Lab Sim 03: Standing Waves on a String

Introduction

A standing wave bridges the gap between our concepts of simple harmonic motion and waves. A standing wave occurs when a wave interferes with itself. We already used this idea in our Speed of Sound lab, but this week our standing wave will be—literally—easy to see, even if we can't actually surf it.

Objectives

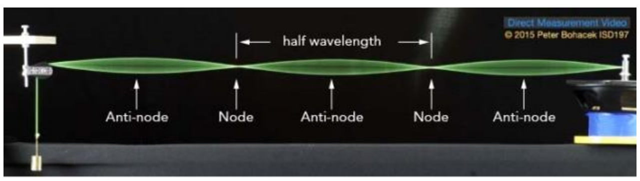
- Observe a standing wave pattern on a vibrating string
- Distinguish between a wave's nodes and anti-nodes
- Identify and measure the wavelength of a standing wave
- Calculate the speed of a wave
- Apply the relationship between wave speed, tension, and linear density for transverse waves on a string

Pivot Interactives

This exercise requires the online simulation (Lab 03: Standing Waves). You should sign in to your Pivot account and choose the correct Interactive from the PHYS 1420 selection.

Standing Wave Basics

Use the figure below to answer the following questions.



1) (1 point) How many nodes does this standing wave have?
   A. 0
   B. 1
   C. 2
   D. 4
   E. 8
2) (1 point) How many anti-nodes does this standing wave have?
   A. 0
   B. 1
   C. 2
   D. 3
   E. 4
3) (1 point) If the string length is L, what is the wavelength λ of the wave shown?
   A. $\lambda = \frac{L}{2}$
   B. $\lambda = \frac{2L}{3}$
   C. $\lambda = \frac{3L}{4}$
   D. $\lambda = L$
4) (1 point) To increase the number of half-wavelengths on the string from three to four,
   A. Increase the frequency.
   B. Decrease the frequency.

Standing Waves Interactive

Make sure that you view the video and understand how to select a combination of cord and hanging mass and which combinations are available to analyze.

Measuring the Wavelength

Select a combination of string and hanging weight. Measure and record the frequency and wavelength of each successive resonance using the same method we developed last week. The red LED reading on the function generator is the frequency in Hz.

5) (0 points) Pick either Cord #1 or Cord #2. Don't use Cord #3 (yet!). Which cord did you choose?
   A. Cord #1
   B. Cord #2
6) (0 points) Which mass did you select?
   A. $m = 50\text{g}$
   B. $m = 70\text{g}$
   C. $m = 100\text{g}$
   D. $m = 150\text{g}$
   E. $m = 200\text{g}$
7) (6 points) You should measure the wavelength for six different frequencies. You will need to add two columns to the data table: one for calculating the wavelength λ and another for calculating the period T.

Frequency f (Hz)	Half-Wavelengths n (count)	Length L (m)

To calculate the wavelength: $\lambda = \frac{L}{n/2}$

where L is the measured length of string and $\frac{n}{2}$ is the number of complete wavelengths measured (i.e., $n = 4$ means four *half*-wavelengths, which corresponds to $\frac{n}{2} = \frac{4}{2} = 2$ *full* wavelengths!).

And we are already familiar with the relationship between frequency and period: $T = \frac{1}{f}$.

Measuring the Linear Mass Density

Extract the wave speed using the same method we used in the previous Lab Sim, then use the experimental value of the wave speed to determine the linear mass density of the string.

8) (2 points) Within the interactive, plot the appropriate graph and perform the linear regression.
9) (2 points) What is the wave speed? Record your value.

10) (2 points) Determine the linear density (mass per length) of the cord: $v = \sqrt{\frac{T}{\mu}}$, where v is the wave speed, T is the tension in the cord in Newtons, and μ is the linear density of the cord in kg/m.

Predicting the Wave Speed

Let's compare the wave speed in the same string, but using a different amount of hanging weight. Use the same cord from the previous experiment, but choose a new hanging mass.

11) Which mass did you select?
    A. $m = 50\text{g}$
    B. $m = 70\text{g}$
    C. $m = 100\text{g}$
    D. $m = 150\text{g}$
    E. $m = 200\text{g}$
12) (2 points) Based on the linear density μ that you just calculated and the tension ($T = mg$) in the cord, predict the speed of the wave: $v = \sqrt{\frac{T}{\mu}}$

For this new mass, record frequency and wavelength data for each of the resonances. Like you did last time, create and populate columns for the wavelength λ and period T.

13) (6 points) Create one more column: wave speed v. Let the table calculate the values for the speed.

Frequency f (Hz)	Half-Wavelengths n (count)	Length L (m)

14) (2 points) Calculate the experimental average wave speed, v_{av}.
15) (2 points) Have you convinced yourself that the tension equation can reliably predict the wave speed? How close is your prediction to your average value? Calculate the percent difference.

Mystery Mass

Determine the mystery mass (Cord #3) using the methods we have just developed. The linear mass density of Cord #3 has been measured: $\mu_3 = 0.00335\frac{\text{kg}}{\text{m}}$.

16) (5 points) Create the appropriate data table (don't forget to label each column and include units), then measure and record the relevant data. Graph what needs graphing to extract what values need extracting!
17) (2 points) Very briefly describe your process. What is the value of the mystery mass?

When you have completed this lab exercise in Pivot, please be sure to submit your responses. This lab is due no later than Tuesday, 19 July 2022, at 11:59 PM CDT.