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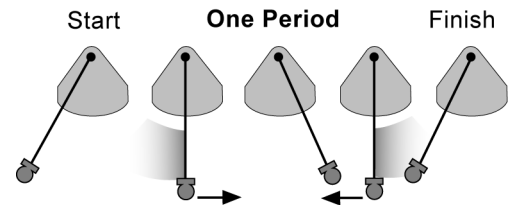
Skill Sheet 13.1

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 takes 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 called the *amplitude*. For pendulums, amplitude is measured in degrees. For other kinds of 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

$$\begin{array}{c} \text{Period (seconds)} \rightarrow \mathbf{T} = \frac{1}{\mathbf{f}} \\ \text{Frequency (hertz)} \rightarrow \mathbf{f} \end{array} \quad \begin{array}{c} \text{Frequency (hertz)} \\ \downarrow \\ \mathbf{f} = \frac{1}{\mathbf{T}} \\ \leftarrow \text{Period (seconds)} \end{array}$$

2. Questions and practice problems

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

a. What is the period of the swing?

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

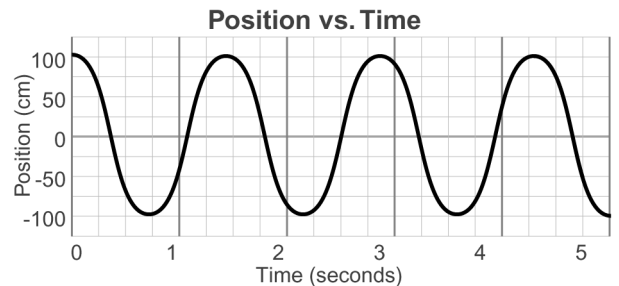
c. What is the amplitude of the swing?

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.



4. The table below lists data from a pendulum experiment. Use the table to help you answer the questions that follow.

Trial number	Length of string (cm)	Mass of pendulum (g)	Amplitude of pendulum (degrees)
1	10	5	30
2	10	10	40
3	20	5	30
4	20	10	40
5	30	5	30
6	30	10	40

- a. Which of the three variables (length of string, mass of the pendulum, and amplitude) affects the period of the pendulum the most?

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- b. For which of the six trials would the pendulum be the slowest? Explain your answer.

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- c. For which of the six trials would the pendulum be the fastest? Explain your answer.

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- d. Does the relationship between the mass and period of a pendulum support Newton's second law of motion? Explain your answer.
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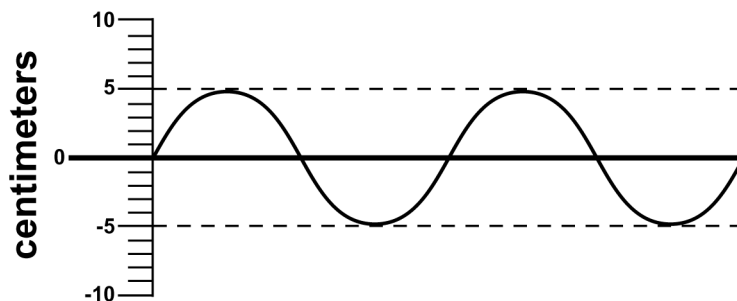
Skill Sheet 14.1

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 it took 0.05 seconds for the number of wavelengths in the graphic to pass a certain point, what is the frequency of this wave?
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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. Recall that the frequency of a wave equals $1/\text{period}$. Be sure to show your work.

The speed of a wave

$$\text{Speed (m/sec)} \rightarrow v = f \lambda$$

Frequency (hertz) \leftarrow f \leftarrow λ \leftarrow Wavelength (meters)

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

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

- The speed of a wave can be calculated by multiplying the frequency by the wavelength. You can also calculate wave speed by dividing wavelength by the period of the wave. Why does this make sense?

- 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?

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

- 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. 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	12.0	1.5	18
5	15.0		18
6		1.0	

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

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

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Skill Sheet 15.1

Decibel Scale Problems

This skill sheet provides practice problems in using the decibel scale.

The decibel scale relates the amplitude of sound waves to their loudness. Since the range of amplitudes our ears can hear is very large, a logarithmic scale is used. By compressing the high end of the scale and expanding the low end of the scale, the logarithmic scale adjusts the very large range of amplitudes so that we can relate the amplitudes to the way they sound. Increasing a sound's amplitude by a factor of 10 raises its level on the logarithmic scale by 20 decibels (dB). Increasing a sound's amplitude by a factor of 100 raises its level by 40 dB; by 1,000, 60 dB and so on.

The loudness of the sound is proportional to the amplitude of the sound wave. Each increase of 20 dB will sound about twice as loud to your ears. Use the following table to help you answer the questions in Parts 1 and 2.

10-15 dB	A quiet whisper 3 feet away
30 dB	A house in the country
40 dB	A house in the city
45-55 dB	The noise level in an average restaurant
65 dB	Ordinary conversation 3 feet away
70 dB	City traffic
90 dB	A jackhammer cutting up the street 10 feet away
110 dB	A hammer striking a steel plate 2 feet away (very loud)
120 dB	The threshold of physical pain from loudness

1. Loudness problems

Solve these loudness problems using the table of decibel scale. The first problem is done for you:

1. Questions about city sounds:

- How many decibels does city traffic have? *Answer:* According to the table, city traffic has a decibel reading of 70 dB.
- How many decibels would a sound have if its loudness was twice that of city traffic? *Answer:* Since every 20 dB increase in decibels sounds about twice as loud, the sound relating to 90 dB (70 dB + 20 dB) would sound twice as loud.
- Which sound corresponds to the decibel level determined in 1(b)? *Answer:* A jackhammer 10 feet away corresponds to 90 dB.

2. How many decibels would a sound have if its loudness was four times that of a 10 dB quiet whisper?

3. How much louder would a 30 dB sound be than a 10 dB quiet whisper?

4. A house in the country has a loudness of 30 dB. How many times louder does a 90 dB jackhammer 10 feet away sound?

5. How many decibels louder is a house in the city than a house in the country?

6. How much louder would a house in the city sound than a house in the country?

2. Amplitude problems

Solve the following amplitude problems using the table of decibel scale. Remember that the amplitude of the sound wave increases by a factor of 10 for every 20 dB difference. The first problem is done for you.

1. How much greater is a jackhammer 10 feet away's amplitude than city traffic?

Answer: Since every 20 dB increase in decibels has 10 times greater amplitude, a jackhammer 10 feet away (90 dB) has an amplitude 10 times greater than city traffic (70 dB).

2. How much larger in amplitude would a 30 dB sound be than a 10 dB quiet whisper?

3. How much greater is the amplitude of the sound waves of the jackhammer 10 feet away than the sound waves of a house in the country?

4. An ordinary conversation is 65 decibels. In a restaurant, people talk more quietly at around 45 decibels. What is the difference in amplitude of sound waves produced during normal conversation and sound produced when people are talking in a restaurant?
