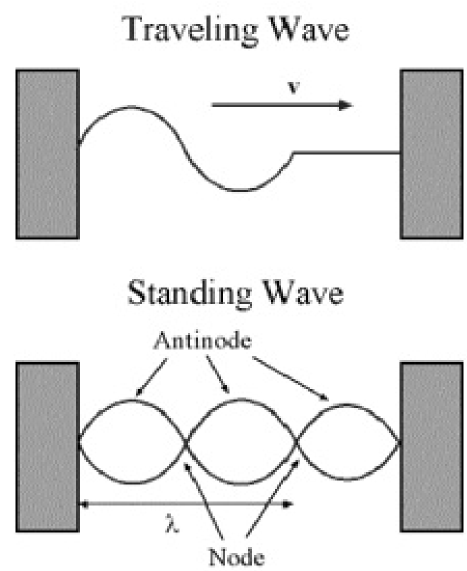
PHYSICS 2204
Unit 4: Waves
Worksheet #6: Standing Waves

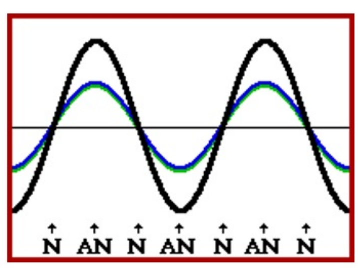
Student Name: ____________________________

Standing Wave:

- wave reflects back on itself with the same frequency, wavelength and speed.
- the result of the a wave interfering constructively and destructively with its reflection
- It is confined in the medium



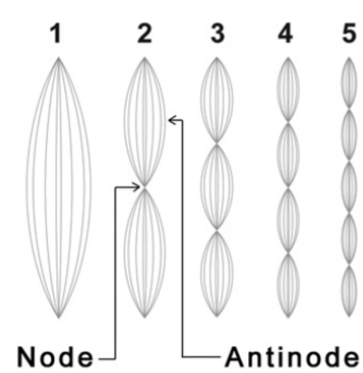
At any given time the incident and reflected wave are added together in accordance with the principle of superposition.



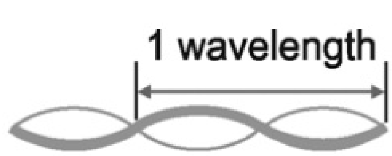
There are two main parts of a standing wave

Nodes are points on the standing wave that remain stationary at all times. It is a place of destructive interference .

Antinodes are points on the standing wave that have the greatest negative and positive displacement. It is a place of constructive interference.

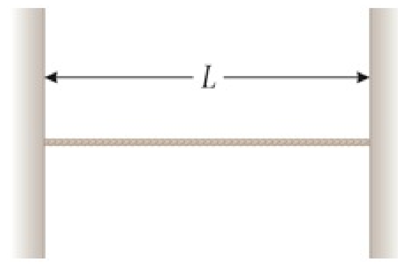


The wavelength of a standing wave can be found by measuring the length of two of the “bumps” on the string. The first harmonic only contains one bump, so the wavelength is twice the length of the individual bump.



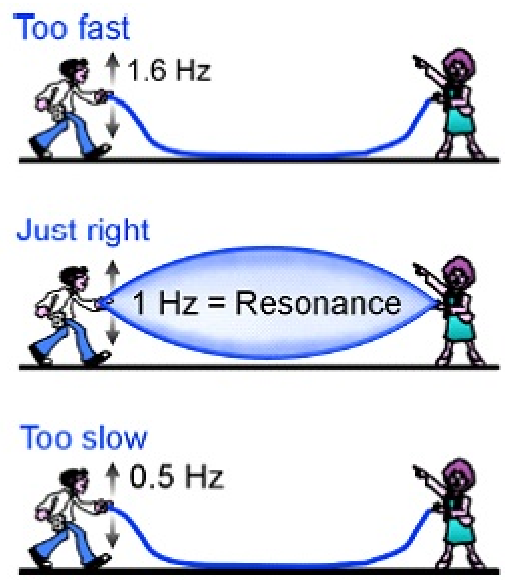
Standing Waves in a String:

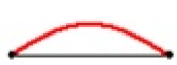
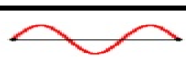
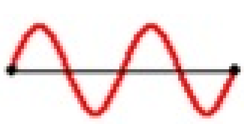
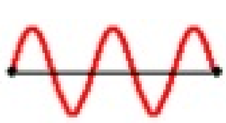
- Consider a string fixed at both ends and has a length **L**:
- Waves can travel both ways on the string.
- Standing waves are set up by a continuous superposition of waves incident on and reflected from the ends.
- The ends of the strings must necessarily be nodes.



- At certain natural frequencies, standing waves can be produced in which the wave appears to be standing still rather than traveling. Each frequency is associated with a different standing wave pattern.
- Fundamental Frequency (F_o) refers to the natural frequency of the first harmonic.

- **Harmonics** refers to the range of natural frequencies in which standing waves are produced. It refer to resonant frequencies which are integer multiples of the fundamental frequency.
- **Overtones** refer to any resonant frequency of a system that has a frequency higher than its fundamental frequency
- The first five harmonics of a standing wave on a string are shown to the right.



Picture	#Anitnode	#Nodes	Wavelength	Frequency	Harmonic	Overtone
	1	2	$\frac{1}{2}\lambda$	F_o	1	fund
	2	3	λ	$2F_0$	2	1
	3	4	$1\frac{1}{2}\lambda$	$3F_0$	3	2
	4	5	2λ	$4F_0$	4	3
	5	6	$2\frac{1}{2\lambda}$	$5F_0$	5	4
----	n	n+1	$\frac{n}{2}\lambda$	nF_0	n	n-1

Example 1:

Complete the chart below for a 60 cm string with a fundamental frequency of 100 Hz

Picture	#Anitnode	#Nodes	Wavelength	Frequency	Harmonic	Overtone
					4	
					6	

Example 2:

A string is vibrating in the 3rd harmonic at a frequency of 360 Hz and with a wavelength of 48 cm. What are the wavelength and frequency of the second harmonic, and the speed of each wave?

Example 3:

A standing wave in a rope has a frequency of 28 Hz at the second harmonic.

a. If the wavelength is 0.20 m, what is the distance between nodes?

b. What is the speed of the waves that make up the standing wave?

c. What would the frequency of a rope vibrating at the third harmonic be?

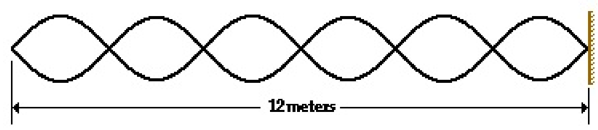
PART A: MULTIPLE CHOICE

Instructions: Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided.

1. Standing waves are produced by the superposition of two waves with

(A) The same amplitude, frequency, and direction of propagation.
(B) The same amplitude and frequency, and opposite propagation directions.
(C) The same amplitude and direction of propagation, but different frequencies.
(D) The same amplitude, different frequencies, and opposite directions of propagation

2. Consider the standing wave pattern shown below. A wave generated at the left end of the medium undergoes reflection at the fixed end on the right side of the medium. What is the number of antinodes in the diagram?



(A) 3.0
(B) 5.0
(C) 6.0
(D) 7.0

3. For question #2, What harmonic is shown in the standing wave pattern ?

(A) Third
(B) Fifth
(C) Sixth
(D) Seventh

4. The distance between successive nodes in any standing wave pattern is equivalent to ____ wavelengths.

(A) 1/4
✔ (B) 1/2
(C) 3/4
(D) 1

5. A node is a point along a medium where there is always ____.

(A) A crest meeting a crest
(B) A trough meeting a trough
(C) Constructive interference
(D) Destructive interference

6. A stretched string vibrates with a fundamental frequency of 100. Hz. The frequency of the second harmonic is ____.

(A) 25.0 Hz
(B) 50.0 Hz
(C) 100. Hz
(D) 200. Hz

7. What type of wave is a result of interference in which portions of the wave are at the rest position and other portions have a large amplitude.

(A) Reflected
(B) Refracted
(C) Standing
(D) Transverse

8. What is created when a guitar string is plucked?

(A) Diffraction waves
(B) Reflected waves
(C) Refracted waves
(D) Standing waves

9. Which term describes the lowest resonant frequency of a standing wave?

(A) Amplitude
(B) Fundamental
(C) Third overtone
(D) Node

10. Resonant frequencies higher than the lowest resonant frequency of a standing wave are called

(A) Amplitudes
(B) Fundamentals
(C) Nodes
(D) Overtones

11. If you blow across the mouth of an empty glass bottle, you hear the lowest resonant frequency which is called the

(A) Fundamental
(B) First overtone
(C) Second overtone
(D) Third overtone

12. A string is plucked producing four loops (antinodes). The length of the string is 12.00 m. The wavelength of the wave must be

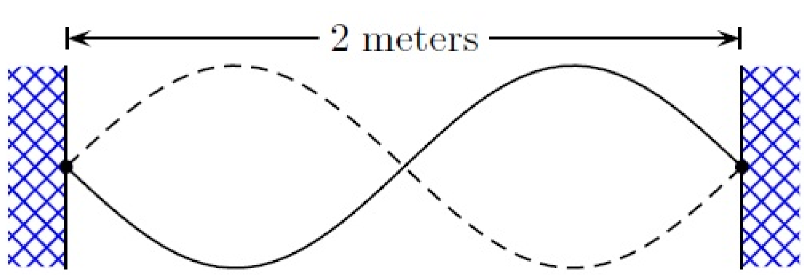
(A) 48.0 m
(B) 24.0 m
(C) 6.00 m
(D) 3.00 m

13. Which of the following occurs in a standing wave?

(A) Reflection and superposition
(B) Reflection and diffraction
(C) Reflection and refraction
(D) Superposition and diffraction

14. A standing wave of frequency 5.0 hertz is set up on a string 2.0 meters long with nodes at both ends and in the center. Find the speed at which waves propagate on the string.

(A) 2.5 m/s
(B) 5.0 m/s
(C) 1.0×10^1 m/s
(D) 2.0×10^1 m/s

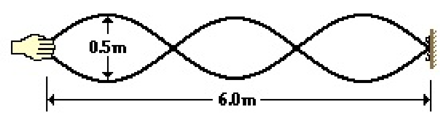


15. Using question 14, what is the fundamental frequency of vibration of the string?

(A) 2.5 Hz
(B) 5.0 Hz
(C) 7.5 Hz
(D) 10 Hz

16. A standing wave experiment is performed to determine the speed of waves in a rope. The standing wave pattern shown below is established in the rope. The rope makes 90.0 complete vibrational cycles in exactly one minute. What is the speed of the waves ?

(A) 3.0 m/s
(B) 6.0 m/s
(C) 180 m/s
(D) 360 m/s



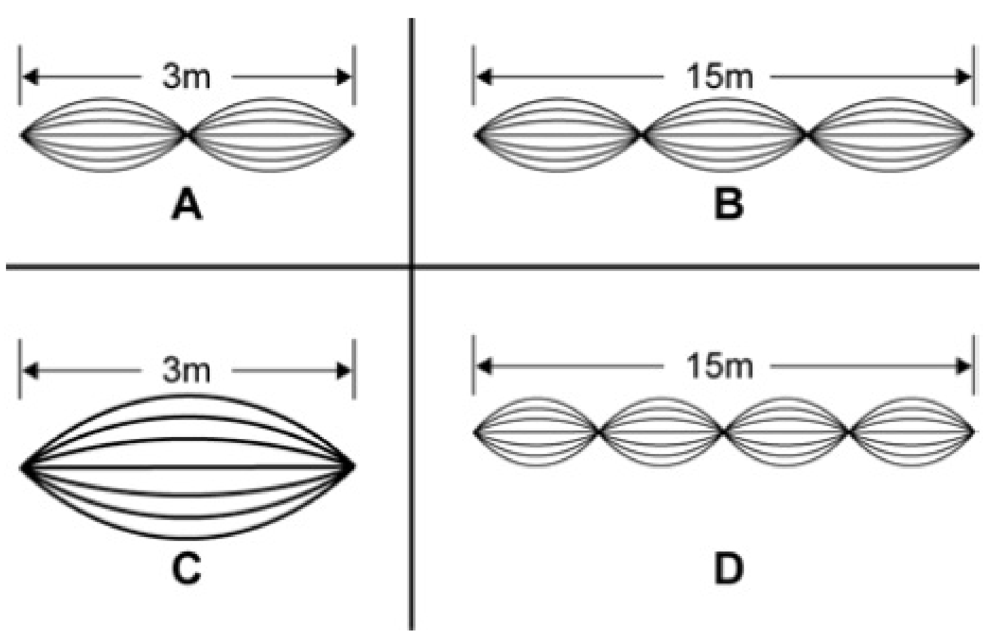
17. Standing waves are produced in a wire by vibrating one end at a frequency of 100. Hz. The distance between the 2nd and the 5th nodes is 60.0 cm. What is the wavelength of the original traveling wave?

(A) 50.0 cm
(B) 40.0 cm
(C) 30.0 cm
(D) 20.0 cm

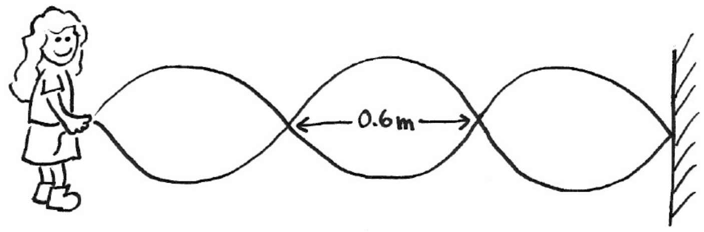
PART B: WRITTEN RESPONSE

1. Use the graphic below to answer these questions.

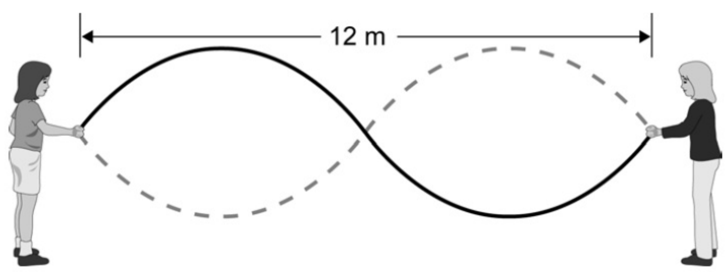
a. Which harmonic is shown in each of the strings below?
b. Label the nodes and antinodes on each of the standing waves shown below.
c. How many wavelengths does each standing wave contain?
d. Determine the wavelength of each standing wave.



2. A student makes a standing wave pattern with a skipping rope as shown. If the waves are moving at 7.0 m/s, with what frequency does the student move her hand up and down?



3. Two students want to use a 12 m long rope to create standing waves. They first measure the speed at which a single wave pulse moves from one end of the rope to another and find that it is 36 m/sec. This information can be used to determine the frequency at which they must vibrate the rope to create each harmonic. Follow the steps below to calculate these frequencies.



a. Draw the standing wave patterns for the first five harmonics.
b. Determine the wavelength for each harmonic on the 12 m rope. Record the values in the table below.
c. Use the equation for wave speed ($v = f\lambda$) to calculate each frequency.

Harmonics	**Speed (m/s)**	**Wavelength (m)**	**Frequency (Hz)**
1			
2			
3			
4			
5			