Superposition of waves on a string

Name:

Group Members:

Date:

TA's Name:

Apparatus: PASCO mechanical vibrator, string, mass hanger (50 g) and set of masses, meter stick, electronic scale, signal generator, two wire leads, pulley and two metal stands with brackets.

Objectives:

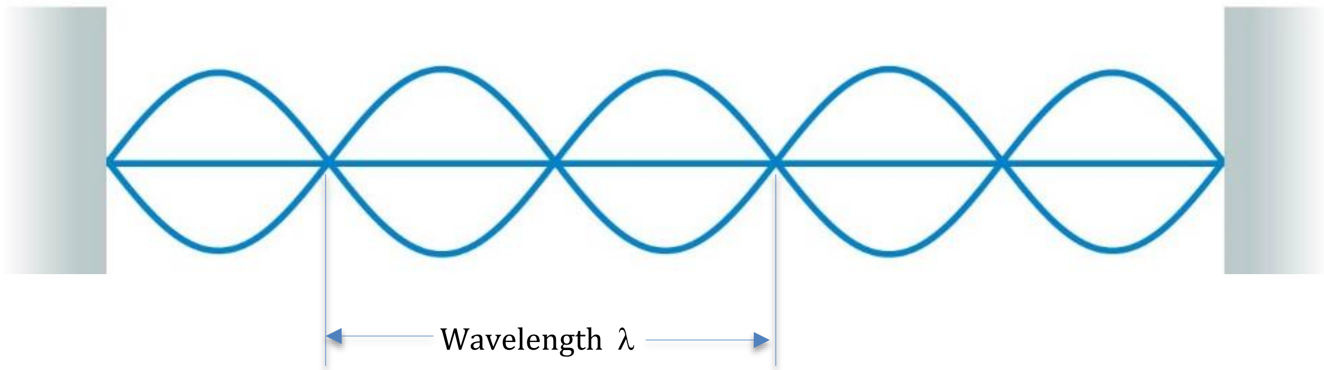
1. To understand superposition of two sinusoidal waves moving in opposite directions.
2. To study wave propagation in a string.
3. To understand the formation of standing waves on a string.

Part 1: Introduction

In your tutorial you studied the reflection and superposition of pulses moving in a slinky and in a string. Here in this experiment you are going to investigate the superposition of two oppositely moving sinusoidal waves moving in a tight string. When two sinusoidal waves of the same frequency are moving in opposite directions in the same medium, a standing wave is the result. This often occurs when a wave is traveling in a medium where there is a reflection at one or both ends.

Figure 1 shows a standing wave pattern resulting from periodic waves of wavelength λ traveling to the right and to the left in the string. In a standing wave, there are points in the medium with zero displacement called "nodes" where the two waves are always in destructive interference. There are also points with maximum displacement called "antinodes" where the two waves are always in constructive interference. The three lines shown in the standing wave pattern indicate the position of the string at three different times in the motion; one when the entire string is at the equilibrium position (flat line), one when the antinodes have a maximum displacement from equilibrium, and one when the antinodes have a maximum displacement in the opposite direction from equilibrium.

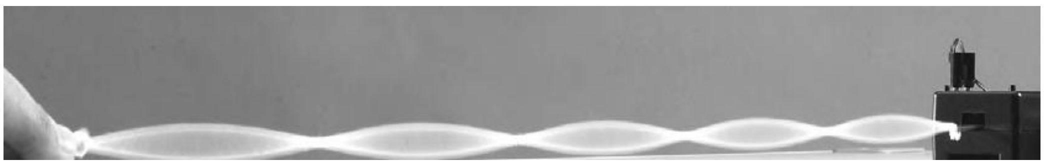
1. Identify all nodes by marking them with the letter **"N"** and all antinodes by marking them with the letter **"A"** in the standing wave pattern shown below.



Part 2: Fixed frequency with different tensions

2. In the last experiment, you investigated the relationship of wave speed with tension. What did you conclude from that experiment?

Fix the string vibrator to a metal stand. Then take the string and attach one end to the string vibrator. Connect the AC power supply to the string vibrator which will vibrate the string at 60 Hz. Hold the free end of the string as shown in the figure below and slowly increase the tension by pulling it away. Observe the standing wave patterns that occur as you stretch the string.



3. What happens to the number of antinodes as you increase the tension?

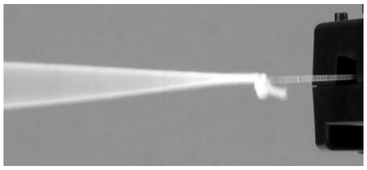
4. What happens to the wavelength as you increase the tension? Refer back to the figure on the first page to see how wavelength is related to nodes and antinodes.

5. Does the frequency of the standing wave change as you increase the tension?

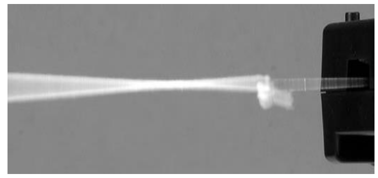
6. What is the justification to your answer in #5?

7. Adjust the tension until the string vibrates with 4 segments. Then adjust the tension slightly (fine tune) so that you get a good node at the blade.

Good node at the vibrator end



Bad node at the vibrator end



Experimentally verify that the displacement of the medium (string) is zero at nodes. Briefly explain what you did to verify that there is no displacement at the nodes.

8. Measure and record the length of a segment or between two adjacent nodes using meter stick.

   Length of a segment:

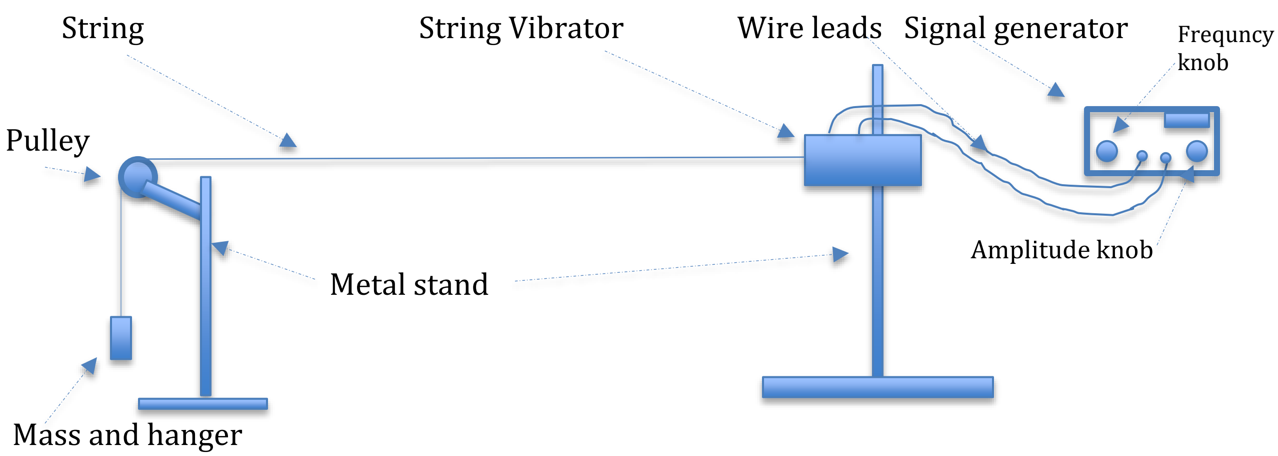
9. Determine the wavelength of the standing wave using a meter stick.

   Wavelength = ___________________________

Part 3: Fixed tension with different frequencies

You just experimentally verified the existence of standing waves with nodes and antinodes. You also observed that for a fixed length of a string the wavelength of a standing wave varies with tension in the string. Now you are going to investigate the formation of standing waves in the string with different frequencies at a fixed tension.

Remove the AC power supply. Setup the apparatus as shown below. Make sure that the string is horizontal. Place 100 g in the mass hanger so that the total mass attached is 150 g. Adjust the length between the pulley and the vibrator to be more than 1.00 m. Connect the frequency generator to the string vibrator. From the function menu select "sin" wave and keep the amplitude knob at about ¾ of its maximum value. Then push 0-50 Hz range button. Connect the signal generator to the power and switch on the generator. You can adjust the frequency from the frequency knob.



10. Now slowly increase the frequency of the signal generator starting at 0 Hz and carefully observe the formation of standing waves which have a good node at the vibrator end. Once you reach such a frequency, fine tune it with fine frequency adjustment. Complete the observation/measurement chart below.

Sketch of the standing wave pattern	# of antinodes	f (Hz)	λ (m)	$f\lambda$

11. The last column is the product of frequency times wavelength, $f\lambda$. What SI units does this quantity have?

12. What kinds of quantities have the same units as does frequency times wavelength?

13. Is the quantity $f\lambda$ approximately the same for all these standing waves?

14. Based on the values in the last column calculate the average speed of the waves in the string?

15. Look at the frequencies you found that give good standing waves. Do you see a pattern for these values? What relationship do you find between frequency and the number of antinodes?

16. Look at the wavelengths you found that give good standing waves. Do you see a pattern for these values? Express the wavelength in terms of the length of the string and the number of antinodes.

Part 4: Same standing wave pattern with different tension

17. Transfer your data for standing wave with 3 antinodes using 150 g hanging mass to the table below. Then repeat #10 with different tensions using 250 g and 350 g total hanging masses to find the frequency which results in a good standing wave with 3 antinodes. Complete the table below.

# of antinodes	mass=150 g			mass=250 g			mass=350 g		
	f (Hz)	λ (m)	$f\lambda$	f (Hz)	λ (m)	$f\lambda$	f (Hz)	λ (m)	$f\lambda$
3									

18. What can you conclude about how tension affects the wave speed? Is this consistent with what you found in the previous experiment?

19. When the wave speed increases, will the wavelength need to increase, decrease or stay the same to get the same standing wave pattern (such as the one with 3 antinodes)?

20. When the wave speed increases, will the frequency need to increase, decrease or stay the same to get the same standing wave pattern (such as the one with 3 antinodes)?

Part 5: Application

21. Based on your experience in this experiment explain tuning a guitar (or any other stringed instrument) by changing the tension of the string.