

STANDING WAVES SIMULATION

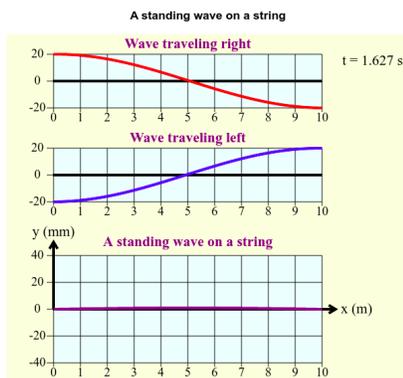
Introduction

The goal of this simulation is to observe the relationships between frequency, wavelength and the speed of waves in a rope. We will explore how they are related to tension in the rope and the observation of standing waves.

Submit your answers using Blackboard.

1 – Basic Interference

To study the interference of two waves open the simulation (http://physics.bu.edu/~duffy/HTML5/transverse_standing_wave.html)



The wave on the top travels to the right and then is reflected back as shown by the wave in the middle which travels to the left. The wave at the bottom is the standing wave generated by the interference of the two waves present in the same rope.

1. How are the wavelengths of the three waves related?

Pause the animation (it does not matter the time you pause it). Look at any two locations (for example $x = 2$ m and $x = 7$ m).

2. How is the amplitude of the standing waves related to the amplitude of the individual two waves?

Increase the number of Harmonic n

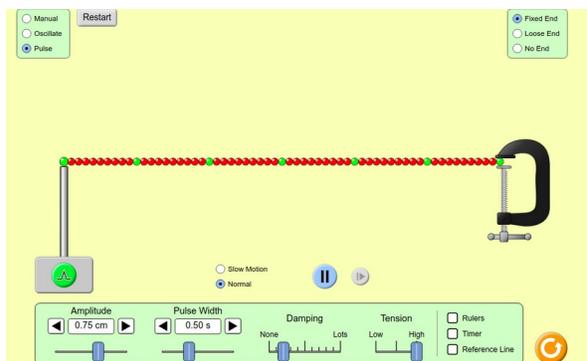
3. How does the wavelength change?

4. How does the velocity change?

5. How does the frequency change?

2 – Speed of the Wave

Open the simulation (<https://phet.colorado.edu/en/simulation/wave-on-a-string>). Run the simulation and select *Pulse* from the top left corner



Set the parameters: *Fixed End*. Damping = *None*. Speed of the simulation: *Normal*. Tension = *Low*. Amplitude = 0.50 cm. Display *Rulers* and *Timer*.

6. What is the length of the string?

Click the button on the pulse generator to send a pulse through the string. Measure the period T : how long it takes for the pulse to travel back and forth (the distance traveled by the pulse is twice the length of the rope).

7. What is the value of T ?

8. From your data calculate the speed of the wave.

For the next two measurements it might be easier to set the speed of the simulation to *Slow Motion*.

9. Set the tension in the middle. Measure the period and calculate the speed of the wave.

10. Set the tension set to *High*. Measure the period and calculate the speed of the wave.

11. What is the effect of a greater Amplitude on the velocity of the wave?

3 – Standing Waves

Use the same simulation entitled *Wave on a String*. You can restart the simulation by clicking the yellow icon located at the bottom right. Select *Oscillate* from the top left corner.

Set the parameters: *Fixed End*. Damping = *first line* from the left (*None* counts as is line 'zero'). Amplitude = 0.20 cm. Tension = *Low*. Frequency = 0.56 Hz

Play the simulation. In order to decide if a standing waves is generated in the string, look at the green dots: they should oscillate the least compared to their adjacent points.

12. Do you see a standing wave?

A standing wave is generated if its wavelength λ satisfies the condition,

$$\lambda = \frac{2L}{n}$$

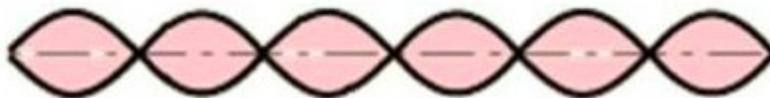
where L is the length of the rope and the n is number of loops.

The goal now is to find the appropriate frequency in order to generate standing wave. Specifically the sixth harmonic ($n = 6$) standing wave. Recall the formula,

$$v = \lambda f$$

The velocity of the wave is equal to the product of its wavelength and its frequency. Using the condition on λ above, the above formula for velocity, and your results from question 8, 13. What is the frequency in order to generate the sixth harmonic?

Input this frequency into the simulator and press restart to check. You should see



with the green dots oscillating the least compared to their adjacent points. If not, repeat your simulation by checking both measurements and calculations.

14. What is the frequency necessary to generate the fourth harmonic?

While the simulation plays the sixth harmonics, reduce the Damping to *None*.

15. How does the velocity of the standing wave change?

16. How does the amplitude of the standing wave change?

17. What is the name of the physical phenomenon which describes the effect on the amplitude?

Change the frequency back to 0.56 HZ and reduce the Damping to *None*

18. Is the wave now affected by what is described in question 17?

4 – Questions

Use the information learned from the simulations to answer the following questions. It can be shown that the wavelength depends on the tension in the string as

$$\lambda = \frac{1}{f} \sqrt{\frac{T}{\mu}}$$

where μ is the mass per unit length of the string and T is the tension in the string.

19. Suppose you have established a standing wave on a string. If you increase the tension until another standing wave is created, how will the new wavelength compare to the original?

20. If the tension is tripled will you get a standing wave?

A standing wave with 5 loops is created on a string of length 3.0 m and mass 5.0 g

21. What is its wavelength?

22. If the tension in the string is measured to be 290 N what is the wave frequency?

23. What is the speed of the wave?