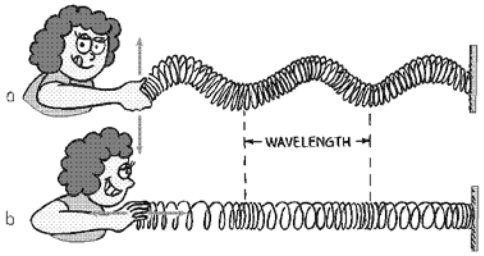
Name _____

Definitions:

A **wave** is a disturbance that transports energy through a medium without transporting the medium (TED)

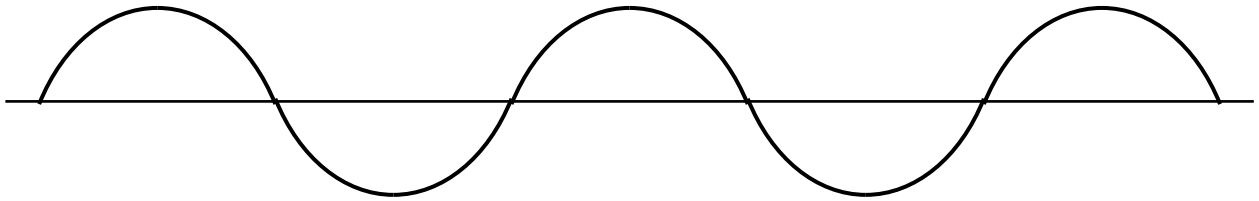
Mechanical Wave:

Transverse Wave:



Longitudinal Wave:

Wave Properties:



FREQUENCY VERSUS PERIOD:

Frequency vs. Period	Symbol	Definition / Equation	Units
Frequency			
Period			

What is the relationship between frequency and period?

Wave Problems:

1. If the period of a pendulum is 0.8 seconds, what is its frequency?

2. If you are standing on a dock and you notice that a wave passes you every 5 seconds, what is the frequency of the waves?

3. After vigorous exercise, an athlete found his heart rate to be 150 beats per minute.
   a. What is the frequency f of his heartbeat in Hz?

   b. What is the period of his heartbeat?

4. A record rotates on a turntable at 33.3 revolutions per minute (rpm), what is the frequency of the record?

5. The orbital period of the moon about the earth is 27.322 days, what is its frequency?

6. A radio station has a frequency of 95.1 MHz, what is the wave's period? M = mega = 10^6

1) 1.25 Hz, 2) 0.20 Hz, 3) 2.5 Hz, 0.4 sec, 4) 0.555 Hz, 5) 4.24×10^{-7} Hz 6) 1.05×10^{-8} sec

Hooke's Law Problems:

1. What property of a spring determines how easy or hard it is to stretch a spring?

2. Graph the relationship between Force and displacement in a spring.

<u>This relationship is referred to as Hooke's Law.</u>

The slope for the graph is the spring constant "K"

The units for K are:

The equation is:

Problems:

1. What is the force on a spring that has a spring constant of 250 N/m that is stretched 20 cm from equilibrium? (**Don't for get to convert cm to m…. divide by 100)**

2. A spring that has a spring constant of 350 N/m how far from equilibrium does the spring have stretch when a force of 60 N applied to it?

3. A spring is displaced 3.2 cm by a force of 15 N. What is the spring constant "K"?

4. A spring having an initial length of 35 cm and a stiffness of 45 N/m is hung vertically from a stand. What is the final length of the spring when a 500 g mass is attached to the end of the spring? **(Hint, draw a free body diagram and calculate the force of gravity on the spring, Fg=mg)**

1) 50 N 2) 17.1 cm 3) 469 N/m 4) 45.89 cm

Harmonic Motion:

1. What factors affect the period of a pendulum and what is their relationship to the period?

2. What factors affect the period of a simple harmonic oscillator (mass and spring) and what is their relationship to the period?

3. Where are the equilibrium positions located for the pendulum and the SHO?

4. What causes the oscillator to move back toward equilibrium in the:

   a) pendulum

   b) SHO

   In an oscillator, this is referred to as the restorative component.

5. What is the inertial component that moves the oscillator away from equilibrium in the:

   c) SHO

   d) pendulum

6. As the inertial component increases, the period _____ and as the restorative component increases the period _____.

7. Equations:

$$T_p = 2\pi\sqrt{\frac{l}{g}} \qquad T_{SHO} = 2\pi\sqrt{\frac{m}{K}} \qquad F = Kx \qquad T = \frac{1}{f} \qquad f = \frac{1}{T}$$

Harmonic Motion Problems:

1. What is the period of a pendulum with a length of 1.8m?

2. A student sets up a pendulum in the classroom with a period of 1.0 seconds and wants to use it as a timer. What length is required in order to obtain the period of 1 second?

3. What would the period be if the student takes the pendulum in problem 2 to the moon where the gravitational constant is approximately 1/6 of the earth's gravitational constant?

4. By what factor must you increase the length of the string of a pendulum in order to double the period?

5. A student sets up a simple harmonic oscillator (SHO) with a mass of 0.25 kg and a spring constant of 65 N/m. What is the period of this oscillator?

   What is the frequency?

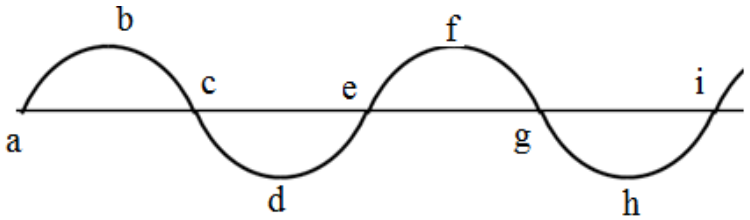
6. What force is required to displace a spring with a spring constant "k" of 98 N/m by 0.28m?

7. A spring is displaced 15 cm by a force of 12.8 N, what is the spring constant "k"?

Name _____

The speed of Waves

On the diagram to the right, draw 1 wavelength.



1. In terms of wave properties, how long does it take for 1 wave to pass a particular point? (What is time per cycle?)

2. In terms of wave properties, what distance did the wave travel in the timeframe in question 1?

3. In general, how do you calculate velocity?

   a. What is the velocity of a wave?

   b. What is another expression for the velocity of a wave?

4. Answer the following from part IV of your wavy lab:

   a. as frequency increases wavelength _____ therefore, the written relationship between wavelength and frequency is?

   b. What value must be constant?

5. Calculate the wave speed for the three different frequencies in part IV of your wavy lab.

   Frequency f = _____ Hz Wavelength λ= _____m V =

   Frequency f = _____ Hz Wavelength λ= _____m V =

   Frequency f = _____ Hz Wavelength λ= _____m V =

6. What is the only way you can change the speed of a wave?

Wave speed worksheet

$$v = f \times \lambda$$

1. The speed of sound in air that is at normal room temperature (20°C) is about 343 m/s. Thunder is a sound wave created when the lightning superheats the air around it, and causes it to rapidly expand and vibrate at a frequency of approximately 25 Hz. What is the wavelength of the sound from this thunderclap?

2. A water wave on the ocean has adjacent crests that are 21.7 meters apart. If 10 waves lap up onto the shore of a particular beach every 2 minutes, what is the speed of a wave while traveling on the ocean?

3. A blue light wave has a wavelength of 490nm (1 nm = 1 x 10^{-9} m). If it also has a frequency of 6.12 x 10^{14} Hz, what is the speed of light?

4. One sound wave with a frequency of 250 Hz and with a wavelength of 88 cm is traveling in some very cold air. If a tuning fork with a frequency of 440 Hz is set into vibration in the same cold air, what will be the wavelength for the generated sound wave?

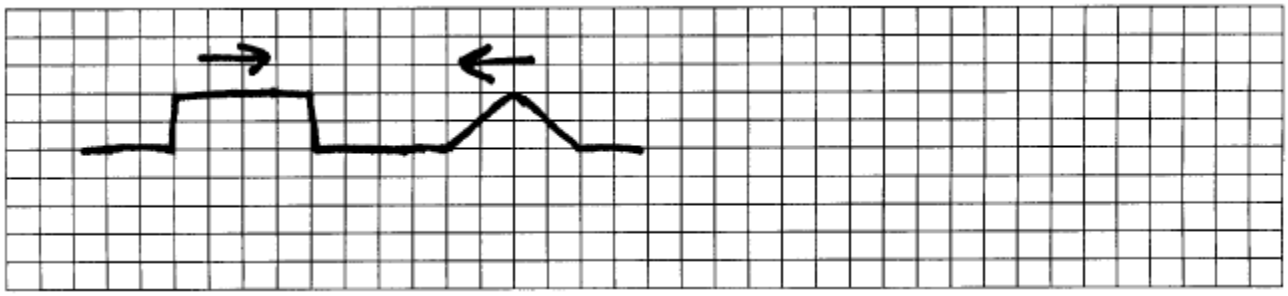
5. A xylophone has a middle-C bar that is 28 cm long, and vibrates with a frequency of 261.6 Hz. The length of a wooden xylophone bar set into vibration is exactly equal to one wavelength. The G bar on the same xylophone will vibrate at a frequency of 392 Hz. If the bars are made of the same material, how long should the G bar be?

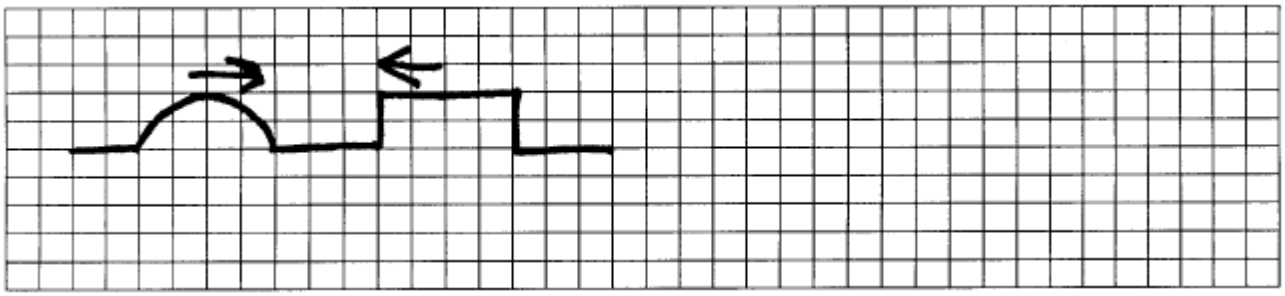
1) 13.7 m 2) 1.8 m/s 3) 2.999 x 10^8 m/s 4) 50 cm 5) 18.7 cm

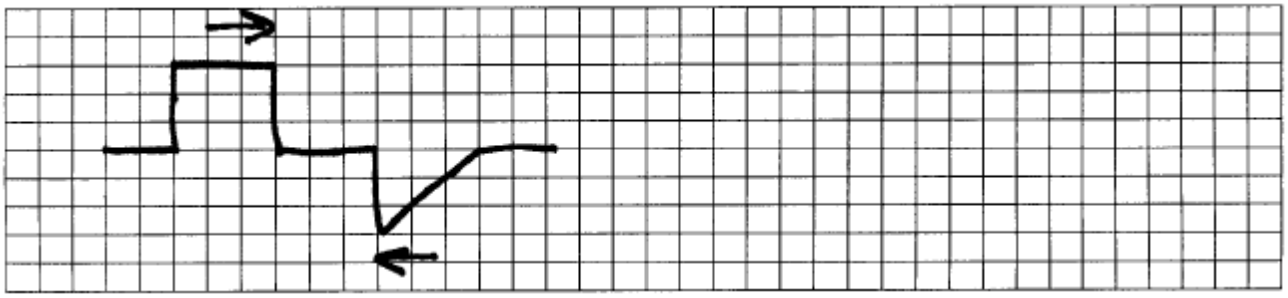
WAVE PRACTICE: INTERFERENCE

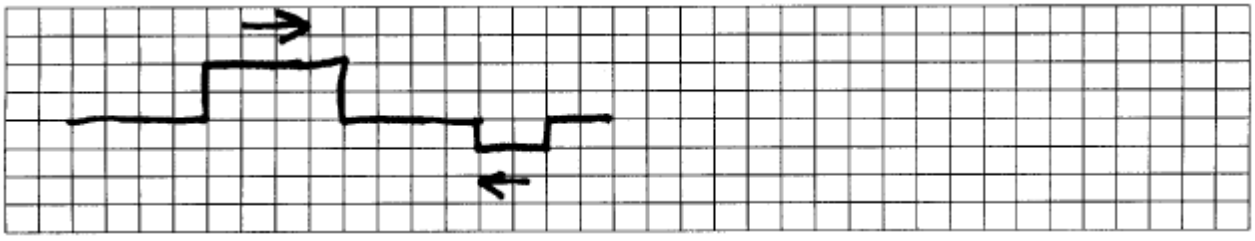
1. What happens when two billiard balls, rolling towards one another, collide head on? How does this differ from two waves or pulses that collide head on?

2. The diagram below shows two pulses approaching one another. On the right side, sketch the appearance of the medium when the centers of the pulses coincide.







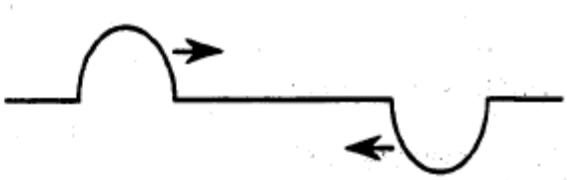


Name _____

Below each diagram, sketch the resulting wave using the principal of superposition when the centers of the wave forms coincide.

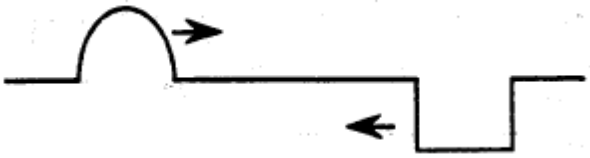
1

2



3

4



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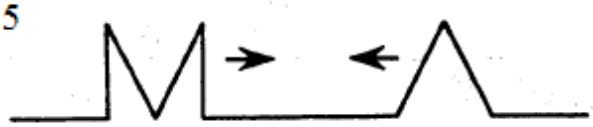

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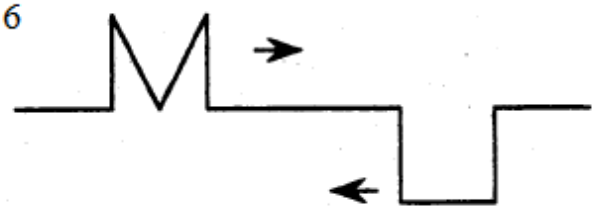

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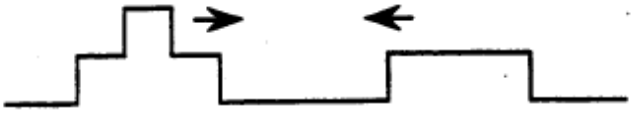

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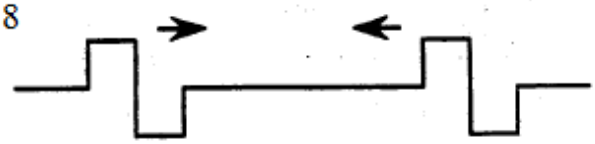


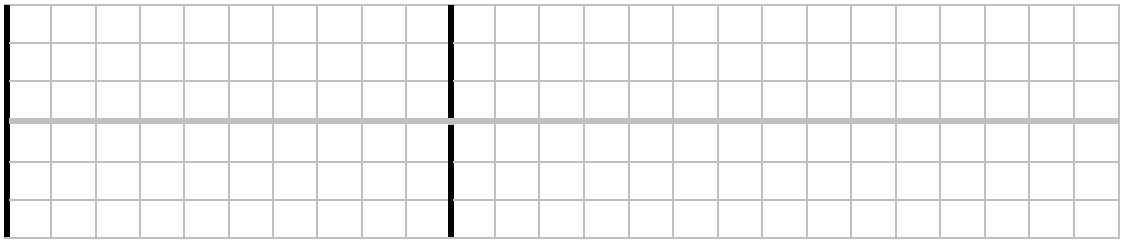
Intro to standing Waves:

1. The source of all wave motion is:

2. What is the only way to change the speed of a wave?

3. What happens to a transverse wave pulse as it strikes a fixed boundary and reflects back along its path? Draw a representation of this below:

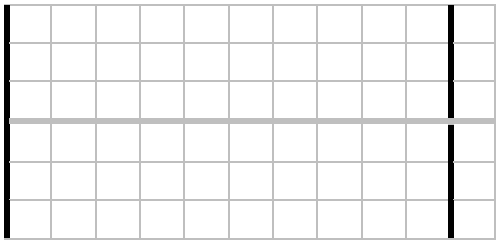
4. Draw a single loop of a standing wave between the two fixed boundaries in the space below. How many wavelengths does this represent? What is the distance between barriers?



5. What relationship exists between the fundamental frequency and the first harmonic?

6. The wave above represents a wave with a wavelength of 2.0m long and has a frequency of 4.0 Hz, what is the speed of the wave?

7. Draw a two loop standing wave between the two fixed boundaries in the space below. How many wavelengths does this represent?



If the space between the boundaries is still 1.0m, find:

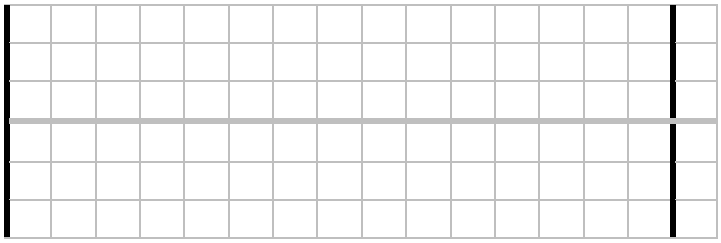
a) The wavelength

b) Frequency

8. What pattern exists between the length of a loop and the wavelength?

9. Draw a 3 loop standing wave between the two fixed boundaries in the space below. How many wavelengths does this represent?

   Note: ***The scale was changed to make it easier to draw but the distance between the boundaries is still 1.0 meters.***



find:

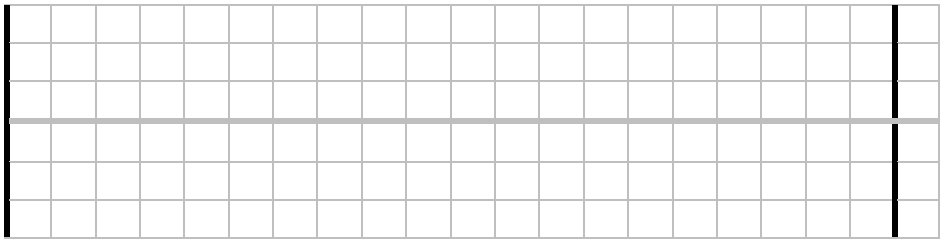
a) The wavelength

b) Frequency

10. What pattern is there between the fundamental frequency and the frequency of each harmonic?

Parts of a standing wave

Draw a 4 loop standing wave between the two fixed boundaries in the space below. How many wavelengths does this represent?



Example:

On the standing wave in the demonstration, there _____ loops. The total length of the string is _____m and the frequency is _____ Hz. What is the length of 1 loop?

What is the speed of the wave?

What is the frequency of _____ loops?

Name _____

Standing waves worksheet

Remember a complete wave is two loops!

1. A piece of string 4 meters long is vibrated so that it holds a two loop standing wave. What is the wavelength of this wave?

2. A string is vibrated with a wave that has a wavelength of 6 meters. How long is one loop of the standing wave?

3. A string is 12 meters long. If the standing wave set up on this string is three loops, what is the wavelength?

4. The speed that a wave can travel down a slinky is 3 m/s. If a 2 meter long slinky creates a four loop standing wave, what is the frequency of vibration?

5. Mr. S. is rock climbing and can't help but make waves on the rope. (Physics over safety any day). If he were to (unwisely) make a standing wave on the rope that had four loops and vibrated at a frequency of 3 Hz, how fast do those waves travel down the rope? (Assume the rope is 10 meters long.)

1) 4 m 2) 3 m 3) 4 m 4) 3 Hz 5) 15 m/s

Intro to Natural Frequency, Resonance, and Beats:

1. When does a standing wave occur?

2. What is an object's natural frequency?

3. When does a resonance occur?

   What are some examples of resonance?

4. When do beats occur?

5. What is beat frequency?

Intro to the Doppler Effect:

If you stand at a railway crossing as a train approaches with its horn blowing, the pitch (perceived frequency) that you hear will be _____ as the train moves toward you and _____ as it moves away. This perceived difference in frequency due to the motion of the sound source or listener is called the Doppler Effect.

One way to illustrate the Doppler Effect is to imagine a bug bobbing up and down in a pond. If the bug is not moving the waves it produces will go out in concentric circles as shown in Figure 1 below. If the bug is moving to the right then the waves in front of the bug will bunch up and have a _____ wavelength. The speed that the waves travel is _____, therefore the frequency of the waves in front of the bug will be _____.This is shown in Figure 2. The opposite is true for the waves behind the bug.

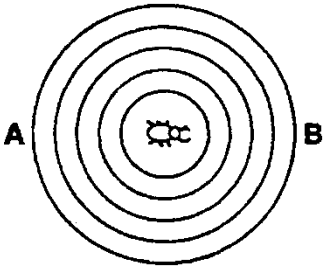


Figure 1

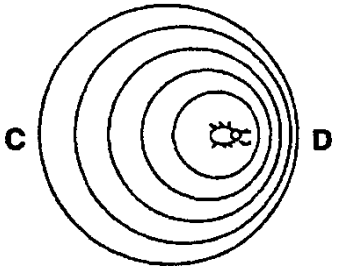


Figure 2

1. How will the frequency of the waves reaching an observer at A compare to the frequency of waves reaching an observer at B?

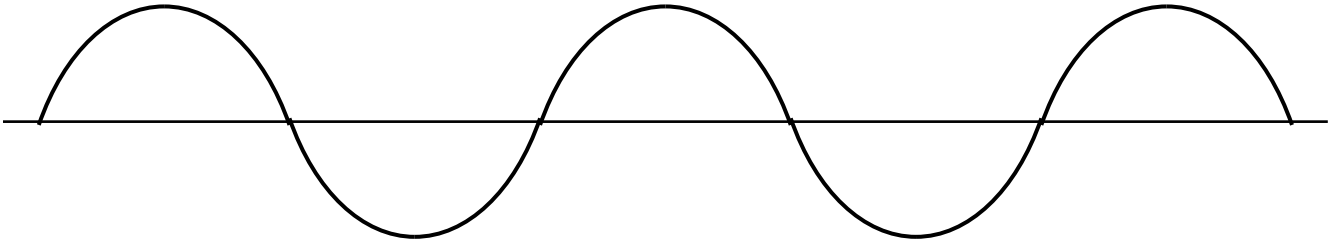
2. How will the frequency of the waves reaching an observer at C compare to the frequency of waves reaching an observer at D?

3. Is the bug actually bobbing up and down with a different frequency in Figure 1 vs. Figure 2?

4. What is causing the perceived change in frequency from Figure 1 to Figure 2?

Vibrations, Waves and Sound Review:

1. A sine curve that represents a transverse wave is drawn below. With a ruler, measure the wavelength and amplitude of the wave.



a. Wavelength =_____ b. Amplitude _____

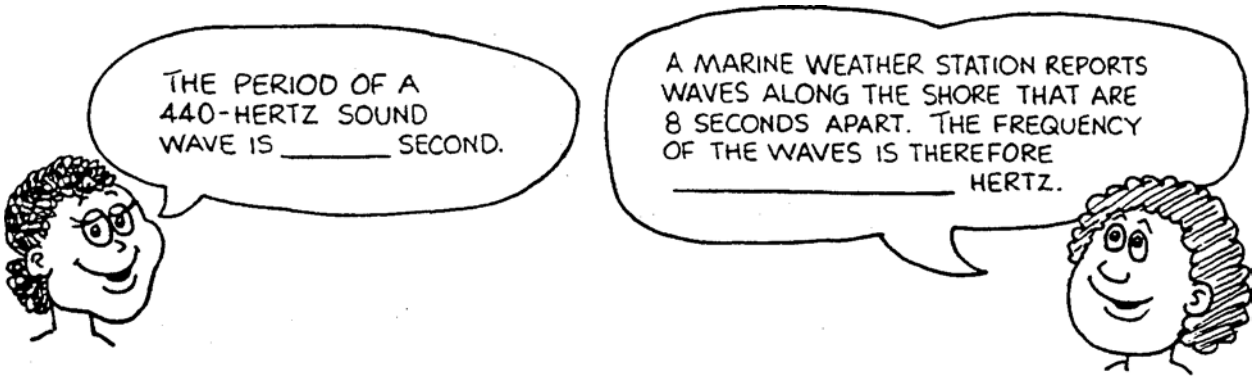
2. A kid on a playground swing makes a complete to-and-fro swing each 2 seconds. The frequency of swing is

(0.5 hertz) (1 hertz) (2 hertz)

and the period is

(0.5 second) (1 second) (2 seconds)

3. Complete the statements.



4. The annoying sound from a mosquito is produced when it beats its wings at the average rate of 600 wingbeats per second. (v = 332 m/s)

a. What is the frequency of the sound wave?

_____

b. What is the wavelength?

_____

5. A machine gun fires 10 rounds per second. The speed of the bullets is 300 m/s.

   a. What is the distance in the air between the flying bullets?

   _____

   b. What happens to the distance between the bullets if the rate of fire is increased?

6. Consider a wave generator that produces 10 pulses per second. The speed of the waves is 300 cm/s.

   a. What is the wavelength of the waves? _____

   b. What happens to the wavelength if the frequency of pulses is increased?

7. The bird at the right watches the wave crests. If 2 crests of the wave pass the pole each second, what is the speed of the wave?

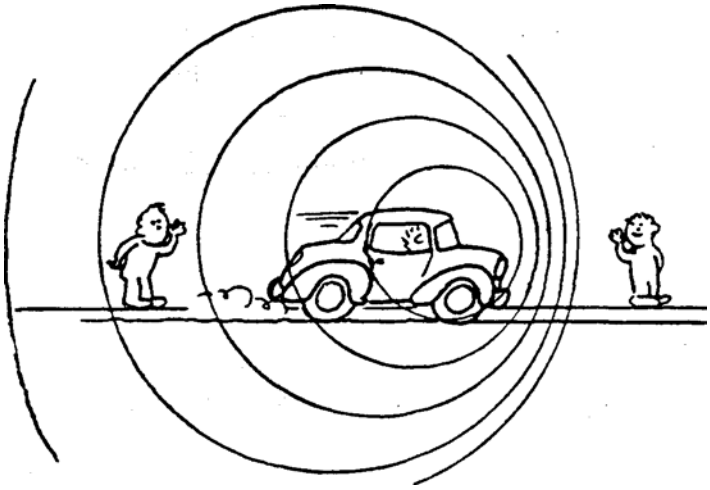
   _____

   What is its period? _____

8. If the distance between crests in the above question were 1.5 meters apart and 2 crests pass the pole each second, what would be the speed of the wave?

   _____

   What is its period? _____



9. When an automobile moves toward a listener, the sound of its horn seems relatively

   (low pitched) (normal)

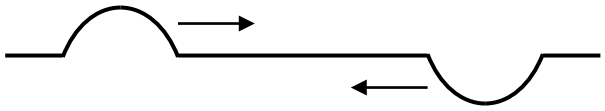
   (high pitched)

   and when it moves away from the listener, its horn seems

   (low pitched) (normal)

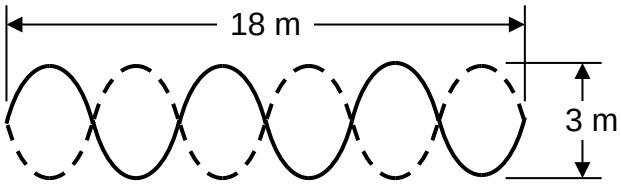
   (high pitched)

10. What type of interference would occur for the following diagram? (describe what would happen to the amplitude)



11. What type of interference would occur for the following diagram? (describe what would happen to the amplitude)

12. For the standing wave shown, determine the wavelength, amplitude, and the number of nodes. Label a node and an antinode.



a) If the frequency of vibration in the standing wave above is 256 Hz, determine the frequency of the first and second harmonics

b) What is the speed of the wave?

13. Which type of interference occurs at nodes and at antinodes?

14. A piano note creates a beat frequency of 3 Hz when played with a tuning fork of 256 Hz. What are the possible frequencies of the piano note?

15. If someone spins a tuning fork in a vertical circle, when will you hear a higher pitch and when will you hear a lower pitch?

16. How do you change the wave speed of waves in a slinky or for that matter any wave?

17. If someone talks in a loud, high pitch voice; describe the sound waves' amplitude, wavelength, wavespeed, frequency, and period versus talking normally.

18. What happens if you force something to vibrate at its natural frequency?

19. Sitting on the dock of the bay, you are counting waves. If ten waves go by in 5 seconds, determine the period of the waves. If the distance from one wave to the next is 2 meters, determine the speed of the waves.

20. The moon is describes as a "silent planet." Explain why.

21. Sound travels at a speed of 343 m/s in air at 20°C. The wavelength of a sound wave is 1.31 m. Find the period of the wave.

22. The magnetic tape of a cassette deck moves with a speed of 0.048 m/s. The recording head records a 15,000 Hz tone on the tape. What is the wavelength of the magnetized regions?

23. Classify the following as longitudinal or transverse waves, a) sound b) light c) ocean wave d) stadium crowd waves e) traffic slowing because of an accident.

24. When waves hit each other do they pass through each other or bounce off? Explain how you know.

25. Use superposition to determine the wave would look like if the two waves below passed through each other.

26. What is the period of a pendulum with a length of 0.75m?

27. A student sets up a pendulum in the classroom with a period of 1.35 seconds. What is the length required in order to obtain the period of 1.35 second?

28. By what factor must you increase the length of the string of a pendulum in order to triple the period?

29. A student sets up a simple harmonic oscillator (SHO) with a mass of 0.55 kg and a spring constant of 165 N/m. What is the period of this oscillator?

What is the frequency?