

The **Wave on a String** simulation allows students to create their own waves and explore wave concepts such as amplitude, frequency, damping, tension, speed, reflection, and interference.

CREATE a wave with an oscillator or pulse generator, or by moving a wrench

PLACE reference line anywhere

CONTROL wave properties

MEASURE distance or time

RESTART the wave while preserving the other settings in the sim

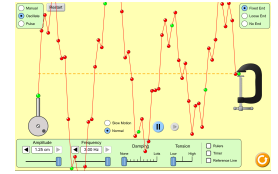
EXPLORE waves with a fixed, loose, or no end point

VIEW the wave in slow motion

PAUSE and step through the motion of the wave

Model Simplifications

- The waves are modeled as a rope on the ground being oscillated from side to side in the absence of gravitational effects and external friction.
- The rope is modeled as a string of particles, and can appear dissociated under extreme conditions, as the processing increments are not infinitesimally small.
- The tension in the string does not have any specific value in the model, as the appearance of tension is achieved by varying the time step used to animate the wave. The tension slider does not behave linearly — it operates on powers of two (High is 4x larger than Low). The functional relationship between the tension and wave speed can be qualitatively observed if tension is given arbitrary units in increasing powers of two (e.g. 2, 4, 8 or 64, 128, 256).



Customization Options

Query parameters allow for customization of the simulation, and can be added by appending a '?' to the sim URL, and separating each query parameter with an '&'. The general URL pattern is:

```
...html?queryParameter1&queryParameter2&queryParameter3
```

For example, in Wave on a String, if you want to run the sim in Spanish (`locale=es`) and disable external links (`allowLinks=false`) use:

https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_all.html?locale=es&allowLinks=false

Query Parameter and Description	Example Links
<code>locale</code> - specify the language of the simulation using ISO 639-1 codes. Available locales can be found on the simulation page on the Translations tab . Note: this only works if the simulation URL ends in “_all.html”.	<code>locale=es</code> (Spanish) <code>locale=fr</code> (French)
<code>allowLinks</code> - when <code>false</code> , disables links that take students to an external URL. Default is <code>true</code> .	<code>allowLinks=false</code>

Insights into Student Use

- Some students struggle with damping, which is like internal resistance. Some students may want to understand more and could use [Masses and Springs](#) (“Damping” is called “Friction” in this sim) or [Resonance](#) sim (the Teacher Tips give a mathematical definition).
- This sim may be helpful for students as an introduction to more difficult concepts like sound, earthquakes, or light.

Suggestions for Use

Sample Challenge Prompts

- Predict the pattern of a reflected wave from a fixed or loose end.
- Develop a method to determine the speed of the wave.
- Design an experiment to find the relationship between the wave speed, wavelength, and frequency.
- Measure the wave speed and at different levels of tension to determine the relationship between speed and tension.

- Predict how two waves will interfere.
- What effect does damping have on a wave?

See all published activities for Wave on a String [here](#).

For more tips on using PhET sims with your students, see [Tips for Using PhET](#).

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

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.)

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

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

			
(4 antinodes)	(3 antinodes)	(2 antinodes)	(1 antinode)
$f_4 = \underline{\hspace{2cm}}$ Hz	$f_3 = \underline{\hspace{2cm}}$ Hz	$f_2 = \underline{\hspace{2cm}}$ Hz	$f_1 = \underline{\hspace{2cm}}$ Hz

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?