare the values in a CLEAR and meaningful analysis, and STATE why you think they do or do not agree.

If they do NOT agree, discuss why that may have happened. (Uncertainty is NOT a valid reason for an experiment working or not working. If done correctly, uncertainty windows will/will not verify agreement, but does not cause a failure in the experiment. Uncertainty is not a mistake.)

If the experimental and reference speeds agree within their uncertainties, discuss the experiment and its procedures. Recommend ways to reduce the uncertainties or make the experiment "better".

Discuss anything else you can think of for this experiment.

Remember: since I am not grading for formal lab report formatting, I expect clear, complete and well thought-out discussions.