Week 2 April 13

To be completed by Monday April 20th 9:00 AM

Physics in the Universe periods 5,7,8

After you have read the section of your book about waves Chapter 7 sections 1 to 5, you should be able to do the following pages.

Once you are done, scan these with your phone. There are picture to PDF apps available for free.

An example of a camera to PDF program on IOS is Genius scan. (It is what my children are using.)

The less preferred scanning method is to bring these completed papers to school to be scanned by the secretary.

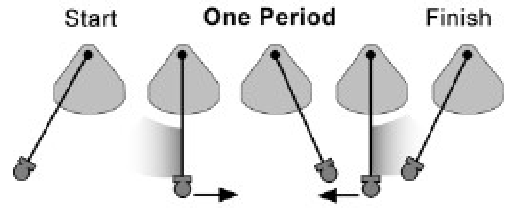
The online version has visuals and videos that make these lessons more interactive.

Name: ______________________ Date: ______________

Period and Frequency

READ

The **period** of a pendulum is the time it takes to move through one cycle. As the ball on the string is pulled to one side and then let go, the ball moves to the side opposite the starting place and then returns to the start. This entire motion equals one cycle.



Frequency is a term that refers to how many cycles can occur in one second. For example, the frequency of the sound wave that corresponds to the musical note "A" is 440 cycles per second or 440 hertz. The unit *hertz* (Hz) is defined as the number of cycles per second.

The terms period and frequency are related by the following equation:

$$T = \frac{1}{f} \qquad f = \frac{1}{T}$$

Period (seconds) → T; Frequency (hertz) → f

PRACTICE

1. A string vibrates at a frequency of 20 Hz. What is its period?
2. A speaker vibrates at a frequency of 200 Hz. What is its period?
3. A swing has a period of 10 seconds. What is its frequency?
4. A pendulum has a period of 0.3 second. What is its frequency?
5. You want to describe the harmonic motion of a swing. You find out that it take 2 seconds for the swing to complete one cycle. What is the swing's period and frequency?
6. An oscillator makes four vibrations in one second. What is its period and frequency?
7. A pendulum takes 0.5 second to complete one cycle. What is the pendulum's period and frequency?
8. A pendulum takes 10 seconds to swing through 2 complete cycles.
   a. How long does it take to complete one cycle?
   b. What is its period?
   c. What is its frequency?
9. An oscillator makes 360 vibrations in 3 minutes.
   a. How many vibrations does it make in one minute?
   b. How many vibrations does it make in one second?
   c. What is its period in seconds?
   d. What is its frequency in hertz?

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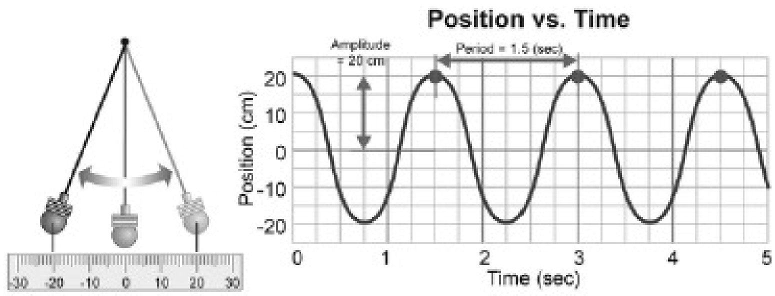
Harmonic Motion Graphs

READ

A graph can be used to show the amplitude and period of an object in harmonic motion. An example of a graph of a pendulum's motion is shown below.

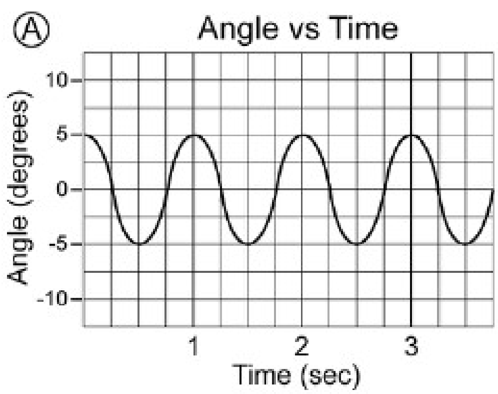


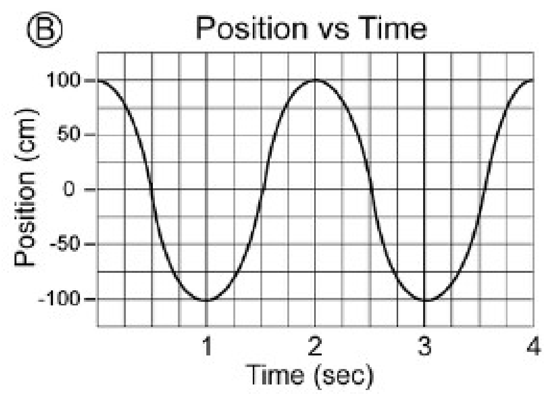
The distance to which the pendulum moves away from this center point is call the **amplitude**. The amplitude of a pendulum can be measured in units of length (centimeters or meters) or in degrees. On a graph, the amplitude is the distance from the x-axis to the highest point of the graph. The pendulum shown above moves 20 cm to each side of its center position, so its amplitude is 20 cm.

The **period** is the time for the pendulum to make one complete cycle. It is the time from one peak to the next on the graph. On the graph above, one peak occurs at 1.5 seconds, and the next peak occurs at 3.0 seconds. The period is 3.0 - 1.5 = 1.5 seconds.

PRACTICE

1. Use the graphs to answer the following questions





   a. What is the amplitude of each vibration?

   b. What is the period of each vibration?

2. Use the grids below to draw the following harmonic motion graphs. Be sure to label the *y*-axis to indicate the measurement scale.

   a. A pendulum with an amplitude of 2 cm and a period of 1 second.

   b. A pendulum with an amplitude of 5 degrees and a period of 4 seconds.

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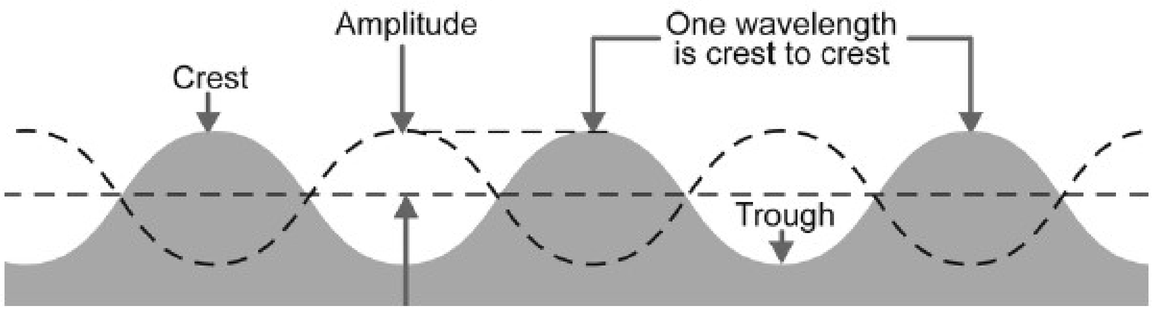
Waves

READ

A **wave** is a traveling oscillator that carries energy from one place to another. A high point of a wave is called a **crest**. A low point is called a **trough**. The amplitude of a wave is half the distance from a crest to a trough. The distance from one crest to the next is called the **wavelength**. Wavelength can also be measured from trough to trough or from any point on the wave to the next place where that point occurs.



The speed of a wave

Speed (m/sec) → $v = f\lambda$ ← Wavelength (meters)

Frequency (hertz) → f

EXAMPLE

The frequency of a wave is 40 Hz and its speed is 100 meters per second. What is the wavelength of this wave?

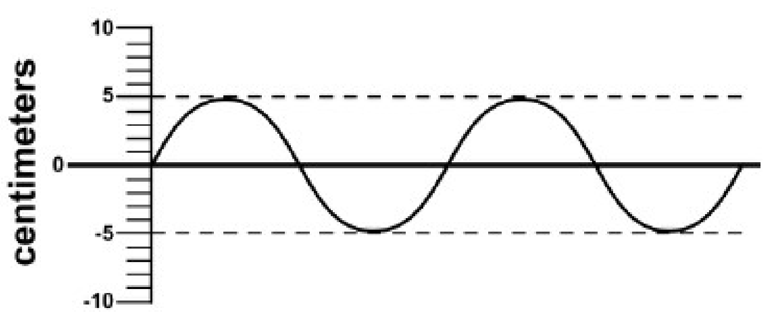
Given	Solution
Frequency = 40 Hz; Speed = 100 m/sec	$\frac{100\text{ m/sec}}{40\text{ Hz}} = \frac{100\text{ m/sec}}{40\text{ cycles/sec}} = \text{Wavelength}$
Looking for	2.5 meters = Wavelength
The wavelength	The wavelength of this wave is 2.5 meters.
Relationships	
Speed = Frequency × Wavelength, therefore	
Speed ÷ Frequency = Wavelength	

PRACTICE

1. On the graphic at right label the following parts of a wave: one wavelength, half of a wavelength, the amplitude, a crest, and a trough.

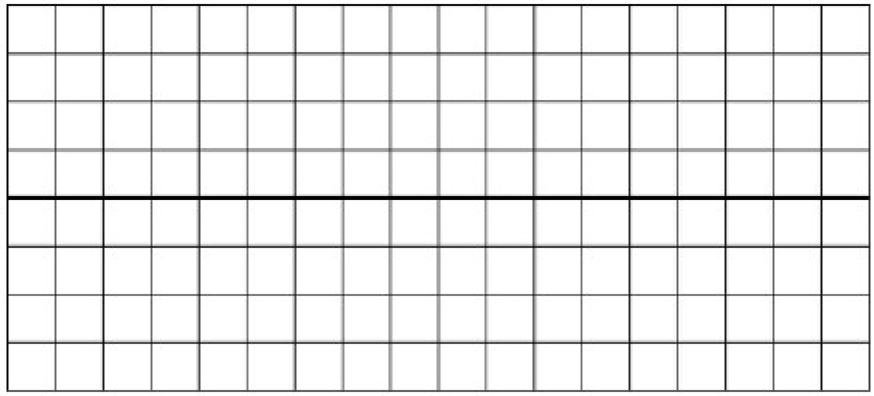
   a. How many wavelengths are represented in the wave above?

   b. What is the amplitude of the wave shown above?

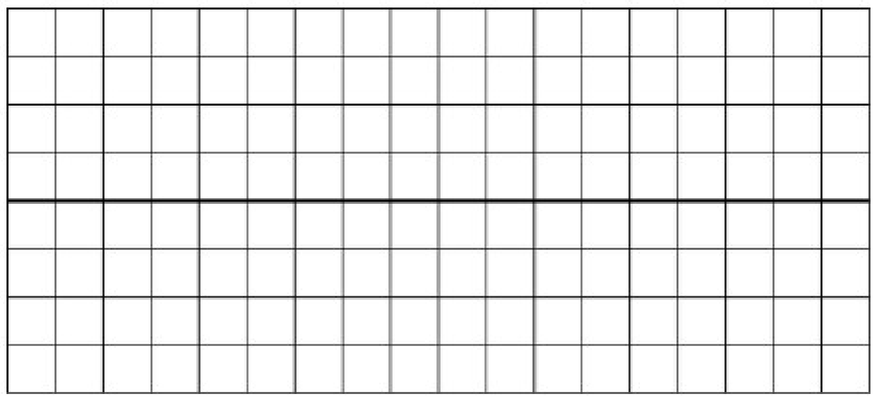


2. Use the grids below to draw the following waves. Be sure to label the *y*-axis to indicate the measurement scale.

   a. A wave with an amplitude of 1 cm and a wavelength of 2 cm

   b. A wave with an amplitude of 1.5 cm and a wavelength of 3 cm

3. A water wave has a frequency of 2 hertz and a wavelength of 5 meters. Calculate its speed.

4. A wave has a speed of 50 m/sec and a frequency of 10 Hz. Calculate its wavelength.

5. A wave has a speed of 30 m/sec and a wavelength of 3 meters. Calculate its frequency.

6. A wave has a period of 2 seconds and a wavelength of 4 meters.Calculate its frequency and speed.
   Note: Recall that the frequency of a wave equals 1/period and the period of a wave equals 1/frequency.

7. A sound wave travels at 330 m/sec and has a wavelength of 2 meters. Calculate its frequency and period.

8. The frequency of wave A is 250 hertz and the wavelength is 30 centimeters. The frequency of wave B is 260 hertz and the wavelength is 25 centimeters. Which is the faster wave?

9. The period of a wave is equal to the time it takes for one wavelength to pass by a fixed point. You stand on a pier watching water waves and see 10 wavelengths pass by in a time of 40 seconds.

   a. What is the period of the water waves?

   b. What is the frequency of the water waves?

   c. If the wavelength is 3 meters, what is the wave speed?

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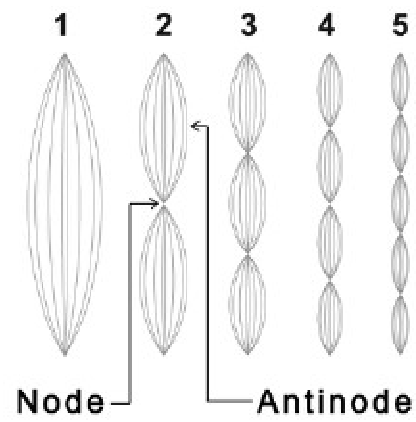
Standing Waves

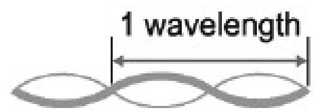
A wave that is confined in a space is called a **standing wave**. Standing waves on the vibrating strings of a guitar produce the sounds you hear. Standing waves are also present inside the chamber of a wind instrument.

A string that contains a standing wave is an oscillator. Like any oscillator, it has natural frequencies. The lowest natural frequency is called the **fundamental**. Other natural frequencies are called **harmonics**. The first five harmonics of a standing wave on a string are shown to the right.

There are two main parts of a standing wave. The **nodes** are the points where the string does not move at all. The **antinodes** are the places where the string moves with the greatest amplitude.

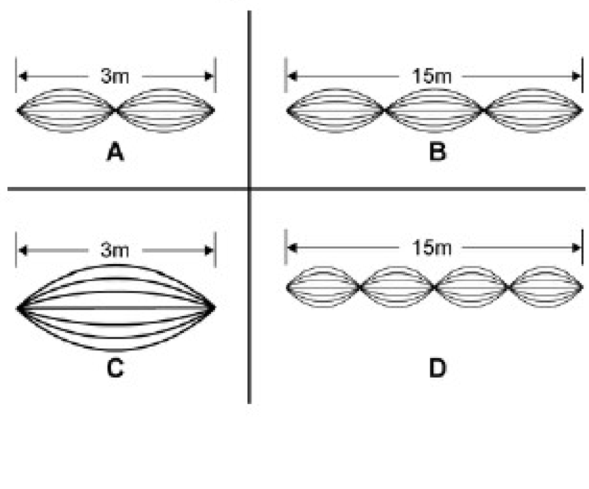


The wavelength of a standing wave can be found by measuring the length of two of the "bumps" on the string. The first harmonic only contains one bump, so the wavelength is twice the length of the individual bump.

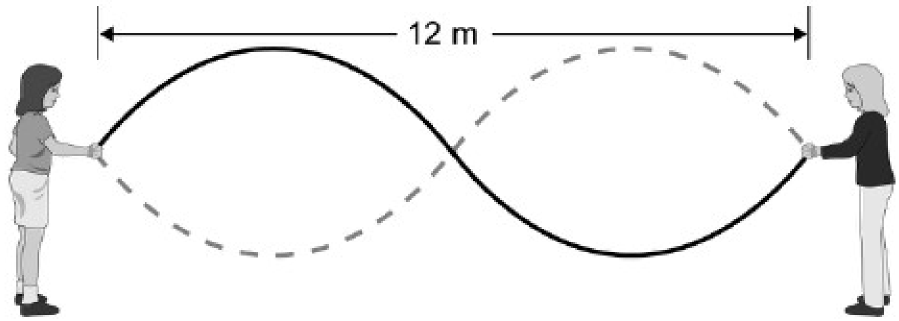


PRACTICE

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. Two students want to use a 12-meter 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 six harmonics.

b. Determine the wavelength for each harmonic on the 12 meter rope. Record the values in the table below.

c. Use the equation for wave speed ($v = f\lambda$) to calculate each frequency.

Harmonic	Speed (m/sec)	Wavelength (m)	Frequency (Hz)
1	36		
2	36		
3	36		
4	36		
5	36		
6	36		

d. What happens to the frequency as the wavelength increases?

e. Suppose the students cut the rope in half. The speed of the wave on the rope only depends on the material from which the rope is made and its tension, so it will not change. Determine the wavelength and frequency for each harmonic on the 6 meter rope.

Harmonic	Speed (m/sec)	Wavelength (m)	Frequency (Hz)
1	36		
2	36		
3	36		
4	36		
5	36		
6	36		

f. What effect did using a shorter rope have on the wavelength and frequency?

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PRACTICE 20.3

Wave Interference

READ

Interference occurs when two or more waves are at the same location at the same time. For example, the wind may create tiny ripples on top of larger waves in the ocean.The **superposition principle** states that the total vibration at any point is the sum of the vibrations produced by the individual waves.

Constructive interference is when waves combine to make a larger wave. Destructive interference is when waves combine to make a wave that is smaller than either of the individual waves. Noise cancelling headphones work by producing a sound wave that perfectly cancels the sounds in the room.

PRACTICE

This worksheet will allow you to find the sum of two waves with different wavelengths and amplitudes. The table below (and continued on the next page) lists the coordinates of points on the two waves.

1. Use coordinates on the table and the graph paper (see last page) to graph wave 1 and wave 2 individually. Connect each set of points with a smooth curve that looks like a wave. Then, answer questions 2 – 9.
2. What is the amplitude of wave 1?
3. What is the amplitude of wave 2?
4. What is the wavelength of wave 1?
5. What is the wavelength of wave 2?
6. How many wavelengths of wave 1 did you draw?
7. How many wavelength of wave 2 did you draw?
8. Use the superposition principle to find the wave that results from the interference of the two waves.
   a. To do this, simply add the heights of wave 1 and wave 2 at each point and record the values in the last column. The first four points are done for you.
   b. Then use the points in last column to graph the new wave. Connect the points with a smooth curve. You should see a pattern that combines the two original waves.
9. Describe the wave created by adding the two original waves.

x-axis (blocks)	Height of wave 1 (*y*-axis blocks)	Height of wave 2 (*y*-axis blocks)	Height of wave 1 + wave 2 (*y*-axis blocks)
0	0	0	0
1	0.8	2	2.8
2	1.5	0	1.5
3	2.2	-2	0.2
4	2.8	0	

x-axis (blocks)	Height of wave 1 (*y*-axis blocks)	Height of wave 2 (*y*-axis blocks)	Height of wave 1 + wave 2 (*y*-axis blocks)
5	3.3	2	
6	3.7	0	
7	3.9	-2	
8	4	0	
9	3.9	2	
10	3.7	0	
11	3.3	-2	
12	2.8	0	
13	2.2	2	
14	1.5	0	
15	0.8	-2	
16	0	0	
17	-0.8	2	
18	-1.5	0	
19	-2.2	-2	
20	-2.8	0	
21	-3.3	2	
22	-3.7	0	
23	-3.9	-2	
24	-4	0	
25	-3.9	2	
26	-3.7	0	
27	-3.3	-2	
28	-2.8	0	
29	-2.2	2	
30	-1.5	0	
31	-0.8	-2	
32	0	0	

PRACTICE 20.3