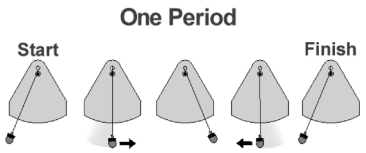
Name:

Skill Sheet 11 — Harmonic Motion

A number of common objects exhibit harmonic motion. A swing, a string on a guitar, sound, and light all move in a harmonic or wave pattern. We can describe the motion of these objects with special terms like period, frequency, amplitude, and hertz. In this skill sheet, you will practice using these terms as you work through the activities, questions, and problems.

1. Reviewing terms

The diagram to the right shows the *period* of a pendulum. 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. The time it take to move through one cycle is equal to one period of the pendulum.



As you can see in the diagram, the ball and string always pass through a center point. The distance to which the ball and string move away from this center point is call the *amplitude*. For pendulums, amplitude is measured in degrees. For waves, amplitude is measured in units of length like centimeters or meters.

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.

Period and Frequency

Period (seconds) → $T = \frac{1}{f}$ ← Frequency (hertz)

Frequency (hertz) → $f = \frac{1}{T}$ ← Period (seconds)

Example: A long pendulum takes 10 seconds to make one complete back and forth motion. What is its period and frequency?

Answer: The period is the time for one cycle, so the period is 10 seconds.

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

$$f = \frac{1}{10 \text{ seconds}} = 0.1 \text{ hertz}$$

The frequency is 0.1 hertz.

2. Questions and practice problems

1. You decide to describe the harmonic motion of a swing. You find out that it take 2 seconds for the swing to complete one cycle. The swing passes through 48 degrees as it goes from high-to-high point in its motion (passing through center).

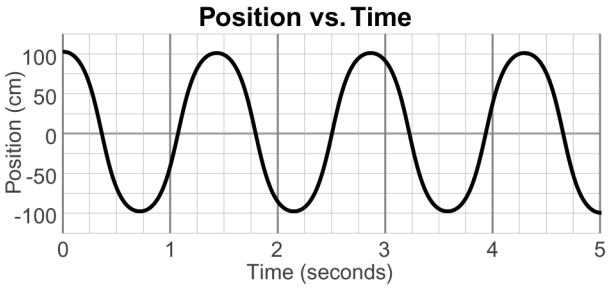
   a. What is the period of the swing?

   b. What is the frequency of the swing in hertz?

   c. What is the amplitude of the swing?

2. If you let the swing's motion continue on its own, what would happen to its amplitude? Why?

3. Use the graphic to answer the following questions.



   a. What is the amplitude of the wave?

   b. How many wavelengths are featured in the graphic? In your response, demonstrate that you understand how to identify one wavelength.

   c. What is the period of the wave?

   d. What is the frequency of the wave?

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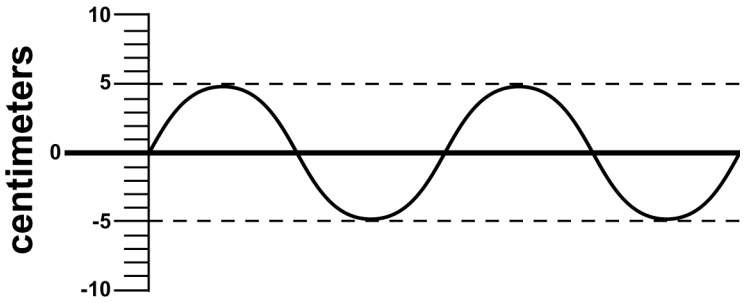
Skill Sheet 12 — Waves

What is a wave? How do you calculate the speed of a wave? In this skill sheet you will review how to answer these questions as you review wave properties.

1. The parts of a wave

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



2. In the graphic above, how many wavelengths are represented?

_____

3. Define *amplitude* of a wave in your own words. What is the amplitude of the wave in the graphic?

_____

4. How do you calculate the *frequency* of a wave?

_____

5. If took 0.05 seconds for the number of wavelengths in the graphic to pass a certain point, what is the frequency of this wave?

_____

2. The speed of a wave

Below is the formula for the speed of a wave. Use this formula to answer the questions on the next page. Be sure to show your work.

$$\text{Speed} = \frac{\text{Distance Traveled}}{\text{Time Taken}} = \frac{\text{Wavelength}}{\text{Period}} = \text{Wavelength} \times \left(\frac{1}{\text{Period}}\right)$$

$$\textbf{Speed} = \textbf{Wavelength} \times \textbf{Frequency}$$

The speed of a wave

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

Frequency (hertz) → f

1. The wavelength of a wave is 50 centimeters. The frequency is 100 Hz. What is the speed of this wave?

2. 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?

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

3. Identifying harmonics

Let's say you have a machine that supports a 3 meter piece of string. Using this machine you can measure the frequency at which the string vibrates at each harmonic. Table 1 is partially filled with data. Use your understanding of harmonics to fill in the rest of the table.

Harmonic #	Frequency (Hz)	Wavelength (m)	Speed of the Wave Frequency times wavelength (m/sec)
1 (fundamental)	**3**		**18**
2	**6**		**18**
3		**2**	
4	**12**	**1.5**	**18**
5	**15**		**18**
6		**1**	

1. When you are looking at a vibrating string, what is the easiest way to determine its harmonic?

2. What is the wavelength of the fundamental harmonic of a string that is 5 meters long?