PHYSICS 208

Waves on a String - Standing Waves Lab

In this lab you are using The Physics Aviary Standing Waves Lab simulation:

https://www.thephysicsaviary.com/Physics/Programs/Labs/StandingWaves/

First some background information:

What is a wave?

For our lab session here, a wave is a periodic wiggle in space and time, where the regularly repeating disturbance in the medium or field transports energy from one place to the next with a zero net transfer of matter.

Two types of waves:

Transverse wave – motion of the medium is transverse or orthogonal to the direction of wave travel.

Longitudinal wave – motion of medium is along the direction of travel of wave.

Figure 1 – Parts of a Transverse Wave

Node – no disturbance of medium from rest position
PHYSICS 208

Waves on a String - Standing Waves Lab

Antinode – disturbance of medium from rest position to positive maximum or negative minimum

Amplitude – measure of distance medium has traveled for maximum disturbance from rest position.

Frequency of wave – number of complete wavelengths which occur each second.

Velocity of a wave, \( V = f \lambda \)

Concerning waves on a string, the string has tension, \( T \) (unit of measure Newtons [N]) and linear density of mass per unit length (m/L) \( \mu \), \( \mu \) (unit of measure kg/m)

Velocity of travel for waves on a string with tension, \( T \) and linear density, \( \mu \) is:

\[ V = \sqrt{\frac{T}{\mu}} \]

Procedure

Part I (a): Confirm Standing Wave Relationship \( \frac{1}{n} = \frac{1}{2L} \cdot \lambda \)

1. Click on the hyperlink below to open simulation page:

   https://www.thephysicsaviary.com/Physics/Programs/Labs/StandingWaves/

2. Click ‘Begin’ to start experiment.
3. Click on dial below ‘Frequency’ to set experiment frequency to 1.0 Hz to begin your experiment.
4. Click on dial below ‘Amplitude’ to set amplitude to 8 cm or 12 cm.
5. Set string ‘Tension’ on 3 N, lowest available option.
6. Set your ‘Linear Density’ on 0.3 kg/m or any value you wish to use.
7. Activate Grid and Enable Ghosting.
PHYSICS 208

Waves on a String - Standing Waves Lab

8. Press ‘Power’ to start simulation. You may have to enable ‘Slo-Mo’ to see exact location of nodes on grid.

9. Your aim is to get a node at location zero (0) on grid. You may press pause and then resume experiment upon pressing play. However, to change your ‘Tension’ value, you must press power and then increase your tension value.

10. Increase ‘Tension’ value until there is a node on the zero grid line. Record following data in Table 1 below, for this situation where there is a node on the zero line:

Table 1: Data For Fundamental Frequencies Where $\mu = 0.3 \text{ kg/m}$

<table>
<thead>
<tr>
<th>$n$</th>
<th>$\lambda$</th>
<th>$f$</th>
<th>$T$</th>
<th>$L$</th>
<th>Amplitude</th>
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$L$, is length of grid with wave phenomenon observed.

11. Using the same Linear Density and Amplitude, adjust your Frequency and Tension to get fundamental frequencies (these occur on a stringed musical instrument) where a node is present on grid value of zero (0). Try to get result for between 2 to 8 nodes. Record data in Table 1 from above.

12. Confirm standing wave relationship: \( \frac{1}{n} = \frac{1}{2L} \cdot \lambda \), by plotting graph $1/n$ Vs $\lambda$. Slope should be $1/(2L)$. 
PHYSICS 208

Waves on a String - Standing Waves Lab

Part I (b): Explore relationship between Tension and Wavelength using a selected fundamental frequency from Table 1.

Choose one of your fundamental frequencies from Table 1 above to set as your constant frequency for this run of the simulation experiment. Therefore, you now have three constants in your experiment mass per length μ (kg/m), frequency $f_{\text{fundamental}}$ (Hz) and length L (m). Here you may or may not have integer number of nodes n. Complete Table 2 below.

Table 2: Relationship between Tension and Wavelength

<table>
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<th>n</th>
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Part II.

Using equations $V = f \lambda$ and $V = \sqrt{\frac{T}{\mu}}$ and data from Table 2, plot the following graphs on the same pair of axes:

(a) Plot Tension on the X-axis vs wavelength on the Y-axis
(b) Plot Tension on the X-axis vs wavelength squared on the Y-axis
(c) Determine the slope of plot in part (b). Slope here is $\frac{1}{\mu f^2}$
PHYSICS 208

Waves on a String - Standing Waves Lab

(d) Determine from the slope in (c) the average frequency \( f_{\text{avg}} \), for your experiment.

(e) Determine percent difference between these two frequency values.

\[
\left( \frac{f_{\text{fundamental}} - f_{\text{avg}}}{f_{\text{fundamental}}} \right) \times 100.
\]

(f) Was there a difference between your two values for frequency in this experiment?

(g) If there was a difference in the values, can you give two reasons why this difference occurred?