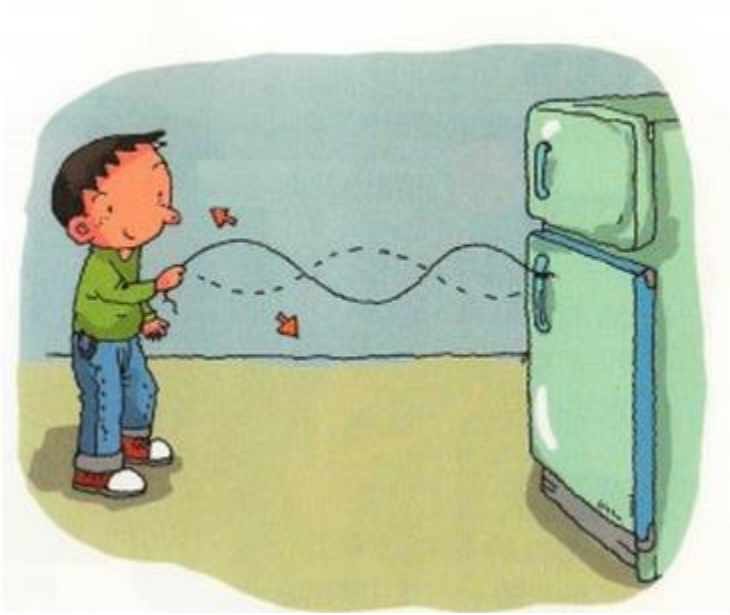
Standing waves in a string



1st year physics laboratories

University of Ottawa

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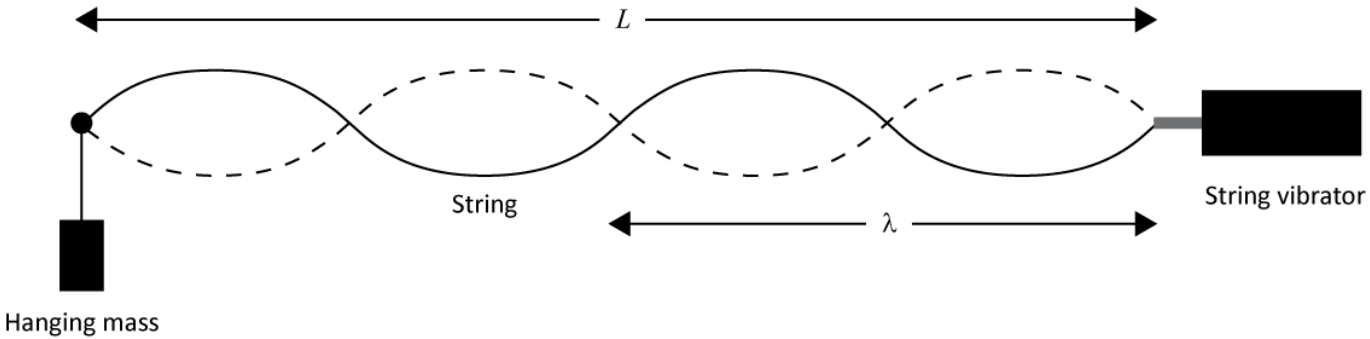
INTRODUCTION

- When you shake a string, a pulse travels down its length and can be reflected.
- A series of periodic waves can interfere with their reflections and with the right conditions, a superposition of these waves leads to a “standing wave.”
- This looks like a stationary wave on the string with some parts hardly moving (nodes) and some regions having large displacement (antinodes).
- In this experiment you will investigate various factors that give rise to standing waves.

WAVELENGTH AND FREQUENCY

- We consider how the speed of the wave is affected by the density of the string, the tension, and the frequency.
- Consider the following standing wave made by a string vibrator



  - Any place the string (with length, $\boldsymbol{L}$) is fixed will be a node (both ends).
  - The number of segments in the wave is referred to as *n*. In this wave, $\boldsymbol{n = 4}$.
  - Each segment of the wave corresponds to one half of a wavelength, $\boldsymbol{\lambda}$. Here, $\boldsymbol{\lambda = L/2}$.

WAVELENGTH AND FREQUENCY (cont.)

- If you drive a string at an arbitrary frequency, you probably won't get a standing wave since many modes of the wave will be mixed together.
- If the tension, the frequency, and the length are adjusted accordingly, you will see one vibrational mode occur at a higher amplitude.
- For a wave with wavelength, $\boldsymbol{\lambda}$, and frequency, $\boldsymbol{f}$, the speed is:

$$v = \lambda f$$

- Where $\boldsymbol{v}$ is measured in m/s, $\boldsymbol{\lambda}$ is measured in m, and $\boldsymbol{f}$ is measured in Hz (1 Hz = 1 s^{-1})

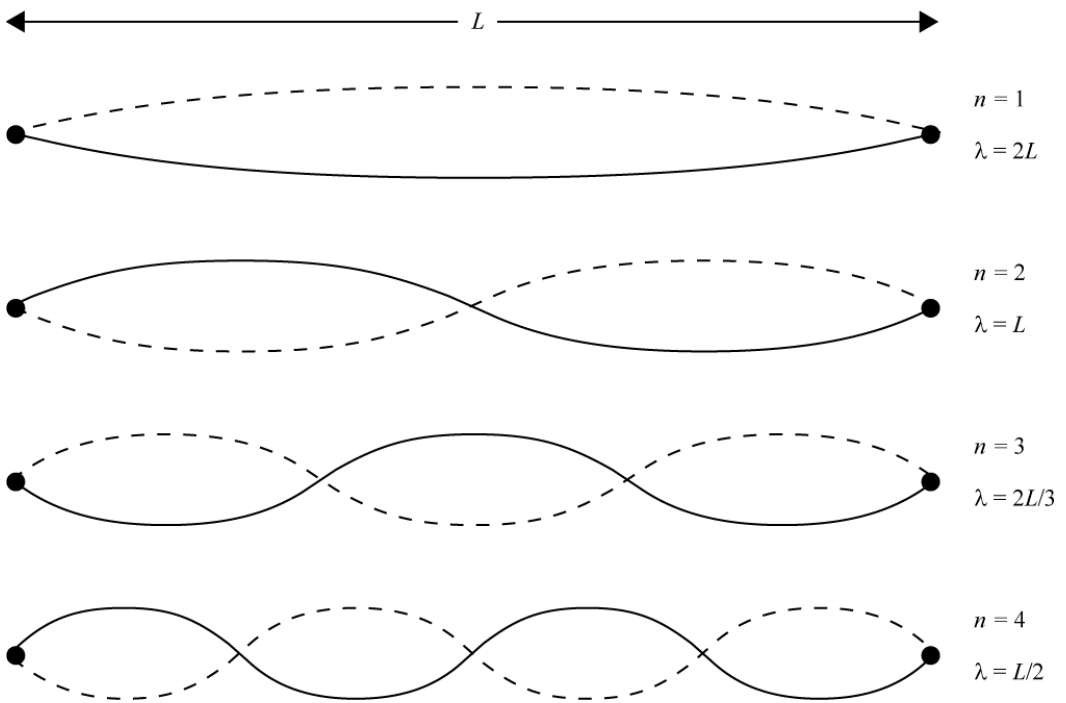
WAVE SPEED AND STRING DENSITY

- For a wave on a string, the speed, $\boldsymbol{v}$, is also related to the tension, $\boldsymbol{T}$, in the string and the linear density, $\boldsymbol{\mu}$:

$$\boldsymbol{v = \sqrt{\frac{T}{\mu}}}$$

  - The linear density is mass per unit length.
  - The tension is created by a hanging mass, $\boldsymbol{m}$

$$\boldsymbol{T = mg}$$

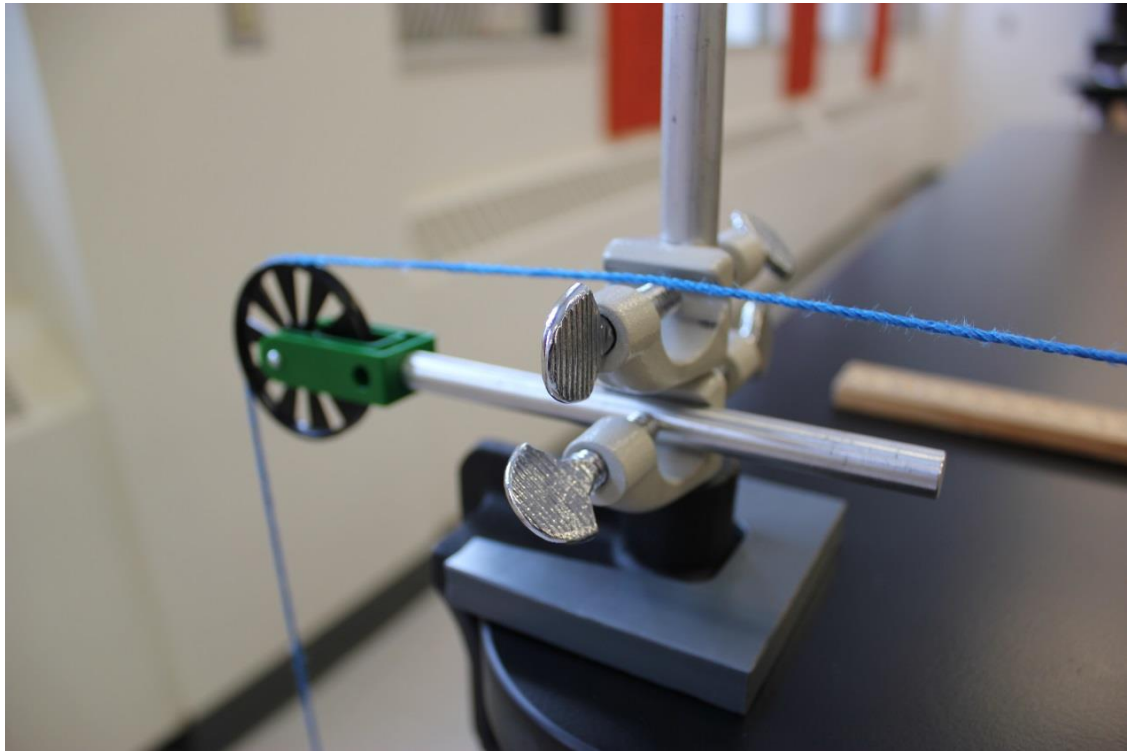


PRELIMINARY STUFF

- Launch Logger Pro and the Function Generator.
- Install the C-clamp with string vibrator 1 m away from the end clamp.
- Run the string to the clamp screw and hang the string over the edge with the mass hanger attached (as shown in the picture to the right).
- Measure the length of the string on the TA's desk as well as its mass. Calculate the linear density, $\boldsymbol{\mu}$.

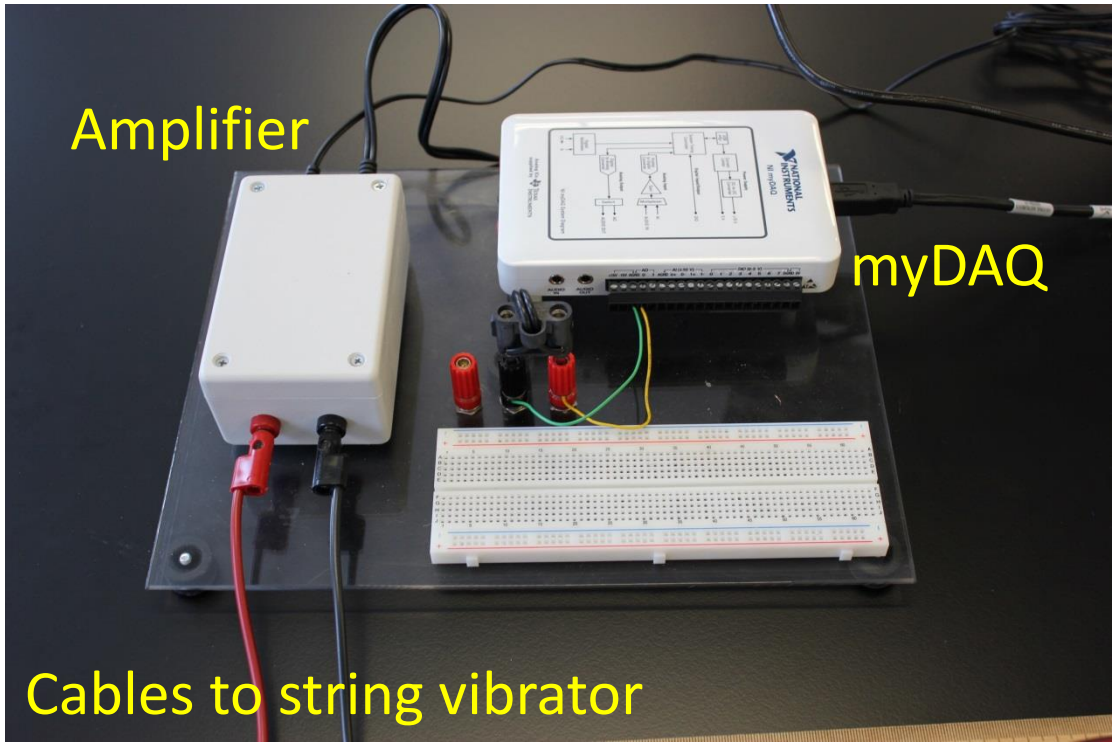
- Calculate the fundamental frequencies for $\boldsymbol{n}$ = 2 – 5 for $\boldsymbol{m}$ = 0.15, 0.25, and 0.35 kg and record your values in *Table 1*.

ZOOMED VIEW CLAMP AND THE PULLEY

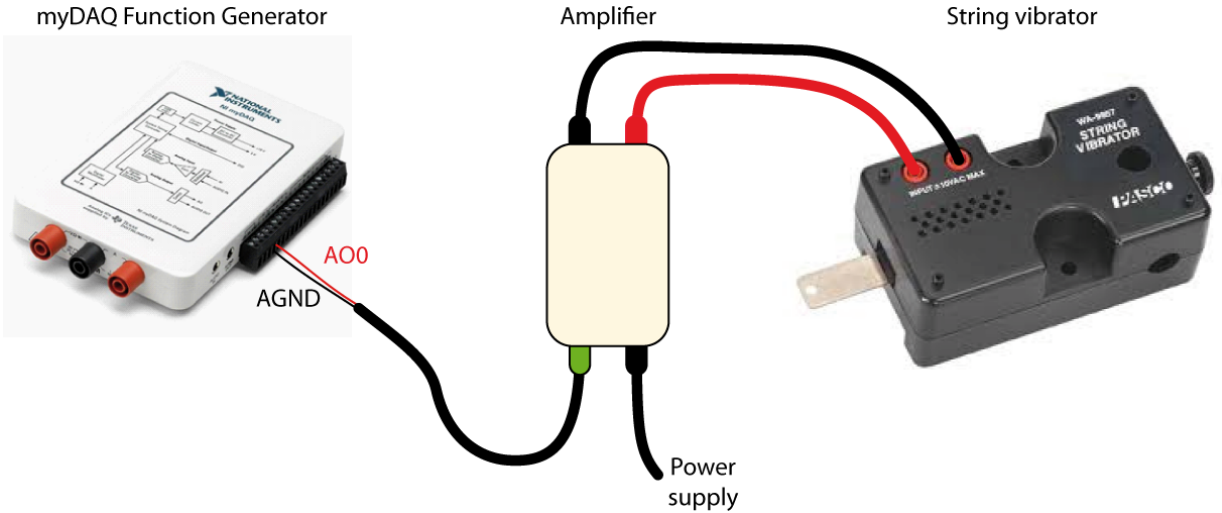


THE myDAQ BOARD

- We will use a myDAQ and a digital function generator to create waves in the string.
- The myDAQ signal is amplified before it reaches the string vibrator.
- The function generator program is found on your desktop.



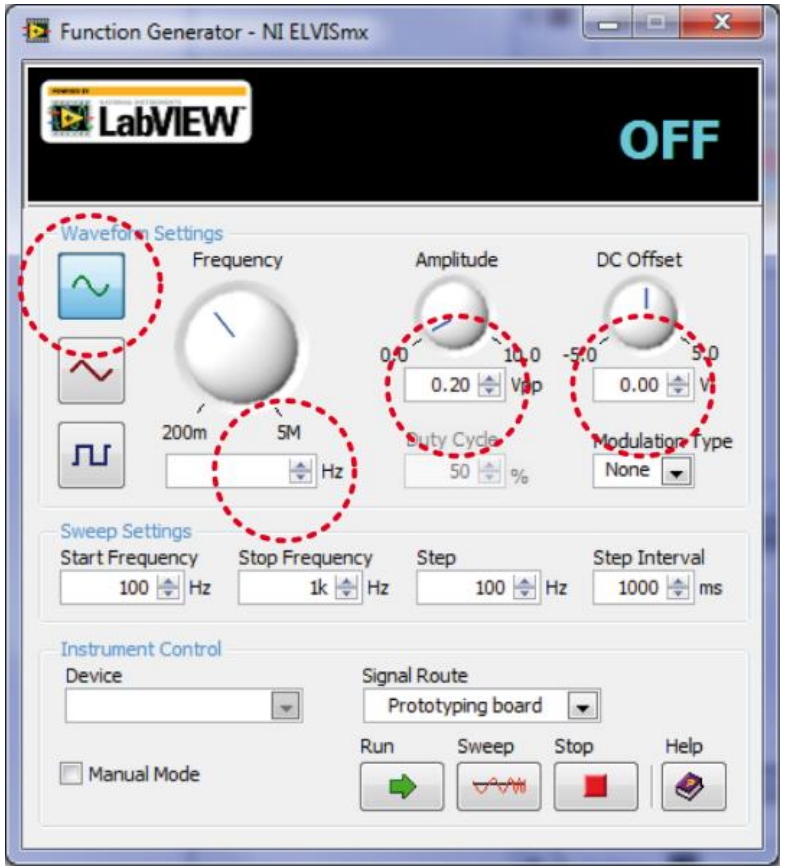
WAVELENGTH AND FREQUENCY



- Connect the myDAQ to the amplifier to the string vibrator as shown in this figure (and previous page).
- The string vibrator will be driven using a sinusoidal pulse from the function generator.

THE FUNCTION GENERATOR

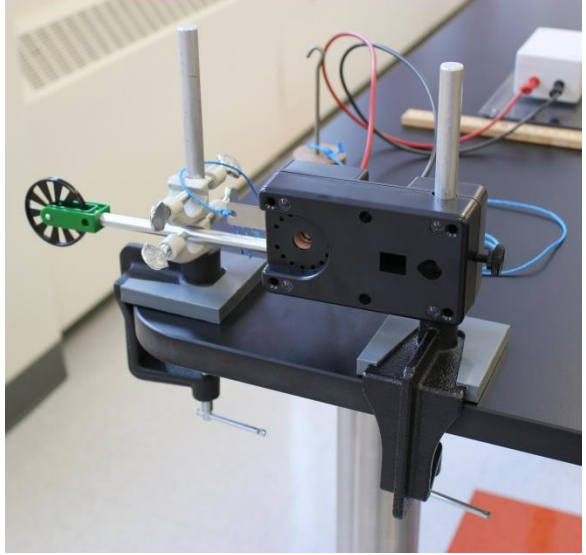
- Select the **sine wave**.
- Set the **Frequency** to the value you calculated for $n = 2$, $m = 0.35\ \text{kg}$.
- Set the **Amplitude** to 0.2 V
- Make sure **DC Offset** is set to 0 V.
- Make sure the **Device** is set to myDAQ and **Signal Route** is set to AO 0.
- Click **Run**



ADJUSTING FREQUENCY

- You can adjust the frequency as necessary to get stable nodes. It is important that the vibrating blade is steady.
- When changing the frequency to find the best standing wave, start incrementing by 1 Hz, then 0.5 Hz, then 0.1 Hz. You do not have to use smaller increments than 0.1 Hz.
- You can either type in the new frequency each time or highlight the value and use the up and down arrow keys to make incremental changes.
- Complete *Table 1* and make your *Graph 1*. You should be able to find the experimental value of μ from the slope.

CLEAN UP



- Turn off the computer and **don't forget to take your USB key.**
- Put back the masses and the hanger on the table.
- Move the string vibrator C-clamp back close to the other C-clamp.
- Please recycle scrap paper and throw away any garbage. Please leave your station as clean as you can.
- Push back the monitor, keyboard, and mouse. Please push your chair back under the table.

- Thank you!

DUE DATE

The report is due at the end of the lab session, i.e., at 12:50pm or 5:20pm.

PRE-LAB

Don't forget to do your pre-lab for the next experiment!