Chapter 12

Sound

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Chapter 12

Section 1 Sound Waves

Objectives

- **Explain** how sound waves are produced.
- **Relate** frequency to pitch.
- **Compare** the speed of sound in various media.
- **Recognize** the Doppler effect, and **determine** the direction of a frequency shift when there is relative motion between a source and an observer.

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Sound Waves

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Chapter 12
Section 1 Sound Waves

The Production of Sound Waves

- Every sound wave begins with a _____, such as the vibrating prong of a tuning fork.
- A _____ is the region of a longitudinal wave in which the density and pressure are at a maximum.
- A _____ is the region of a longitudinal wave in which the density and pressure are at a minimum.

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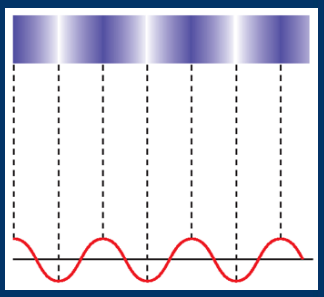
The Production of Sound Waves, *continued*

- Sound waves are _____.
- The simplest longitudinal wave produced by a vibrating object can be represented by a _____ _____
- In the diagram, the _____ of the sine curve correspond to _____, and the _____ correspond to _____.



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Frequency of Sound Waves

- As discussed earlier, _____ is defined as the number of cycles per unit of time.
- Sound waves that the average human ear can hear, called _____ sound waves, have frequencies between _____.
- Sound waves with frequencies _____ are called _____waves.
- Sound waves with frequencies _____ are called _____ waves.

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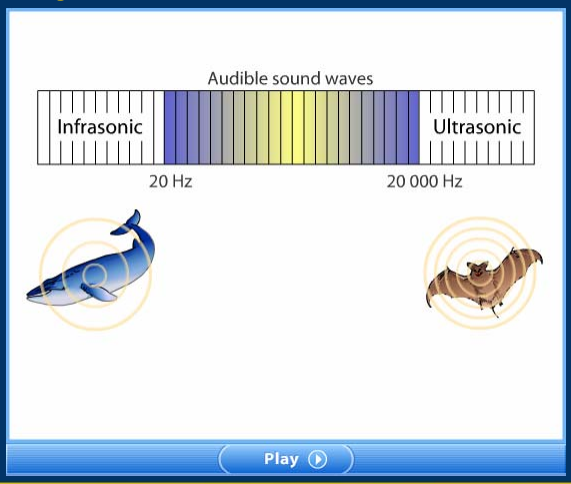
Frequency of Sound Waves



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Chapter 12 Section 1 Sound Waves

Frequency and Pitch

- The _____ of an audible sound wave determines how _____ we perceive the sound to be, which is known as _____.
- As the frequency of a sound wave _____, the pitch _____.
- The frequency of a wave is an objective quantity that can be measured, while pitch refers to how different frequencies are perceived by the human ear.

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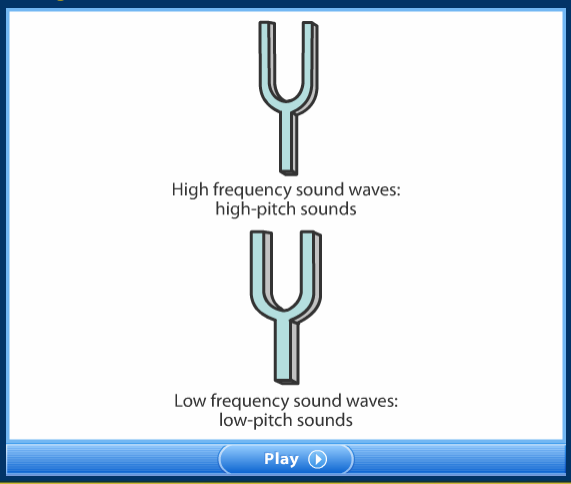
Frequency and Pitch



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The Speed of Sound

- The speed of sound depends on the _____.
  - Because waves consist of particle vibrations, the speed of a wave depends on how quickly one particle can transfer its motion to another particle.
  - For example, sound waves generally travel faster through solids than through gases because the molecules of a solid are closer together than those of a gas are.
- The speed of sound also depends on the _____ of the medium. This is most noticeable with gases.

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The Speed of Sound in Various Media

Medium	v (m/s)
Gases	
air (0°C)	331
air (25°C)	346
air (100°C)	366
helium (0°C)	972
hydrogen (0°C)	1290
oxygen (0°C)	317
Liquids at 25°C	
methyl alcohol	1140
sea water	1530
water	1490
Solids	
aluminum	5100
copper	3560
iron	5130
lead	1320
vulcanized rubber	54

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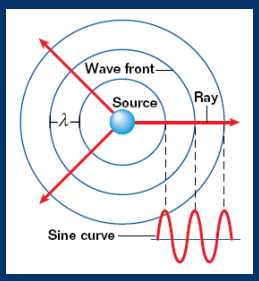
The Propagation of Sound Waves

- Sound waves propagate in three dimensions.
- Spherical waves can be represented graphically in two dimensions, as shown in the diagram.



- The circles represent the centers of compressions, called _____.
- The radial lines perpendicular to the wave fronts are called _____.
- The **sine curve** used in our previous representation corresponds to a single ray.

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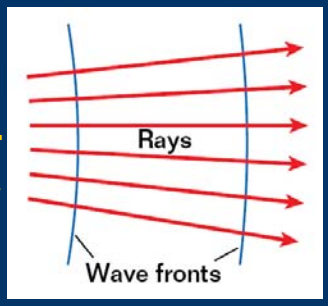
The Propagation of Sound Waves, *continued*

- At distances from the source that are great relative to the wavelength, we can approximate _____ _____ with _____.
- Such waves are called _____ _____.
- Plane waves can be treated as one-dimensional waves all traveling in the same direction.



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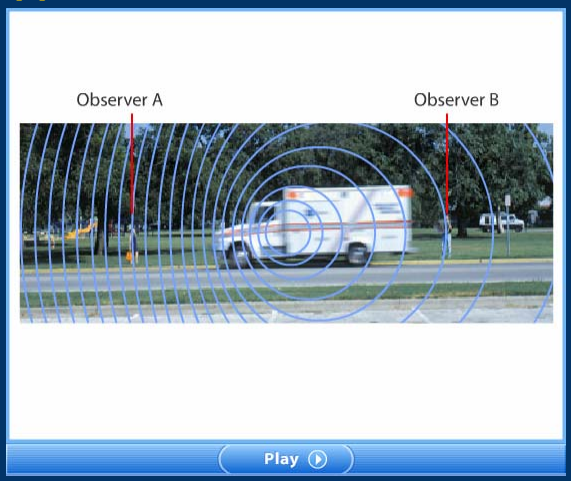
The Doppler Effect



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The Doppler Effect

- The _____ is an observed change in frequency when there is _____ between the source of waves and an observer.
- Because frequency determines pitch, the Doppler effect affects the _____ heard by each listener.
- Although the Doppler effect is most commonly experienced with sound waves, it is a phenomenon common to all waves, including electromagnetic waves, such as visible light.

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Objectives

- **Relate** intensity, decibel level, and perceived loudness with amplitude of the wave
- **Explain** why resonance occurs.

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Sound Intensity

- As sound waves travel, energy is transferred from one molecule to the next. The rate at which this energy is transferred through a unit area of the plane wave is called the _____ of the wave.

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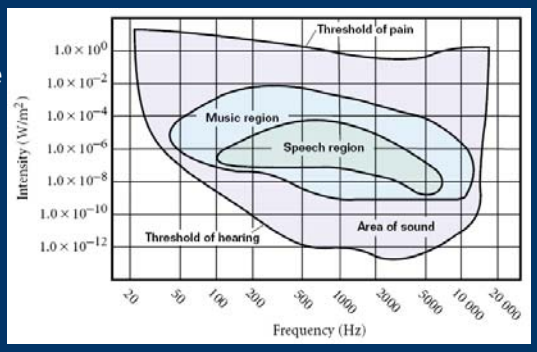
Chapter 12
Section 2 Sound Intensity and Resonance

Sound Intensity, *continued*

- Human hearing depends on both the _____ and the _____ of sound waves.
- Sounds in the middle of the spectrum of frequencies can be heard more easily (at lower intensities) than those at lower and higher frequencies.



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Sound Intensity, *continued*

- The _____ of a wave approximately determines its perceived _____ **and** _____ **of the wave.**
- However, loudness is not directly proportional to intensity. The reason is that the sensation of loudness is approximately **logarithmic** in the human ear.
- _____ is the ratio of the intensity of a given sound wave to the intensity at the threshold of hearing.

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Chapter 12
Section 2 Sound Intensity and Resonance

Sound Intensity, *continued*

- Because of the logarithmic dependence of perceived loudness on intensity, using a number equal to **10 times the logarithm of the relative intensity** provides a good indicator for human perceptions of loudness.
- This is referred to as the _____.
- A dimensionless unit called the _____ is used for values on this scale.

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Conversion of Intensity to Decibel Level

Intensity (W/m^2)	Decibel level (dB)	Examples
1.0×10^{-12}	0	threshold of hearing
1.0×10^{-11}	10	rustling leaves
1.0×10^{-10}	20	quiet whisper
1.0×10^{-9}	30	whisper
1.0×10^{-8}	40	mosquito buzzing
1.0×10^{-7}	50	normal conversation
1.0×10^{-6}	60	air conditioning at 6 m
1.0×10^{-5}	70	vacuum cleaner
1.0×10^{-4}	80	busy traffic, alarm clock
1.0×10^{-3}	90	lawn mower
1.0×10^{-2}	100	subway, power motor
1.0×10^{-1}	110	auto horn at 1 m
1.0×10^{0}	120	threshold of pain
1.0×10^{1}	130	thunderclap, machine gun
1.0×10^{3}	150	nearby jet airplane

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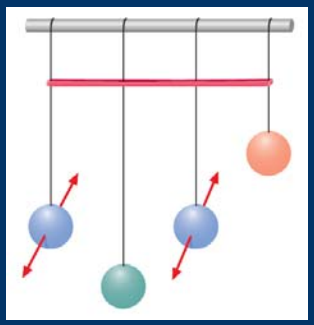
Chapter 12
Section 2 Sound Intensity and Resonance

Forced Vibrations and Resonance

- If one of the pendulums is set in motion, its vibrations are transferred by the rubber band to the other pendulums, which will also begin vibrating. This is called a _____.
- Each pendulum has a _____ based on its length.



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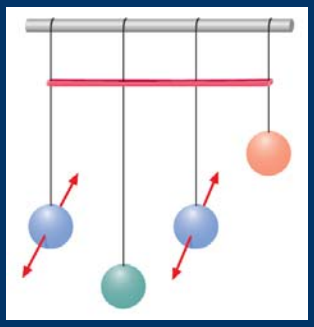
Forced Vibrations and Resonance, *continued*

- _____is a phenomenon that occurs when the frequency of a force applied to a system matches the _____ of vibration of the system, resulting in a _____ _____.
- If one blue pendulum is set in motion, only the other blue pendulum, whose length is the same, will eventually resonate.



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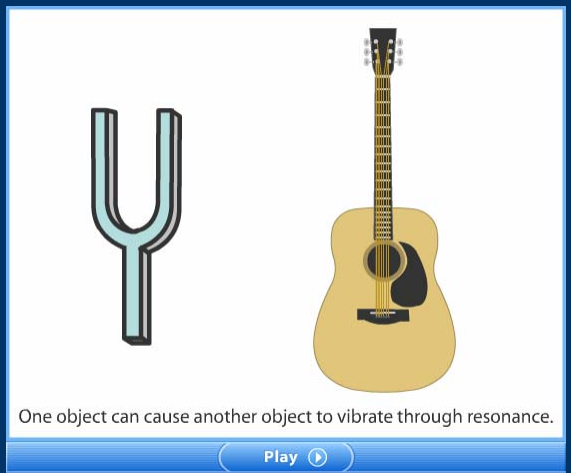
Chapter 12
Section 2 Sound Intensity and Resonance

Resonance



One object can cause another object to vibrate through resonance.

Play

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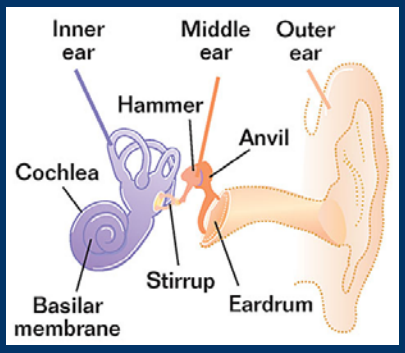
The Human Ear

- The human ear is divided into three sections—outer, middle, and inner.
- Sound waves travel through the three regions of the ear and are then transmitted to the brain as impulses through nerve endings on the basilar membrane.



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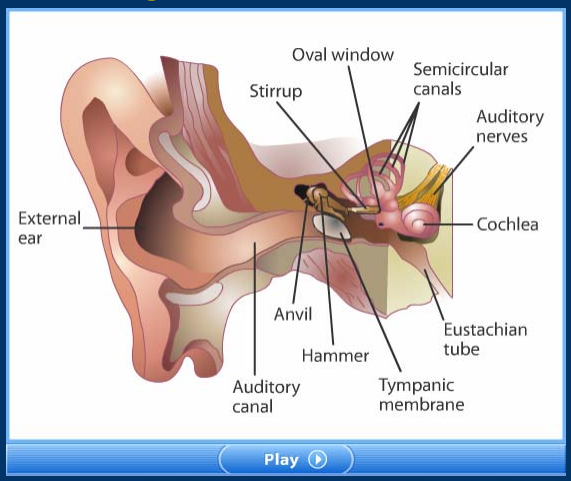
Chapter 12
Section 2 Sound Intensity and Resonance

Human Hearing



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Extra Material

- Non-Regents Concepts
- Practice Questions for Section 12.1 – 12.2 Follow

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Chapter 12 Section 3 Harmonics

Fundamental Frequency

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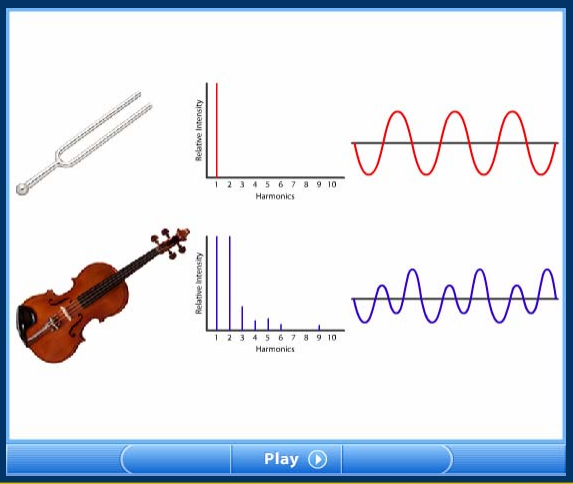
Timbre



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Chapter 12 Section 3 Harmonics

Timbre

- **Timbre** is the the musical quality of a tone resulting from the combination of harmonics present at different intensities.
- A clarinet sounds different from a viola because of **differences in timbre,** even when both instruments are sounding the same note at the same volume.
- The rich harmonics of most instruments provide a much fuller sound than that of a tuning fork.

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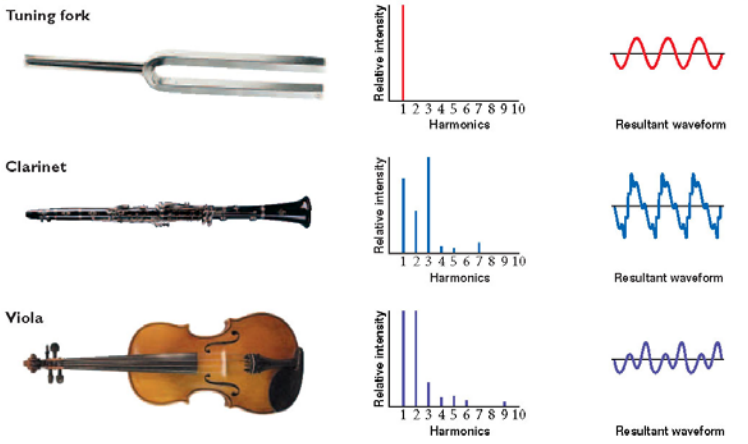
Harmonics of Musical Instruments



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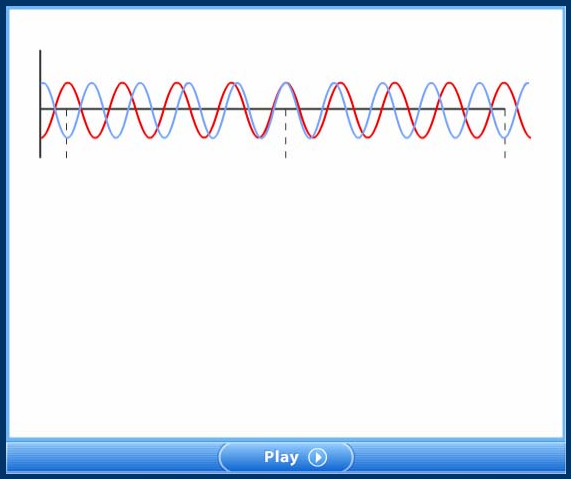
Chapter 12 Section 3 Harmonics

Beats



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Beats

- When two waves of **slightly different frequencies** interfere, the interference pattern varies in such a way that a listener hears an alternation between loudness and softness.
- The variation from soft to loud and back to soft is called a **beat.**
- In other words, a **beat** is the periodic variation in the amplitude of a wave that is the superposition of two waves of slightly different frequencies.

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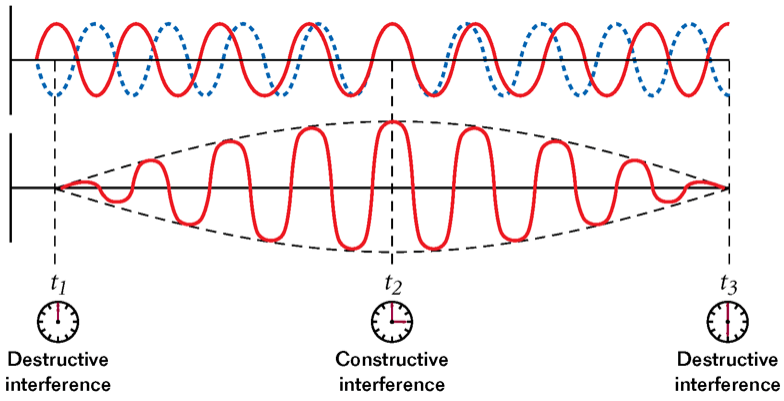
Chapter 12 Section 3 Harmonics

Beats



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Multiple Choice

1. When a part of a sound wave travels from air into water, which property of the wave remains unchanged?

A. speed
B. frequency
C. wavelength
D. amplitude

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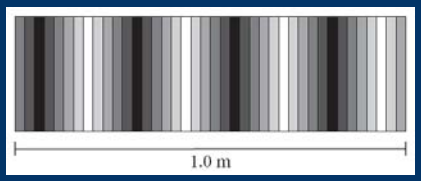
Multiple Choice, *continued*

2. What is the wavelength of the sound wave shown in the figure?



F. 1.00 m
G. 0.75 m
H. 0.50 m
J. 0.25 m

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Multiple Choice, *continued*

3. If a sound seems to be getting louder, which of the following is probably increasing?

A. speed of sound
B. frequency
C. wavelength
D. intensity

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Chapter 12 Standardized Test Prep

Multiple Choice, *continued*

5. The Doppler effect occurs in all but which of the following situations?

A. A source of sound moves toward a listener.
B. A listener moves toward a source of sound.
C. A listener and a source of sound remain at rest with respect to each other.
D. A listener and a source of sound move toward or away from each other.

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Multiple Choice, *continued*

7. Why can a dog hear a sound produced by a dog whistle, but its owner cannot?

A. Dogs detect sounds of less intensity than do humans.

B. Dogs detect sounds of higher frequency than do humans.

C. Dogs detect sounds of lower frequency than do humans.

D. Dogs detect sounds of higher speed than do humans.

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Multiple Choice, *continued*

8. The greatest value ever achieved for the speed of sound in air is about 1.0×10^{4} m/s, and the highest frequency ever produced is about 2.0×10^{10} Hz. If a single sound wave with this speed and frequency were produced, what would its wavelength be?

F. 5.0×10^{-6} m

G. 5.0×10^{-7} m

H. 2.0×10^{6} m

J. 2.0×10^{14} m

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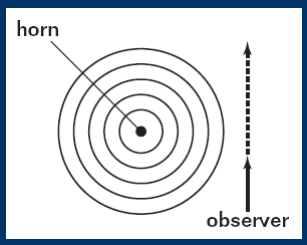
Multiple Choice, *continued*

9. The horn of a parked automobile is stuck. If you are in a vehicle that passes the automobile, as shown in the diagram, what is the nature of the sound that you hear?



A. The original sound of the horn rises in pitch

B. The original sound of the horn drops in pitch.

C. A lower pitch is heard rising to a higher pitch.

D. A higher pitch is heard dropping to a lower pitch.

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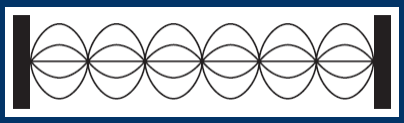
Short Response, *continued*

13. The figure shows a string vibrating in the sixth harmonic. The length of the string is 1.0 m. What is the wavelength of the wave on the string?



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