Framing Questions

1. When we hear a recording of our own voice, most of us feel that the recorded voice sounds different from the voice we normally hear. Are we victims of an illusion or is the difference real?

2. When you are in a quiet room put both thumbs in your ears and listen carefully: you will hear a low rumbling sound. What produces this sound?

3. In the shower, even a bad singer's voice can occasionally sound beautiful. What causes this illusion?

4. A high pitched sound is produced in air and then travels in water. What changes for this sound when it travels through water: pitch (frequency), wavelength, or speed?

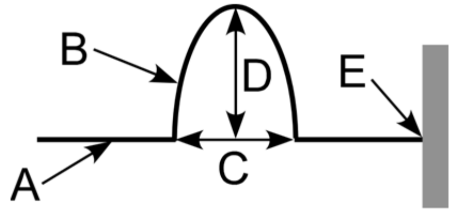
5. What happens when two sound waves meet in a region?

6. A steel tent stake can be driven into hard ground easily and will fit snugly, while an identically shaped wooden stake is hard to drive in and will end up fitting loosely. Why such a dramatic difference?

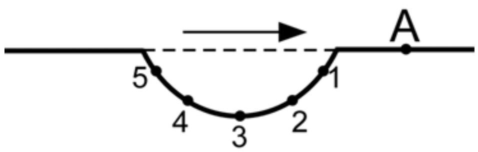
8.1. Practice: **Traveling Pulses**

1. Match the letters below to the corresponding terms:

amplitude_____
equilibrium_____
transverse pulse_____
fixed end_____
pulse length_____



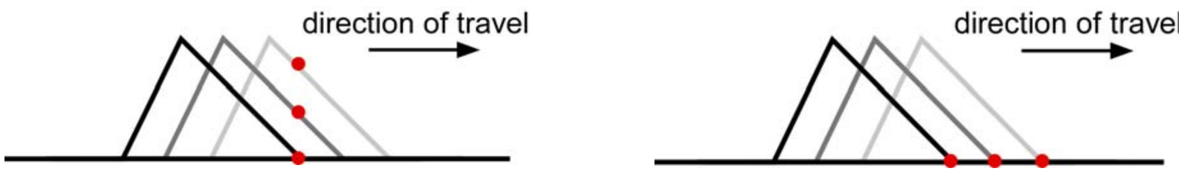
2. Point A represents a particle in a string. A pulse of the shape shown below moves right toward point A, with a velocity v.



Describe in detail the motion of particle A as the pulse goes through it. For each of the positions, be sure to indicate (a) the direction of the motion of the particle A (up, down or not moving), and (b) state whether the particle's speed at A (in the vertical direction) is increasing, decreasing, or zero. Fill out the table below:

Particle A at position	Direction of motion	Speed is
1		
2		
3		
4		
5		

3. A hand steadily wiggles the left end of a string up and down. The figure below shows snapshots of the pulse on the string at three instants in time as the wave travels to the right. A red dot is painted on the string. The pictures below show two possible physical situations. Three students, Andrew, Sarah and Kelly, argue about which picture is physically correct.



Andrew: "The picture on the right is correct, because the wave is traveling to the right. Since the wave and the string look exactly the same, the dot must move with the wave to the right."

Sarah: "The picture on the left is correct, because the wave is a disturbance of the string, not the string itself. As the wave travels to the right, the string moves up and down. Therefore, the dot moves up and down with the string."

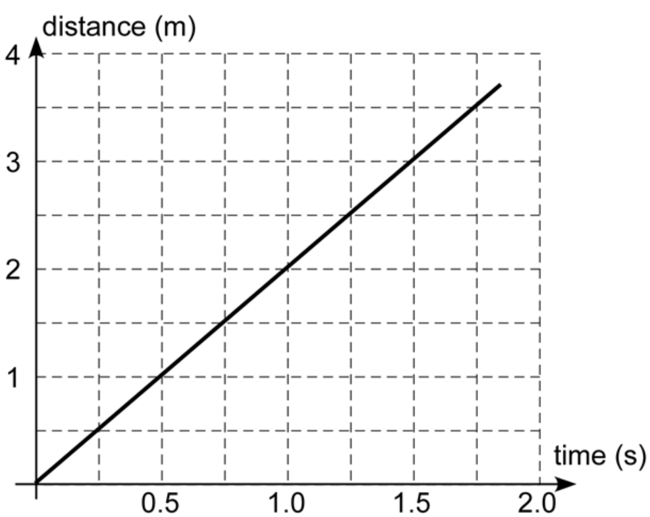
Kelly: "Neither picture is correct. The string's position is at y=0 at point 1, which means the dot just sits there."

Which student do you agree with? Explain.

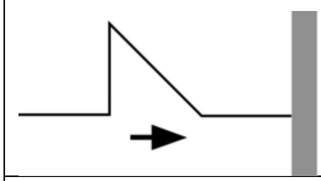
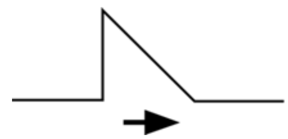
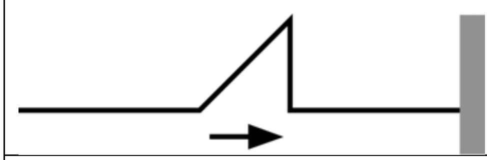
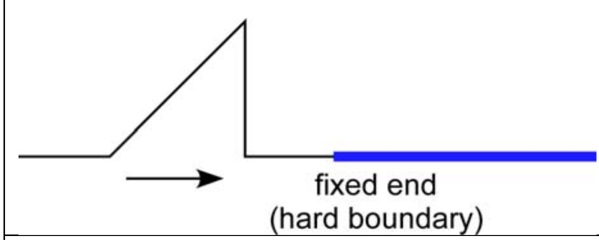
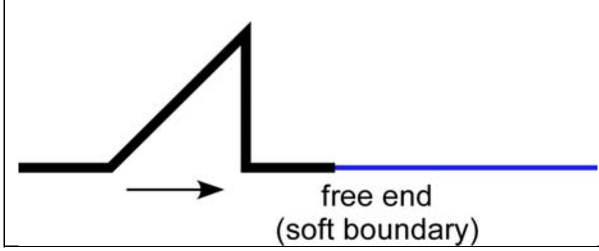
4. Two students, 5.0 m apart, each hold an end of a long spring. It takes 1.5 seconds for a pulse to travel from the student generating the pulse to the lab partner at the opposite end of the spring.
   a) Explain the motion of the pulse passing through the spring.
   b) How long will it take for the pulse to return to the "generator"?
   c) Calculate the speed of the pulse.
   d) The "generator" repeats the experiment with a pulse of twice the original amplitude. Will the pulse take more time, less time, or the same time as in (b)? Explain your answer.

5. The students in problem 4 move now so that they are now 10 m apart but use the same spring. How will the speed of the pulse now compare to the speed of the pulse when they were 5.0 m apart? Explain your answer.

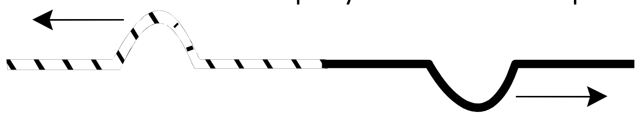
6. The graph below was produced by plotting data for the distance a pulse traveled along a spring in time t.
   a) What can you find from this graph?
   b) Write the mathematical model for the data graphed below.



8.2. Practice: **Reflection and Transmission of Pulses**

1. In the boxes below, draw the pulse as it returns after reflecting from a fixed end.	2. In the box below, draw the pulse as it returns after reflecting from a free end.
	
	
3. The diagram below shows a pulse traveling from a “light” string to a “heavy” string. In the box at right, draw the reflected and transmitted pulses after the original pulse has crossed the boundary between the two media.	
	
4. The diagram below shows a pulse traveling from a “heavy” string to a “light” string. Draw the reflected and transmitted pulses after the original pulse has crossed the boundary between the two media.	
	

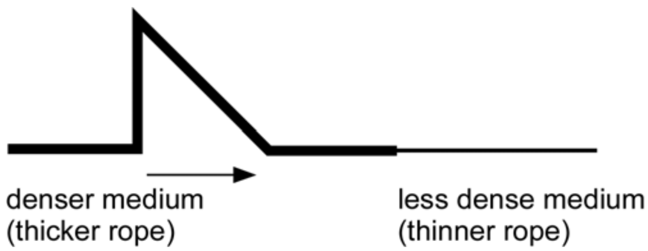
5. Below is shown a two-rope system soon after a pulse arrived at the center.



   a) If the right rope is the heavy rope, what did the system look like just after the system was shaken? In other words, show with a sketch which end was shaken and if the shake was up or down.

   b) If the left rope is the heavy rope, what did the system look like just after the system was shaken?

6. A pulse in a denser medium (medium 1) is traveling towards the boundary with a less dense medium (medium 2).



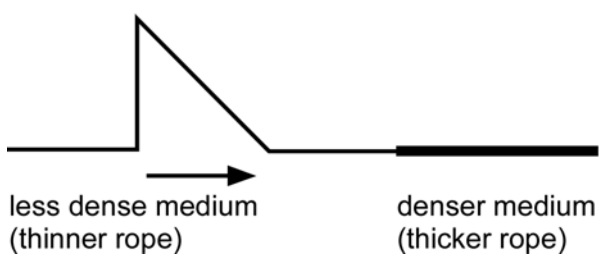
   a) The reflected pulse in medium 1 ________ (will, will not) be inverted because _______________________

   b) The speed of the transmitted pulse will be ___________ (greater than, less than, the same as) the speed of the incident pulse.

   c) The speed of the reflected pulse will be ______________ (greater than, less than, the same as) the speed of the incident pulse.

   d) The wavelength of the transmitted pulse will be ___________ (greater than, less than, the same as) the wavelength of the incident pulse.

7. A pulse in a less dense medium (medium 1) is traveling towards the boundary with a denser medium (medium 2).



   a) The reflected pulse in medium 1 ________ (will, will not) be inverted because ___________________________

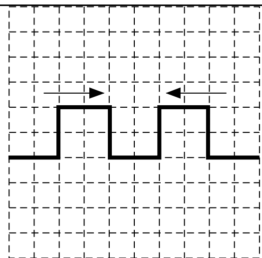
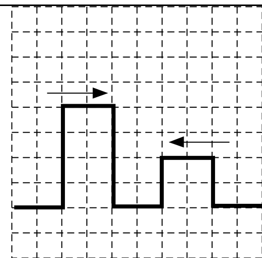
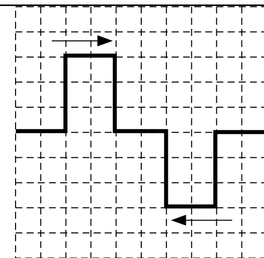
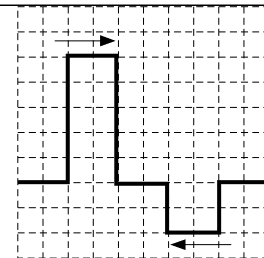
   b) The speed of the transmitted pulse will be ___________ (greater than, less than, the same as) the speed of the incident pulse.

c) The speed of the reflected pulse will be _______________ (greater than, less than, the same as) the speed of the incident pulse.

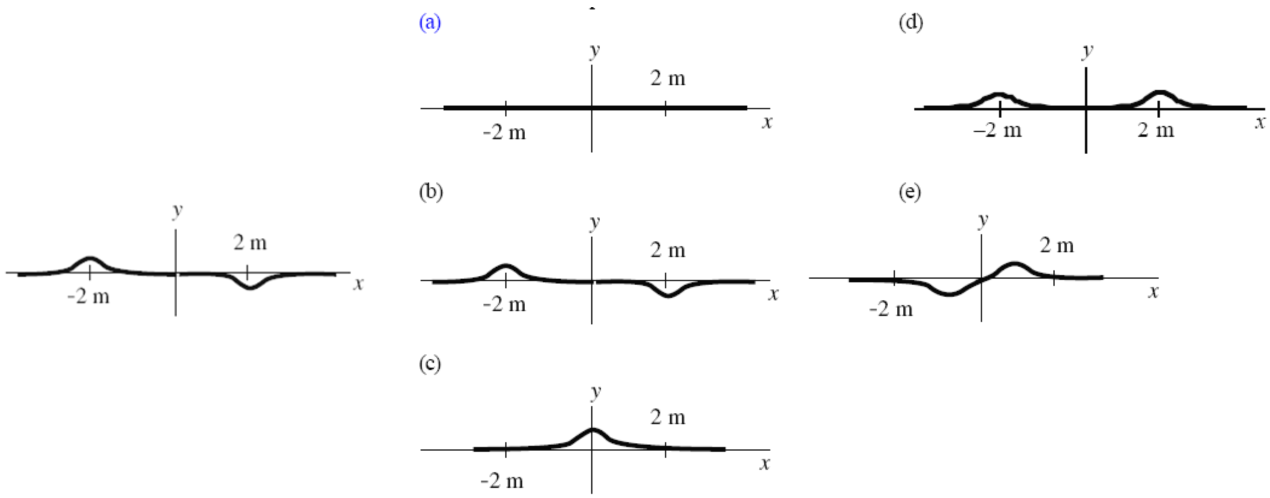
d) The wavelength of the transmitted pulse will be ____________ (greater than, less than, the same as) the wavelength of the incident pulse.

8.3. Practice: **Pulse Propagation and Interference**

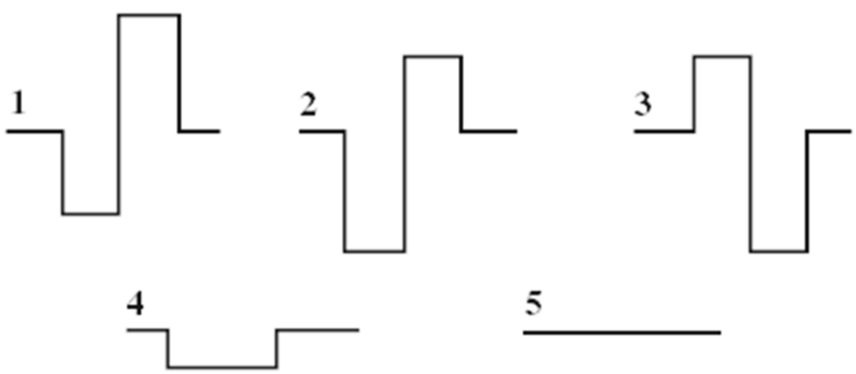
1. The figures below show pulses A, B, C, and D at time = 0 as they move. The direction of motion for each pulse is indicated by the arrow. Each pulse travels at a constant speed of 1 square per second on a string which is 10 squares long. Show the position of pulse A in red and pulse B in blue at t = 1 s, 2 s, and 3 s, on the graphs provided. Then, using the principle of superposition, show the resultant displacement of the string in green on the last graph (for t = 3 sec). Repeat for waves B and C, C and D and D and A.

time	A	B	C	D
T = 0 s				
T = 1 s				
T = 2 s				
T = 3 s				

2. Two traveling pulses on a rope move toward each other at a speed of 1.0 m/s. The waves have the same amplitude. The drawing on the left shows the position of the waves at time t = 0 s. Which one of the following drawings depicts the waves on the rope at t = 2.0 s?



The next three problems refer to the figures below, which show rectangular pulses on a string moving to the right.



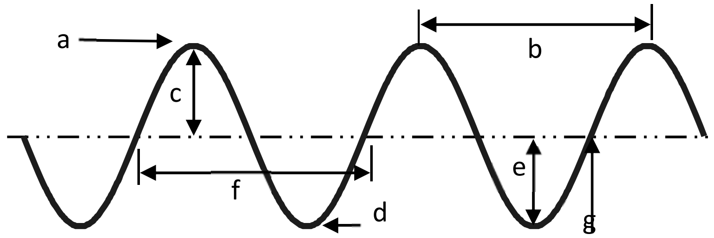
3. If pulse 1 were reflected from a wall, which one of the patterns above would represent the reflected pulse?
   a) 1 b) 2 c) 3 d) 4 e) 5

4. Complete the following statement: If pulse 2 were superimposed on pulse 3,
   a) constructive interference would occur.
   b) the resulting pattern would be represented by 1.
   c) the resulting pattern would be represented by 4.
   d) the resulting pattern would be represented by 5.
   e) the resulting pattern would be different than 1, 4, and 5.

5. Which pulses must be superimposed to give the situation shown in 5?
   a) 1 and 2 b) 1 and 3 c) 2 and 4 d) 1, 2, and 4 e) 2, 3, and 4.

8.4. Practice: **Standing Waves**

1. The illustration below shows a standing wave. Label each part in the space provided.
   a. _
   b. _
   c. _
   d. _
   e. _
   f. _
   g. _



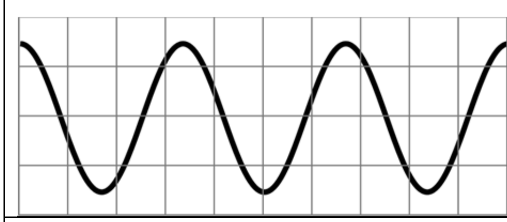
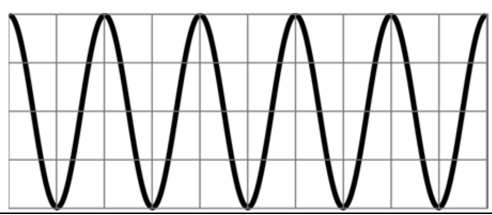
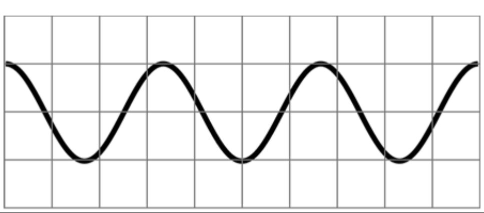
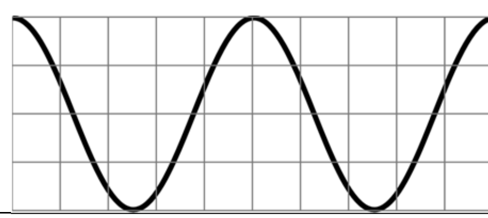
2. Fill in the blanks:
   a) Waves carry ___________ from one place to another.

   b) The highest point on a transverse wave is the _________ while the lowest part is the _________________

   c) The _________________ is the height of the wave.

   d) The distance from one crest to the next is the ______________

3. Below are shown four sound waves made up of a series of identical pulses. Considering that all 4 propagate with the same speed, answer the questions:

A 	B 
C 	D 

a) Which one of the waves above has the smallest amplitude?
b) Which one of the waves above has the longest wavelength?
c) Which one of the waves above has the shortest wavelength?
d) Which one of the waves above has the highest frequency?
e) Which one of the waves above has the lowest frequency?

4. Express in words and mathematically the relationship between
   a) period and frequency
   b) wavelength and frequency
   c) wavelength and period

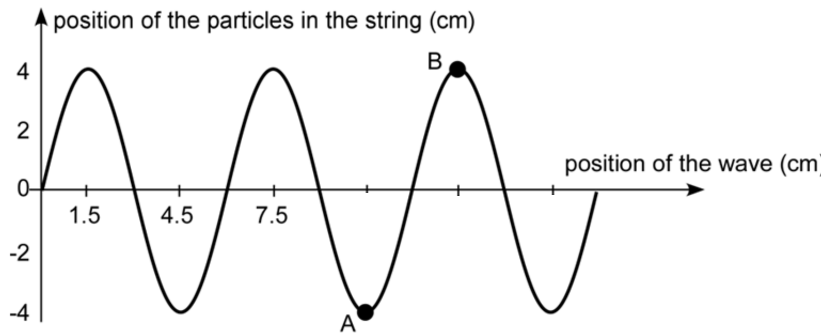
5. Which one of the following will result in standing waves?
   a) the superposition of waves that travel with different speeds
   b) the superposition of identical waves that travel in the same direction
   c) the superposition of identical waves that travel in opposite directions
   d) the superposition of nearly identical waves of slightly different amplitudes
   e) the superposition of nearly identical waves of slightly different frequencies

6. Which one of the following statements is true concerning the points on a string that sustain a standing wave pattern?
   a) All points vibrate with the same energy.
   b) All points undergo the same displacements.
   c) All points vibrate with different frequencies.
   d) All points vibrate with different amplitudes.
   e) All points undergo motion that is purely longitudinal.

7. What is the distance from the fixed end of a guitar string vibrating in the fundamental mode to the nearest antinode?
   a) λ b) 2λ c) $\lambda/2$ d) $\lambda/4$ e) $3\lambda/4$

8. A rope of length L is clamped at both ends. Which one of the following is not a possible wavelength for standing waves on this rope?
   a) L/2 b) 2L/3 c) L d) 2L e) 4L

The following three problems refer to the figure below. The displacement of a vibrating string versus position along the string is shown in the figure. The periodic waves have a speed of 10.0 cm/s. A and B are two points on the string.



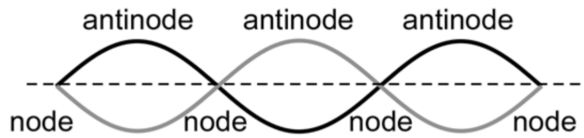
9. What is the amplitude of the wave?
   a) 2 cm b) 4 cm c) 8 cm d) 12 cm e) 16 cm

10. What is the wavelength of the wave?

a) 3.0 cm b) 9.0 cm c) 15 cm d) 6.0 cm e) 12 cm

11. What is the frequency of the wave?
    a) 0.60 Hz b) 0.90 Hz c) 1.1 Hz d) 1.3 Hz e) 1.7 Hz

The two problems below refer to a 3.00-m long string that sustains a three-loop standing wave pattern as shown in the figure. The wave speed is 100 m/s.



12. What is the frequency of vibration?
    a) 25 Hz b) 33 Hz c) 50 Hz d) 75 Hz e) 100 Hz

13. What is the lowest possible frequency for standing waves on this string?
    a) 50.0 Hz b) 33.3 Hz c) 25.0 Hz d) 16.7 Hz e) 8.33 Hz

14. Consider a wave generator that produces 10 pulses per second. The speed of the waves is 200 cm/s. a) What is the wavelength of the waves? b) What happens to the wavelength if the frequency of pulses is increased?

15. A wave on Beaver Dam Lake passes by two docks that are 50.0 m apart. A) If there is a crest at each dock and another three crests between the two docks, determine the wavelength. B) If 10 waves pass one dock every 16.0 seconds, determine the period and frequency of the wave. C) What is the speed of the wave?

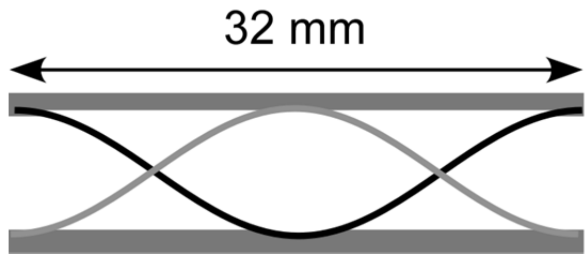
16. Ben loves physics and enjoyed collecting data from the standing waves lab. He and his partner held the ends of their spring 2.00 meters apart. There were 5 nodes in the standing wave produced. Ben moved his hand from the rest position back and forth along the floor 20 times in 4.00 s. Sketch the situation and determine the following:
    a) the wavelength of the wave Ben sent
    b) the frequency of the wave produced
    c) the speed of the wave

17. What frequency and period would be required for Ben and his partner to produce a standing wave with three nodes? Explain your reasoning by identifying your steps.

18. The wavelength of a sound wave in this room is 1.2 m and the frequency is 305 Hz. a) What is the speed of the wave in the room? b) If you double the frequency of the sound wave, determine its speed. c) What happens to the wavelength if you cut the frequency in half? How do you know?

8.5. Practice: **Sound Waves**

1. The picture shows a sound standing wave in a 32 mm long tube of air that is open at both ends.

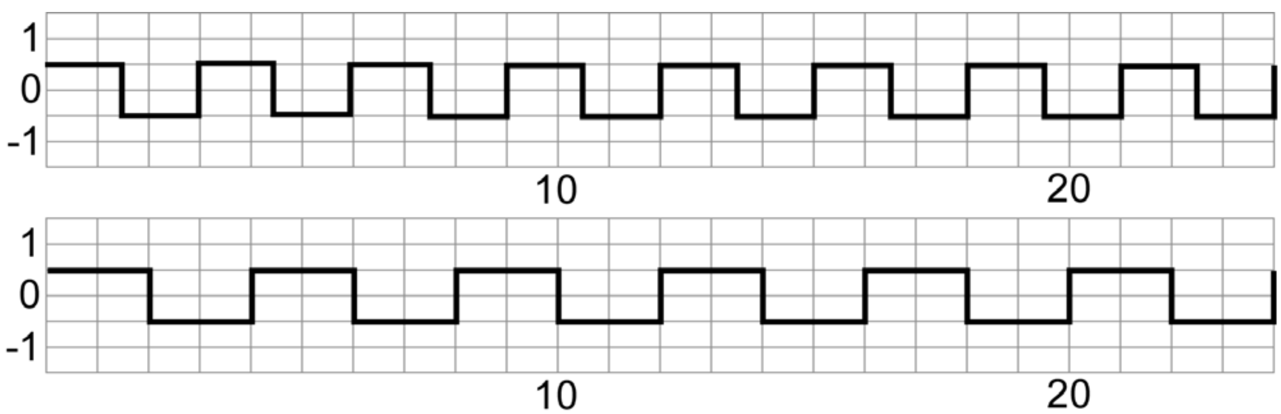


   a) what is the mode in which this standing wave is vibrating?

   b) are the air molecules vibrating vertically or horizontally?

   c) at what distance from the left end of the tube do the molecules oscillate with maximum amplitude?

2. Two sound waves from two separate sources, traveling at 330 m/s, arrive simultaneously at the same point in space.



   a) What is the wavelength of wave 1?

   b) What is the wavelength of wave 2?

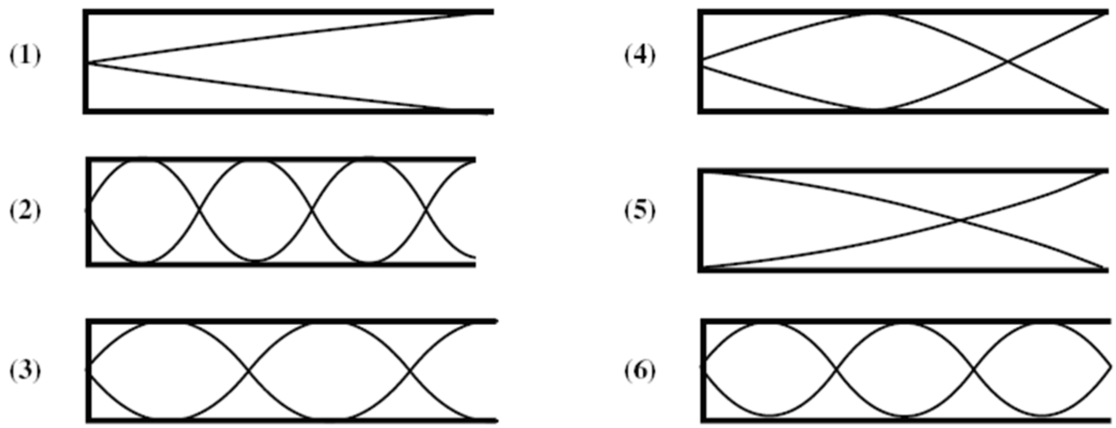
   c) What is the period of wave 1?

   d) What is the period of wave 2?

   e) What is the frequency of wave 1?

f) What is the frequency of wave 2?

3. The four problems below refer to the figures showing standing waves of sound in six organ pipes of the same length. Each pipe has one end open and the other end closed. Note: some of the figures show situations that are not possible.



4. Which figures do not illustrate possible resonant situations?
   a) 1 and 4 b) 2 and 3 c) 4 and 5 d) 5 and 6 e) 4, 5, and 6

5. Which one of the pipes emits sound with the lowest frequency?
   a) 1 b) 2 c) 3 d) 4 e) 6

6. Which one of the pipes emits sound with the highest frequency?
   a) 1 b) 2 c) 3 d) 4 e) 6

7. Which one of the pipes is resonating in its third harmonic?
   a) 1 b) 2 c) 3 d) 4 e) 6

8.6. Practice: **Light as a Wave**

1. A light wave is an electromagnetic wave which is different from mechanical waves. The differences are that electromagnetic waves……
   a. can travel through materials and mechanical waves cannot
   b. come in a range of frequencies and mechanical waves exist with only certain frequencies
   c. can travel through a region that does not contain matter and mechanical waves cannot
   d. electromagnetic waves cannot transport energy and mechanical waves can transport energy
   e. electromagnetic waves have an infinite speed and mechanical waves have a finite speed

2. In the electromagnetic spectrum:
   a. Which region has the highest frequency?
   b. Which region has the longest wavelength?
   c. Which region travels with the fastest speed?

3. In the visible light spectrum:
   a. Which color has the greatest frequency?
   b. Which color has the greatest wavelength?