Standing Waves Lab

Resource: https://phet.colorado.edu/en/simulation/wave-on-a-string

In this simulation you can investigate the behavior of waves on a string.

Part 1 Waves on a string with no end

Select the 'No end' option and 'oscillate'.

Challenge: Determine the speed of the waves at each tension setting (high, medium and low). Explain what measurements you made to calculate the speed.

Settings: amplitude: 0.75 cm   damping: zero

high tension:

medium tension:

low tension:

Does the speed of the wave depend on the frequency or is it the same for all frequencies? Collect data to support your answer:

Part 2 Waves on a string with a fixed end

The reflected wave interferes with the original wave and creates a standing wave composed of nodes and antinodes if the frequency is just right. A node will always exist at the fixed end because the phase of the wave is inverted upon reflection and therefore always destructively interferes at that position. Adjust the frequency until maximum amplitude results. (You can use the reference line to help you detect small changes in the amplitude as you fine tune the frequency.)

Settings: amplitude: 0.05 cm   tension: high   damping: none

Challenge: Draw and measure the frequencies of the 4th, 3rd, 2nd, and 1st harmonics.

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 (4 antinodes)   (3 antinodes)   (2 antinodes)   (1 antinode)

$f_4 =$ _____ Hz $f_3 =$ _____ Hz $f_2 =$ _____ Hz $f_1 =$ _____ Hz

Divide each higher harmonic by the first harmonic:

$f_4 / f_1 =$ _____ $f_3 / f_1 =$ _____ $f_2 / f_1 =$ _____

Are the higher harmonics whole-number multiples of the first harmonic (fundamental frequency)? _____

Predict the frequency of the 5th harmonic: (show calculation)

Set the wave driver to that frequency and draw the result here: --|

Part 3 Waves on a string with a loose end

The reflected wave interferes with the original wave and creates a standing wave composed of nodes and antinodes if the frequency is just right. Instead of a node, an antinode will always exist at the loose end. (This happens because the phase of the wave is **not** inverted upon reflection from a loose end and therefore always constructively interferes at that position.)

Challenge: Draw and measure the frequency of the 1st harmonic (node near driver end followed by an antinode on loose end)

Settings: amplitude: 0.05 cm   tension: high   damping: none

-------------------------------------0   What fraction of a wavelength is this? _____

$f_1 =$ _____ Hz

Predict the frequencies of several higher harmonics:

Use the wave simulator to test each of your calculated harmonics. Note which ones appeared and which ones did not appear!

Draw and label the standing waves for each of the harmonics you discovered:

----------------0   ----------------0   ----------------0   ----------------0

Divide each higher harmonic by the first harmonic:

Are the higher harmonics even-number or odd-number multiples of the first harmonic? _____

Explain why there are missing harmonics for standing waves on a string with a loose (free) end. (Hint: Is there a pattern to how much of a wavelength fits between the ends of the string with a loose end?)

Extra credit: The speed of a transverse wave on a string of length **L** and mass **m** under tension **T** is given by the formula

$$v = \sqrt{T / (m/L)}$$

If the maximum tension in the simulation is 10.0 N, what is the linear mass density (m/L) of the string?