Checking your Understanding of Waves

Section 1: What is a Wave?

1. **TRUE** or **FALSE**:

In order for John to hear Jill, air molecules must move from the lips of Jill to the ears of John.

2. Curly and Moe are conducting a wave experiment using a slinky. Curly introduces a disturbance into the slinky by giving it a quick back and forth jerk. Moe places his cheek (facial) at the opposite end of the slinky. Using the terminology of this unit, describe what Moe experiences as the pulse reaches the other end of the slinky.

3. Mac and Tosh are experimenting with pulses on a rope. They vibrate an end up and down to create the pulse and observe it moving from end to end. How does the position of a point on the rope, before the pulse comes, compare to the position after the pulse has passed?

4. Minute after minute, hour after hour, day after day, ocean waves continue to splash onto the shore. Explain why the beach is not completely submerged and why the middle of the ocean has not yet been depleted of its water supply.

5. A medium is able to transport a wave from one location to another because the particles of the medium are ____.

a. frictionless
b. isolated from one another

c. able to interact

d. very light

Section 2: Types of Waves

1. A transverse wave is transporting energy from east to west. The particles of the medium will move_____.

a. east to west only
b. both eastward and westward

c. north to south only

d. both northward and southward

2.A wave is transporting energy from left to right. The particles of the medium are moving back and forth in a leftward and rightward direction. This type of wave is known as a ____.

a. mechanical
b. electromagnetic

c. transverse
d. longitudinal

3. Describe how the fans in a stadium must move in order to produce a longitudinal stadium wave.

4. A sound wave is a mechanical wave; not an electromagnetic wave. This means that

a. particles of the medium move perpendicular to the direction of energy transport.
b. a sound wave transports its energy through a vacuum.

c. particles of the medium regularly and repeatedly oscillate about their rest position.

d. a medium is required in order for sound waves to transport energy.

5. A science fiction film depicts inhabitants of one spaceship (in outer space) hearing the sound of a nearby spaceship as it zooms past at high speeds. Critique the physics of this film.

6. If you strike a horizontal rod vertically from above, what can be said about the waves created in the rod?

a. The particles vibrate horizontally along the direction of the rod.
b. The particles vibrate vertically, perpendicular to the direction of the rod.

c. The particles vibrate in circles, perpendicular to the direction of the rod.

d. The particles travel along the rod from the point of impact to its end.

7. Which of the following is not a characteristic of mechanical waves?

a. They consist of disturbances or oscillations of a medium.
b. They transport energy.

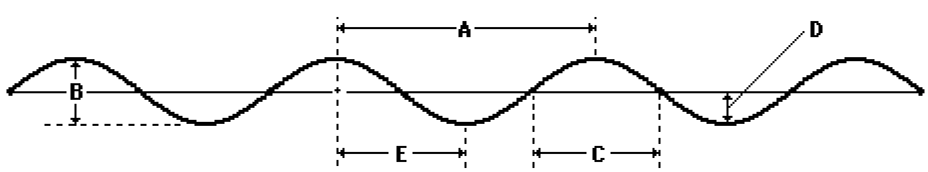
c. They travel in a direction which is at right angles to the direction of the particles of the medium.

d. They are created by a vibrating source.

8. The sonar device on a fishing boat uses underwater sound to locate fish. Would you expect sonar to be a longitudinal or a transverse wave?

Section 3a: Properties of Waves--Anatomy

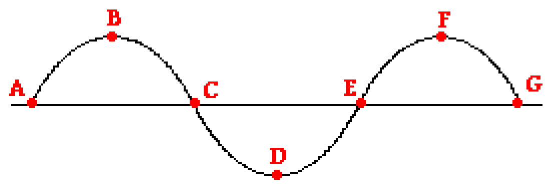
Consider the diagram below in order to answer questions #1-2.



1. The wavelength of the wave in the diagram above is given by letter _______.

2. The amplitude of the wave in the diagram above is given by letter ______.

3. Indicate the interval which represents one full wavelength.



a. A to C
b. B to D

c. A to G

d. C to G

Section 3b: Properties of Waves—Frequency & Period

Throughout this unit, internalize the meaning of terms such as period, frequency, and wavelength. Utilize the meaning of these terms to answer conceptual questions; avoid a *formula fixation*.

1. A wave is introduced into a thin wire held tight at each end. It has an amplitude of 3.8 cm, a frequency of 51.2 Hz and a distance from a crest to the neighboring trough of 12.8 cm. Determine the period of such a wave.

2. Frieda the fly flaps its wings back and forth 121 times each second. The period of the wing flapping is _____ sec.

3. A tennis coach paces back and forth along the sideline 10 times in 2 minutes. The frequency of her pacing is _________ Hz.

a. 5.0 b. 0.20 c. 0.12 d. 0.083

4. Non-digital clocks (which are becoming more rare) have a second hand which rotates around in a regular and repeating fashion. The frequency of rotation of a second hand on a clock is ________ Hz.

a. 1/60 b. 1/12 c. 1/2

d. 1 e. 60

5. Olive Udadi accompanies her father to the park for an afternoon of fun. While there, she hops on the swing and begins a motion characterized by a complete back-and-forth cycle every 2 seconds. The frequency of swing is __________.

a. 0.5 Hz b. 1 Hz c. 2 Hz

6. In problem #5, the period of swing is ___________.

a. 0.5 second b. 1 second c. 2 second

7. A period of 5.0 seconds corresponds to a frequency of ________ Hertz.

a. 0.2 b. 0.5 c. 0.02

d. 0.05 e. 0.002

8. A common physics lab involves the study of the oscillations of a pendulum. If a pendulum makes 33 complete back-and-forth cycles of vibration in 11 seconds, then its period is ______.

9. A child in a swing makes one complete back and forth motion in 3.2 seconds. This statement provides information about the child's

a. speed
b. frequency

c. period

10. The period of the sound wave produced by a 440 Hertz tuning fork is ___________.

11. As the frequency of a wave increases, the period of the wave ___________.

a. decreases
b. increases

c. remains the same

Section 3c: Properties of Waves—Energy & Amplitude

1. Mac and Tosh stand 8 meters apart and demonstrate the motion of a transverse wave on a snakey. The wave e can be described as having a vertical distance of 32 cm from a trough to a crest, a frequency of 2.4 Hz, and a horizontal distance of 48 cm from a crest to the nearest trough. Determine the amplitude, period, and wavelength of such a wave.

2. An ocean wave has an amplitude of 2.5 m. Weather conditions suddenly change such that the wave has an amplitude of 5.0 m. The amount of energy transported by the wave is __________.

a. halved
b. doubled

c. quadrupled

d. remains the same

3. Two waves are traveling through a container of an inert gas. Wave A has an amplitude of .1 cm. Wave B has an amplitude of .2 cm. The energy transported by wave B must be __________ the energy transported by wave A.

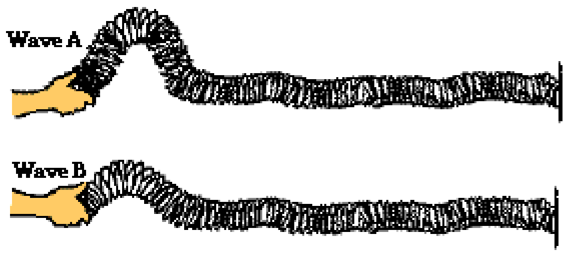
a. one-fourth
b. one-half

c. two times larger than

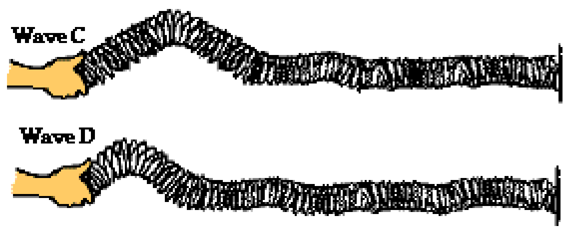
d. four times larger than

Section 3d: Properties of Waves—Wave Speed

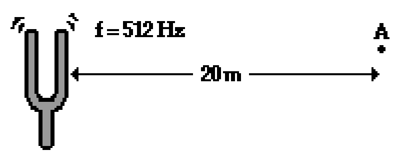
1. A teacher attaches a slinky to the wall and begins introducing pulses with different amplitudes. Which of the two pulses (A or B) below will travel from the hand to the wall in the least amount of time? Justify your answer.



2. The teacher then begins introducing pulses with a different wavelength. Which of the two pulses (C or D) will travel from the hand to the wall in the least amount of time ? Justify your answer.



3. The time required for the sound waves (v = 340 m/s) to travel from the tuning fork to point A is ____ .



a. 0.020 second   b. 0.059 second

c. 0.59 second   d. 2.9 second

4. Two waves are traveling through the same container of nitrogen gas. Wave A has a wavelength of 1.5 m. Wave B has a wavelength of 4.5 m. The speed of wave B must be ________ the speed of wave A.

a. one-ninth   b. one-third

c. the same as   d. three times larger than

5. An automatic focus camera is able to focus on objects by use of an ultrasonic sound wave. The camera sends out sound waves which reflect off distant objects and return to the camera. A sensor detects the time it takes for the waves to return and then determines the distance an object is from the camera. The camera lens then focuses at that distance. Now that's a smart camera! Try this problem for practice:

If a sound wave (speed = 340 m/s) returns to the camera 0.150 seconds after leaving the camera, then how far away is the object?

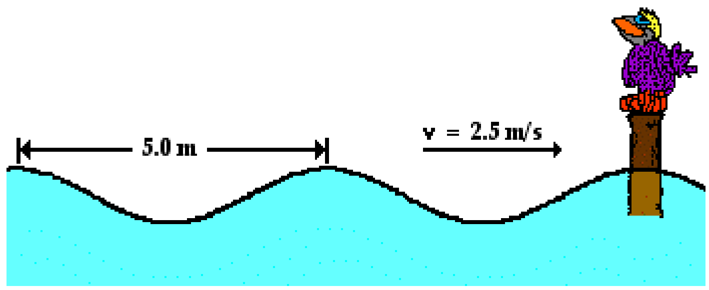
6. **TRUE** or **FALSE**:

Doubling the frequency of a wave source doubles the speed of the waves.

7. While hiking through a canyon, Noah Formula lets out a scream. An echo (reflection of the scream off a nearby canyon wall) is heard 0.82 seconds after the scream. The speed of the sound wave in air is 342 m/s. Calculate the distance from Noah to the nearby canyon wall.

8. Mac and Tosh are resting on top of the water near the end of the pool when Mac creates a surface wave. The wave travels the length of the pool and back in 25 seconds. The pool is 25 meters long. Determine the speed of the wave.

9. The water waves below are traveling along the surface of the ocean at a speed of 2.5 m/s and splashing periodically against Wilbert's perch. Each adjacent crest is 5 meters apart. The crests splash Wilbert's feet upon reaching his perch. How much time passes between each successive drenching? Answer and explain using complete sentences.



As a test of your understanding of the wave equation and its mathematical use in analyzing wave motion, consider the following three-part question:

10. Stan and Anna are conducting a slinky experiment. They are studying the possible affect of several variables upon the speed of a wave in a slinky. Their data table is shown below. Fill in the blanks in the table, analyze the data, and answer the following questions.

Medium	Wavelength	Frequency	Speed
Zinc, 1-in. dia. coils	1.75 m	2.0 Hz	_______
Zinc, 1-in. dia. coils	0.90 m	3.9 Hz	_______
Copper, 1-in. dia. coils	1.19 m	2.1 Hz	_______
Copper, 1-in. dia. coils	0.60 m	4.2 Hz	_______
Zinc, 3-in. dia. coils	0.95 m	2.2 Hz	_______
Zinc, 3-in. dia. coils	1.82 m	1.2 Hz	_______

a. As the wavelength of a wave in a uniform medium increases, its speed will ______.

a. decrease b. increase c. remain the same

b. As the wavelength of a wave in a uniform medium increases, its frequency will _____.

a. decrease　　　b. increase　　　c. remain the same

c. The speed of a wave depends upon (i.e., is causally affected by) ...

a. the properties of the medium through which the wave travels
b. the wavelength of the wave.

c. the frequency of the wave.

d. both the wavelength and the frequency of the wave.

11. Two waves on identical strings have frequencies in a ratio of 2 to 1. If their wave speeds are the same, then how do their wavelengths compare?

a. 2:1　　　b. 1:2　　　c. 4:1　　　d. 1:4

12. Mac and Tosh stand 8 meters apart and demonstrate the motion of a transverse wave on a snakey. The wave e can be described as having a vertical distance of 32 cm from a trough to a crest, a frequency of 2.4 Hz, and a horizontal distance of 48 cm from a crest to the nearest trough. Determine the amplitude, period, and wavelength and speed of such a wave.

13. Dawn and Aram have stretched a slinky between them and begin experimenting with waves. As the frequency of the waves is doubled,

a. the wavelength is halved and the speed remains constant
b. the wavelength remains constant and the speed is doubled

c. both the wavelength and the speed are halved.

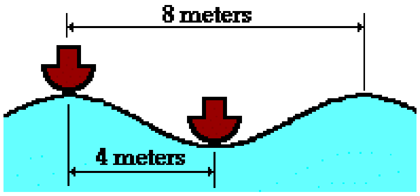
d. both the wavelength and the speed remain constant.

14. A ruby-throated hummingbird beats its wings at a rate of about 70 wing beats per second.

a. What is the frequency in Hertz of the sound wave?
b. Assuming the sound wave moves with a velocity of 350 m/s, what is the wavelength of the wave?

15. Ocean waves are observed to travel along the water surface during a developing storm. A Coast Guard weather station observes that there is a vertical distance from high point to low point of 4.6 meters and a horizontal distance of 8.6 meters between adjacent crests. The waves splash into the station once every 6.2 seconds. Determine the frequency and the speed of these waves.

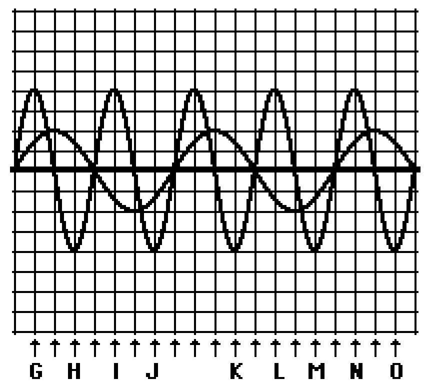
16. Two boats are anchored 4 meters apart. They bob up and down, returning to the same up position every 3 seconds. When one is up the other is down. There are never any wave crests between the boats.



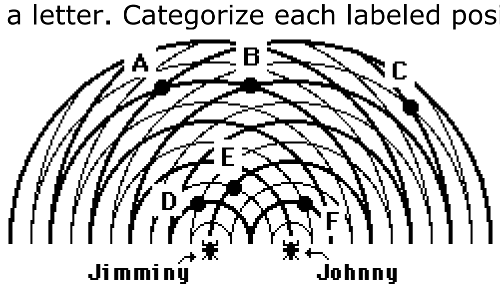
Calculate the speed of the waves.

Section 4: Intereference of Waves

1. Several positions along the medium are labeled with a letter. Categorize each labeled position along the medium as being a position where either constructive or destructive interference occurs.



2. Twin water bugs Jimminy and Johnny are both creating a series of circular waves by jiggling their legs in the water. The waves undergo interference and create the pattern represented in the diagram at the right. The thick lines in the diagram represent wave crests and the thin lines represent wave troughs. Several of positions in the water are labeled with a letter. Categorize each labeled position as being a position where either constructive or destructive interference occurs.



Section 5: Standing Waves

1. Suppose that there was a *ride* at an amusement park which was titled *The Standing Wave*, Which location - node or antinode - on the ride would give the greatest thrill?

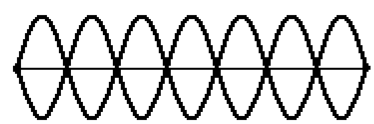
2. A standing wave is formed when ____.

a. a wave refracts due to changes in the properties of the medium.
b. a wave reflects off a canyon wall and is heard shortly after it is formed.

c. red, orange, and yellow wavelengths bend around suspended atmospheric particles.

d. two identical waves moving different directions along the same medium interfere.

3. The number of nodes in the standing wave shown in the diagram at the right is ____.



a. 6   b. 7

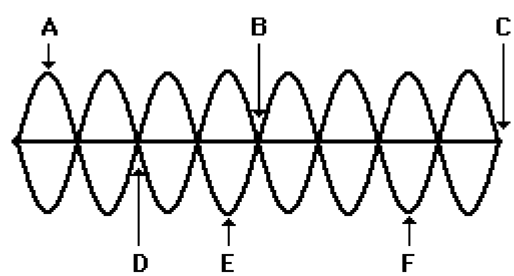
c. 8   d. 14

4. The number of antinodes in the standing wave shown in the diagram above right is ____.

a. 6   b. 7   c. 8   d. 14

Consider the standing wave pattern at the right in answering this next two questions.

5. The number of nodes in the entire pattern is ___.



a. 7   b. 8

c. 9   d. 16

6. Of all the labeled points, destructive interference occurs at point(s) ____.

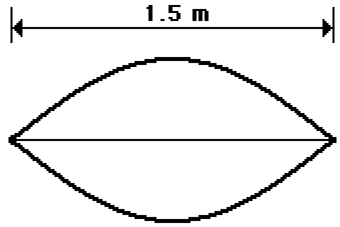
a. B, C, and D   b. A, E, and F   c. A only

d. C only   e. all points

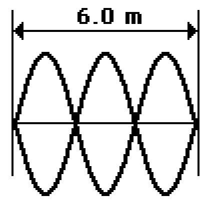
Section 6: Harmonics

1. Suppose that a string is 1.2 meters long and vibrates in the first, second and third harmonic standing wave patterns. Determine the wavelength of the waves for each of the three patterns.

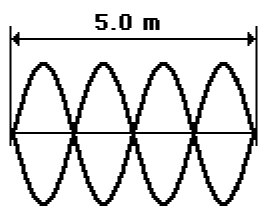
2. The string at the right is 1.5 meters long and is vibrating as the first harmonic. The string vibrates up and down with 33 complete vibrational cycles in 10 seconds. Determine the frequency, period, wavelength and speed for this wave.



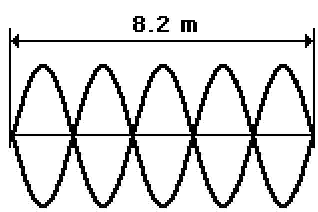
3. The string at the right is 6.0 meters long and is vibrating as the third harmonic. The string vibrates up and down with 45 complete vibrational cycles in 10 seconds. Determine the frequency, period, wavelength and speed for this wave.



4. The string at the right is 5.0 meters long and is vibrating as the fourth harmonic. The string vibrates up and down with 48 complete vibrational cycles in 20 seconds. Determine the frequency, period, wavelength and speed for this wave.



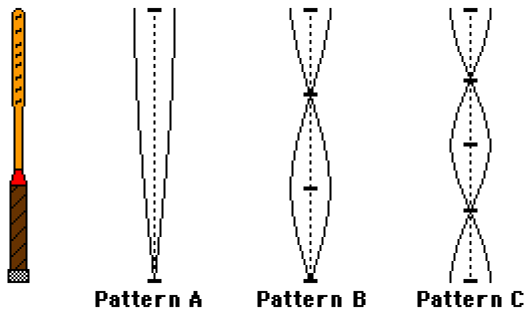
5. The string at the right is 8.2 meters long and is vibrating as the fifth harmonic. The string vibrates up and down with 21 complete vibrational cycles in 5 seconds. Determine the frequency, period, wavelength and speed for this wave.



6. The sound produced by blowing over the top of a partially filled soda pop bottle is the result of the air column inside of the bottle vibrating at its natural frequency. The actual frequency of vibration is inversely proportional to the wavelength of the sound; and thus, the frequency of vibration is inversely proportional to the length of air inside the bottle. Express your understanding of this resonance phenomenon by filling in the following table.

Bottle	Length of Air (m)	Wavelength (m)	Frequency (Hz)	Speed (m/s)
A	0.06	0.24	1418	a
B	0.12	0.48	708	b
C	c	0.64	d	340
D	0.20	e	425	f

7. When a tennis racket strikes a tennis ball, the racket begins to vibrate. There is a set of selected frequencies at which the racket will tend to vibrate. Each frequency in the set is characterized by a particular standing wave pattern. The diagrams below show the three of the more common standing wave patterns for the vibrations of a tennis racket.



a. Compare the wavelength of pattern A to the wavelength of pattern B. In other words, how does the wavelength of B compare to the wavelength of A? Repeat for pattern C, comparing A and C.

b. Compare the frequency of pattern A to the frequency of pattern B. Repeat for pattern C.

c. When the racket vibrates as in pattern A, its frequency of vibration is approximately 30 Hz. Determine the frequency of vibration of the racket when it vibrates as in pattern B and pattern C.

8. A guitar string with a length of 80.0 cm is plucked. The speed of a wave in the string is 400 m/sec. Calculate the frequency of the first, second, and third harmonics.

9. A pitch of Middle D (first harmonic = 294 Hz) is sounded out by a vibrating guitar string. The length of the string is 70.0 cm. Calculate the speed of the standing wave in the guitar string.

10. A frequency of the first harmonic is 587 Hz (pitch of D5) is sounded out by a vibrating guitar string. The speed of the wave is 600 m/sec. Find the length of the string.

EXTRA CREDIT

OPEN-END COLUMN PROBLEMS:

1. Stan Dinghwaives is playing his open end pipe. The frequency of the second harmonic is 880 Hz (a pitch of A5). The speed of sound through the pipe is 350 m/sec. Find the frequency of the first harmonic and the length of the pipe.

2. On a cold frigid day, Matthew blows on a toy flute, causing resonating waves in a open-end air column. The speed of sound through the air column is 336 m/sec. The length of the air column is 30.0 cm. Calculate the frequency of the first, second, and third harmonics.

3. A flute is played with a first harmonic of 196 Hz (a pitch of G3). The length of the air column is 89.2 cm (quite a long flute). Find the speed of the wave resonating in the flute.

CLOSED-END COLUMN PROBLEMS:

1. Titan Tommy and the Test Tubes at a night club this weekend. The lead instrumentalist uses a test tube (closed end air column) with a 17.2 cm air column. The speed of sound in the test tube is 340 m/sec. Find the frequency of the first harmonic played by this instrument.

2. A closed end organ pipe is used to produce a mixture of sounds. The third and fifth harmonics in the mixture have frequencies of 1100 Hz and 1833 Hz respectively. What is the frequency of the first harmonic played by the organ pipe?

3. Pipin' Pete and the Pop Bottles are playing at City Park next weekend. One of the pop bottles is capable of sounding out a first harmonic of 349.2 Hz. The speed of sound in the pop bottle is 350 m/sec. Find the length of the air column.