Section 1: Types of Waves

Preview

Key Ideas

- What does a wave carry?
- How are waves generated?
- What is the difference between a transverse wave and a longitudinal wave?
- How do the particles in ocean waves move?

Bellringer

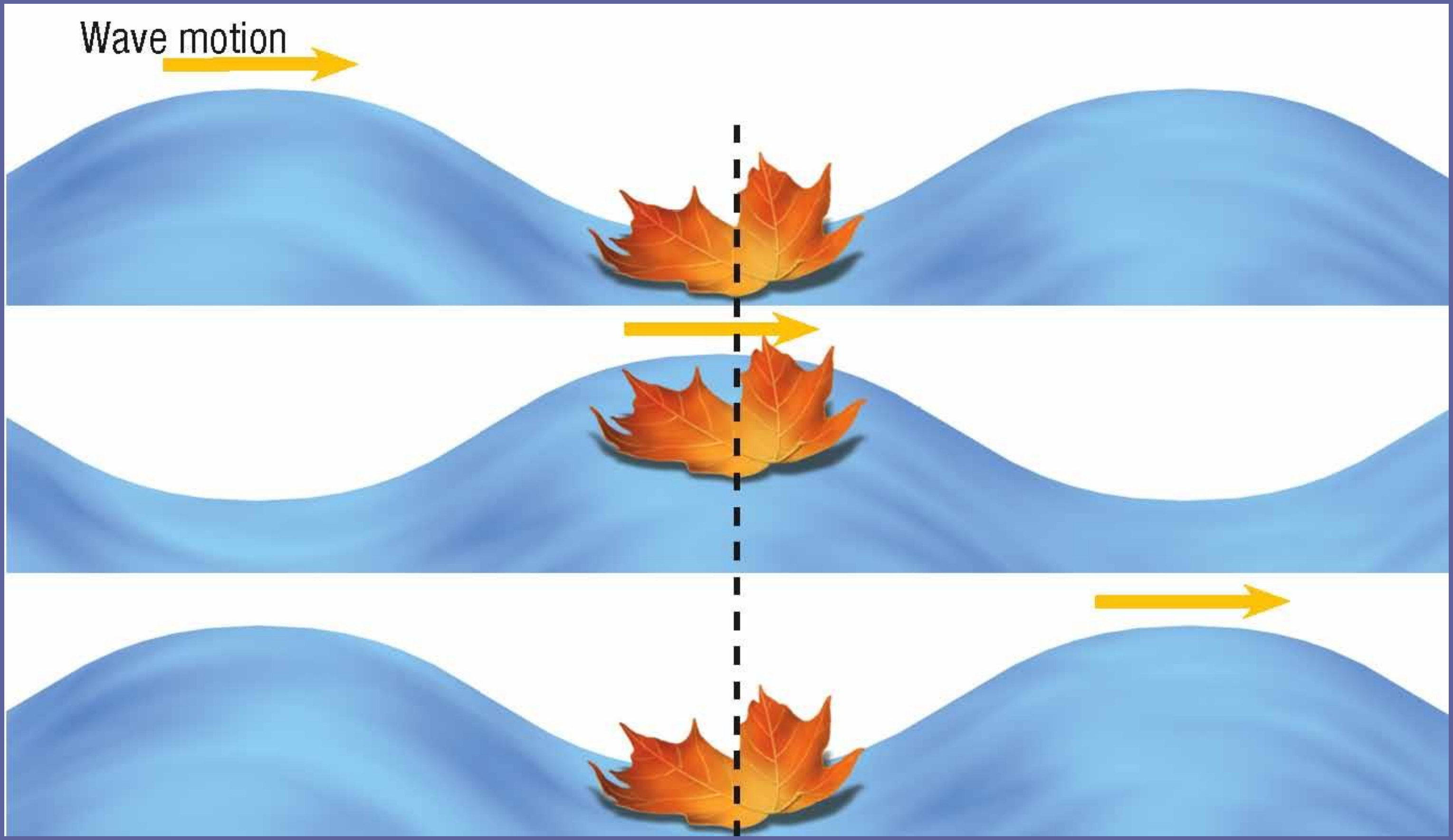
1. Imagine throwing a rock into a pond or lake. Describe the effect that the rock has on the surface of the water.
2. When surfing, a person moves just ahead of a wave. Where does the energy come from to move the surfer through the water?
3. What happens to a string on a guitar or other stringed instrument when it is plucked?

What Is a Wave?

- What does a wave carry?

- A wave is a disturbance that carries energy through matter or space.

What Is a Wave?, *continued*



What Is a Wave?, *continued*

- Most waves travel through a medium.
  - **medium:** a physical environment in which phenomena occur
  - **mechanical wave:** a wave that requires a medium through which to travel
  - examples: sound waves, water waves

What Is a Wave?, *continued*

- Electromagnetic waves do not require a medium.
  - **electromagnetic wave:** a wave that consists of oscillating electric and magnetic fields, which radiate outward at the speed of light
  - examples: visible light waves, radio waves

What Is a Wave?, *continued*

- Waves transfer energy.
  - Tsunamis carry enough energy to cause damage to coastal towns.
  - The energy of normal ocean waves breaks up rocks into pieces to form sandy beaches.

What Is a Wave?, *continued*

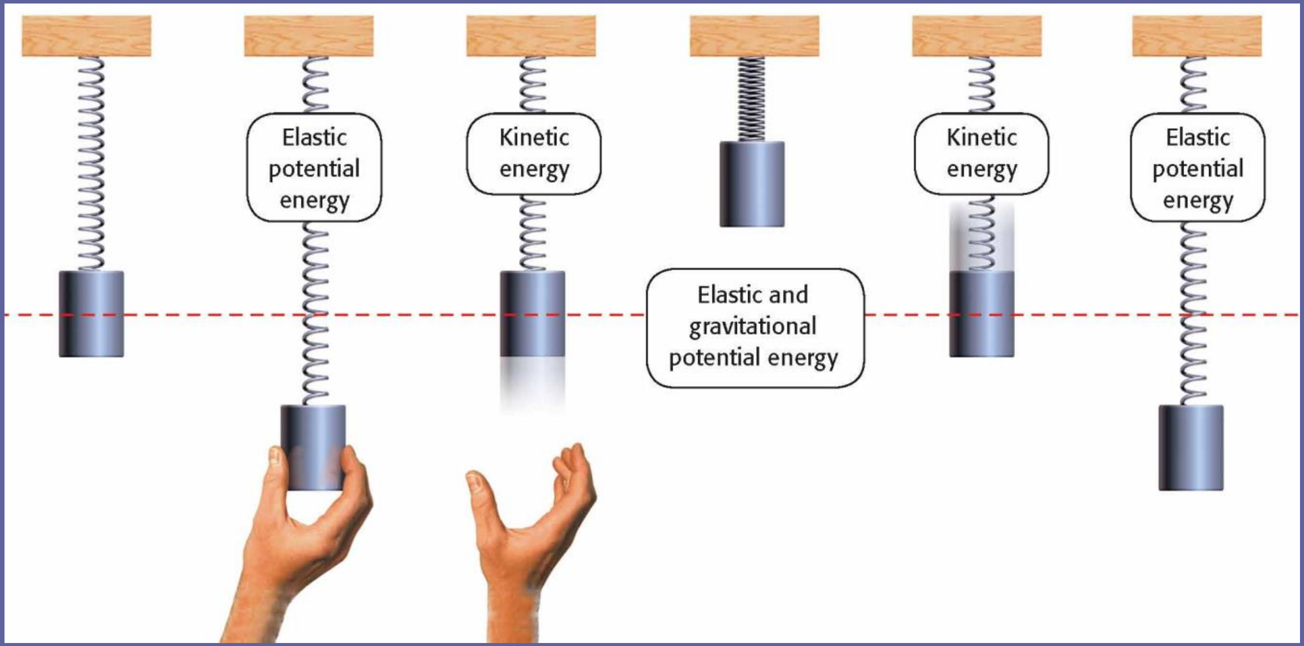
- Energy may spread out as a wave travels.
  - When sound waves travel in air, the waves spread out in spheres.
  - As the waves travel outward, the spherical wave fronts get bigger, so the energy spreads out over a larger volume.

Vibrations and Waves

- How are waves generated?
- Most waves are caused by vibrating objects.
  - The sound waves produced by a singer are caused by vibrating vocal cords.
  - Electromagnetic waves may be caused by vibrating charged particles.
  - For mechanical waves, the particles in the medium through which the wave passes vibrate, too.

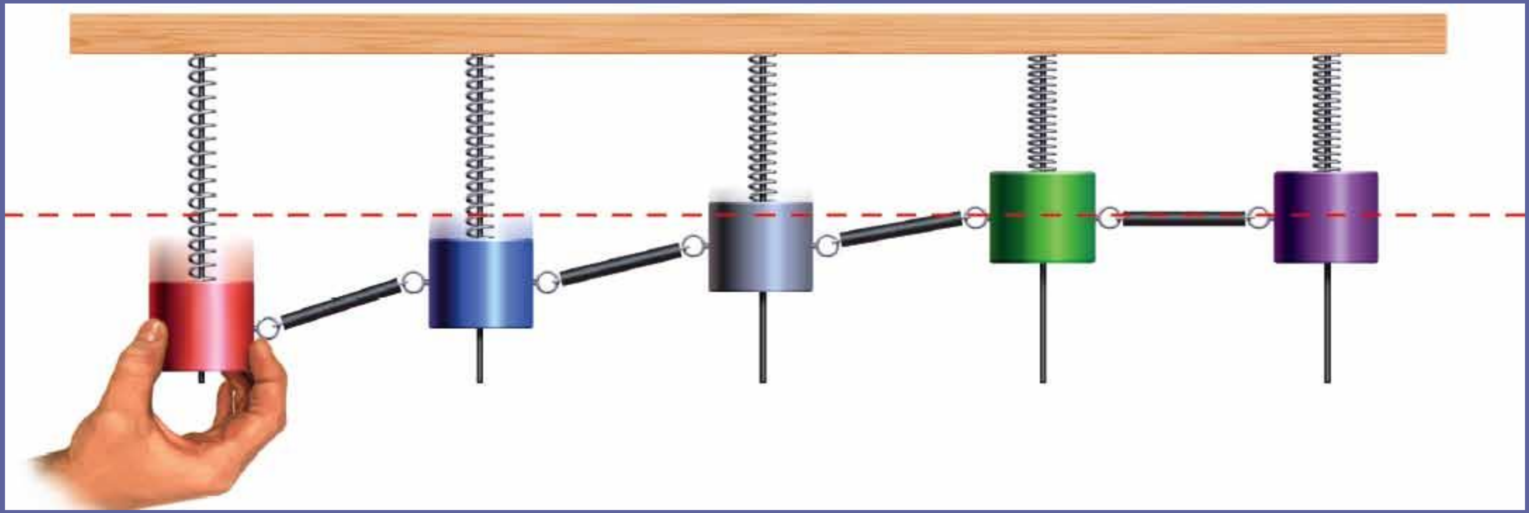
Vibrations and Waves, *continued*

- The mechanical energy of a vibrating mass-spring system changes form.
- This type of vibration is called *simple harmonic motion.*



Vibrations and Waves, continued

- A wave can pass through a series of vibrating objects.
  - The disturbance travels down the row as energy is transferred from one mass to another.
- Wave particles move like masses on springs.



Transverse and Longitudinal Waves

- What is the difference between a transverse wave a longitudinal wave?

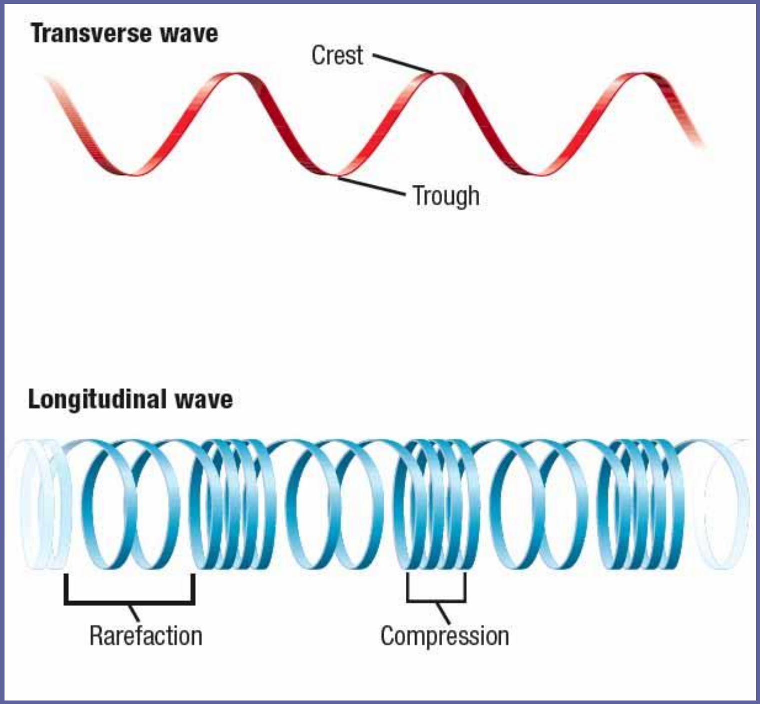
- A transverse wave is a wave in which the wave motion is perpendicular to the particle motion. A longitudinal wave is a wave in which the wave motion is parallel to the particle motion.

Transverse and Longitudinal Waves, *continued*

- Transverse waves have perpendicular motion.
  - **transverse wave:** a wave in which the particles of the medium move perpendicularly to the direction the wave is traveling
- Longitudinal waves have parallel motion.
  - **longitudinal wave:** a wave in which the particles of the medium vibrate parallel to the direction of wave motion

Transverse and Longitudinal Waves, *continued*

- Waves have crests and troughs or compressions and rarefactions.
  - **crest:** the highest point of a wave
  - **trough**: the lowest point of a wave
  - *compressions:* the crowded areas of a longitudinal wave
  - *rarefactions:* the stretched-out areas of a longitudinal wave



Surface Waves

〉 How do the particles in ocean waves move?

〉 The particles in a surface wave move both perpendicularly and parallel to the direction in which the wave travels.

- *surface waves:* waves that occur at the boundary between two different mediums, such as water and air

Section 2: Characteristics of Waves

Preview

Key Ideas

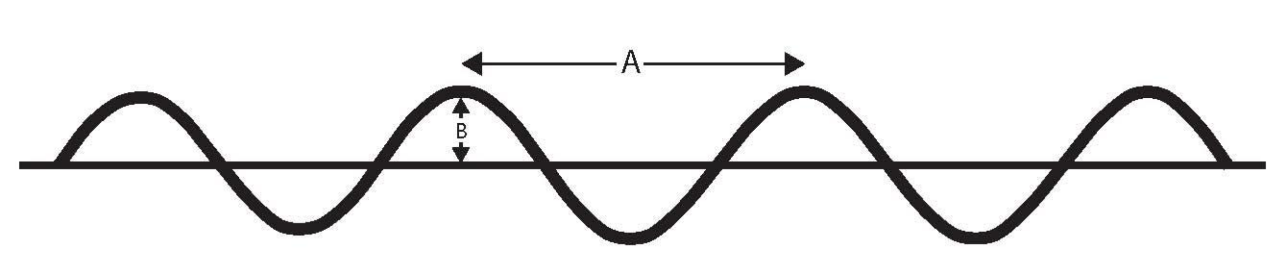
- What are some ways to measure and compare waves?
- How can you calculate the speed of a wave?
- Why does the pitch of an ambulance siren change as the ambulance rushes past you?

Bellringer

In the diagram, A is the distance from a point on one wave to an identical point on the next wave. What might this distance be called?

1. In the diagram, B is the *amplitude* of a wave. What do you think this is a measure of?

2. Twenty waves pass by a point in a certain amount of time. Would this be a measure of a wave's speed or frequency?



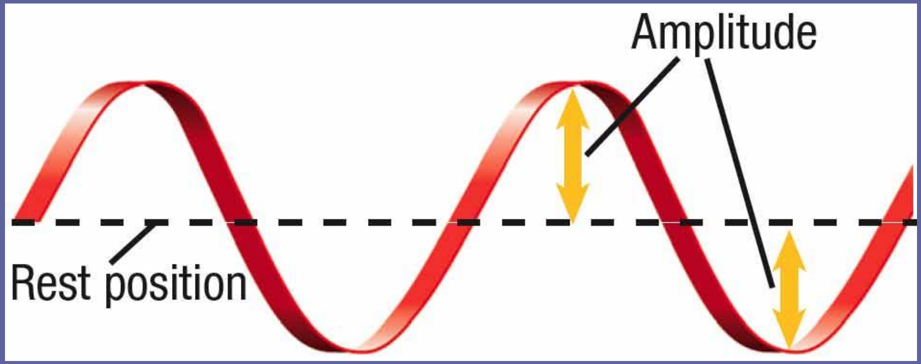
Wave Properties

- What are some ways to measure and compare waves?

- Amplitude and wavelength are measurements of distance. Period and frequency are measurements based on time.

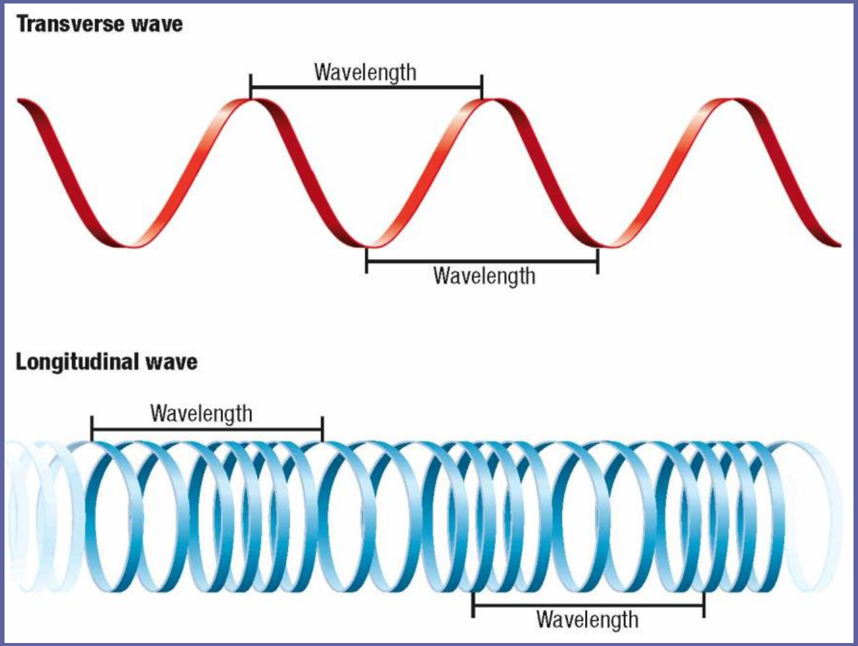
Wave Properties, *continued*

- Amplitude measures the amount of particle vibration.
  - **amplitude:** the maximum distance that the particles of a wave's medium vibrate from their rest position
  - for a transverse wave, measured from the rest position to the crest or the trough
  - expressed in the SI unit meters (m)



Wave Properties, *continued*

- Wavelength is the distance between two equivalent parts of a wave.
  - **wavelength:** the distance from any point on a wave to an identical point on the next wave
  - for a transverse wave, measured from crest to crest or trough to trough
  - represented by the symbol λ
  - expressed in the SI unit meters (m)

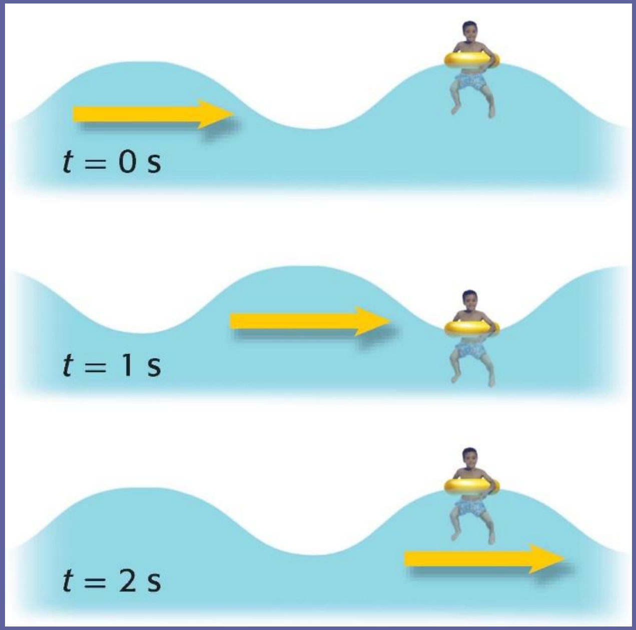


Wave Properties, *continued*

- Amplitude and wavelength tell you about energy.
  - larger amplitude = more energy
  - shorter wavelength = more energy

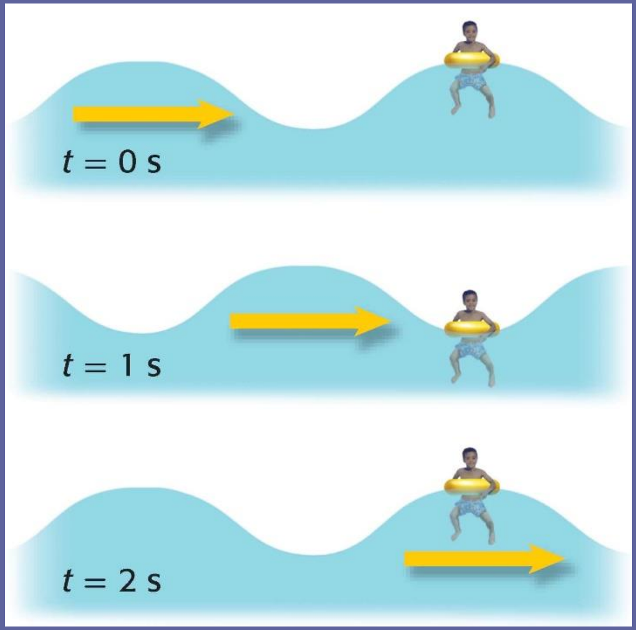
Wave Properties, *continued*

- The period is a measurement of the time it takes for a wave to pass a given point.
  - **period:** in physics, the time that it takes a complete cycle or wave oscillation to occur
  - represented by the symbol T
  - expressed in the SI unit seconds (s)
  - in the diagram, $T = 2$ s



Wave Properties, *continued*

- Frequency is a measurement of the vibration rate.
  - **frequency:** the number of cycles or vibrations per unit of time; also the number of waves produced in a given amount of time
  - represented by the symbol f
  - expressed in the SI unit hertz (Hz), which equals 1/s
  - in the diagram, f = 0.5 Hz



Wave Properties, *continued*

- The frequency and period of a wave are related.
  - The frequency is the inverse of the period.

$$\text{frequency} = \frac{1}{\text{period}}, \text{ or } f = 1/T$$

Wave Speed

- How can you calculate the speed of a wave?

- The speed of a wave is equal to wavelength divided by period, or to frequency multiplied by wavelength.

Wave Speed, *continued*

- Wave speed equals wavelength divided by period.

  speed = distance/time

  wave speed = wavelength/period, or $v=\lambda/T$

- Wave speed equals frequency times wavelength.

$$\text{frequency} = \frac{1}{T}$$

wave speed = frequency × wavelength, or $v = f \times l$

Math Skills

Wave Speed

The string of a piano that produces the note middle C vibrates with a frequency of 262 Hz. If the sound waves produced by this string have a wavelength in air of 1.30 m, what is the speed of the sound waves?

1. List the given and unknown values.

Given: *frequency, f* = 262 Hz

wavelength, λ = 1.30 m

Unknown: *wave speed, v* = ? m/s

Math Skills, *continued*

2. **Write the equation for wave speed.**

$$v = f \times \lambda$$

3. **Insert the known values into the equation, and solve.**

$$v = 262\ \text{Hz} \times 1.30\ \text{m}$$

$$\boxed{v = 341\ \text{m/s}}$$

Wave Speed, *continued*

- The speed of a wave depends on the medium.
  - In general, wave speed is greatest in solids and least in gases.
  - In a given medium, the speed of waves is constant.
- Kinetic theory explains differences in wave speed.
- Light has a finite speed.
  - the speed of light (c) = 3.00×10^8 m/s
  - for electromagnetic waves, $c = f \times \lambda$

The Doppler Effect

- Why does the pitch of an ambulance siren change as the ambulance rushes past you?
- Motion between the source of waves and the observer creates a change in observed frequency.

The Doppler Effect, *continued*

- Pitch is determined by the frequency of sound waves.
  - The *pitch* of a sound (how high or low it is) is determined by the frequency at which sound waves strike the eardrum in your ear.
  - A higher-pitched sound is caused by sound waves of higher frequency.

The Doppler Effect, *continued*

- Frequency changes when the source of waves is moving.
  - **Doppler effect:** an observed change in the frequency of a wave when the source or observer is moving
  - The Doppler effect occurs for many types of waves, including sound waves and light waves.

Section 3: Wave Interactions

Preview

Key Ideas

- How do waves behave when they hit a boundary, when they pass around an edge or opening, and when they pass from one medium to another?
- What happens when two waves are in the same location?
- How are standing waves formed?

Bellringer

1. Why do we see rainbows on rainy days?

2. a. When you throw a ball against a wall, what happens to the ball?

   b. When light waves hit a barrier, what happens to the light waves?

3. When two objects meet, share the same space, and overlap with each other, what is it called?

Reflection, Diffraction, and Refraction

- How do waves behave when they hit a boundary, when they pass around an edge or opening, and when they pass from one medium to another?

- When a wave meets a surface or a boundary, the wave bounces back. When a wave passes the edge of an object or passes through an opening, the wave bends. A wave also bends when it passes from one medium to another at an angle.

Reflection, Diffraction, and Refraction, *continued*

- Reflection occurs when a wave meets a boundary.
  - **reflection:** the bouncing back of a ray of light, sound, or heat when the ray hits a surface that it does not go through
- Examples:
  - The reflection of light waves in a lake can create a mirror image of a landscape.
  - Water waves are reflected when they hit the side of a boat.

Reflection, Diffraction, and Refraction , *continued*

- Diffraction is the bending of waves around an edge.
  - **diffraction:** a change in the direction of a wave when the wave finds an obstacle or an edge, such as an opening
- Examples:
  - Water waves diffract around a block in a tank of water.
  - Sound waves passing through a door diffract.

Reflection, Diffraction, and Refraction , *continued*

- Waves can also bend by refraction.
  - **refraction:** the bending of a wavefront as the wavefront passes between two substances in which the speed of the wave differs
  - All waves are refracted when they pass from one medium to another at an angle.

Interference

- What happens when two waves are in the same location?

- When several waves are in the same location, they combine to produce a single, new wave that is different from the original waves. This interaction is called interference.

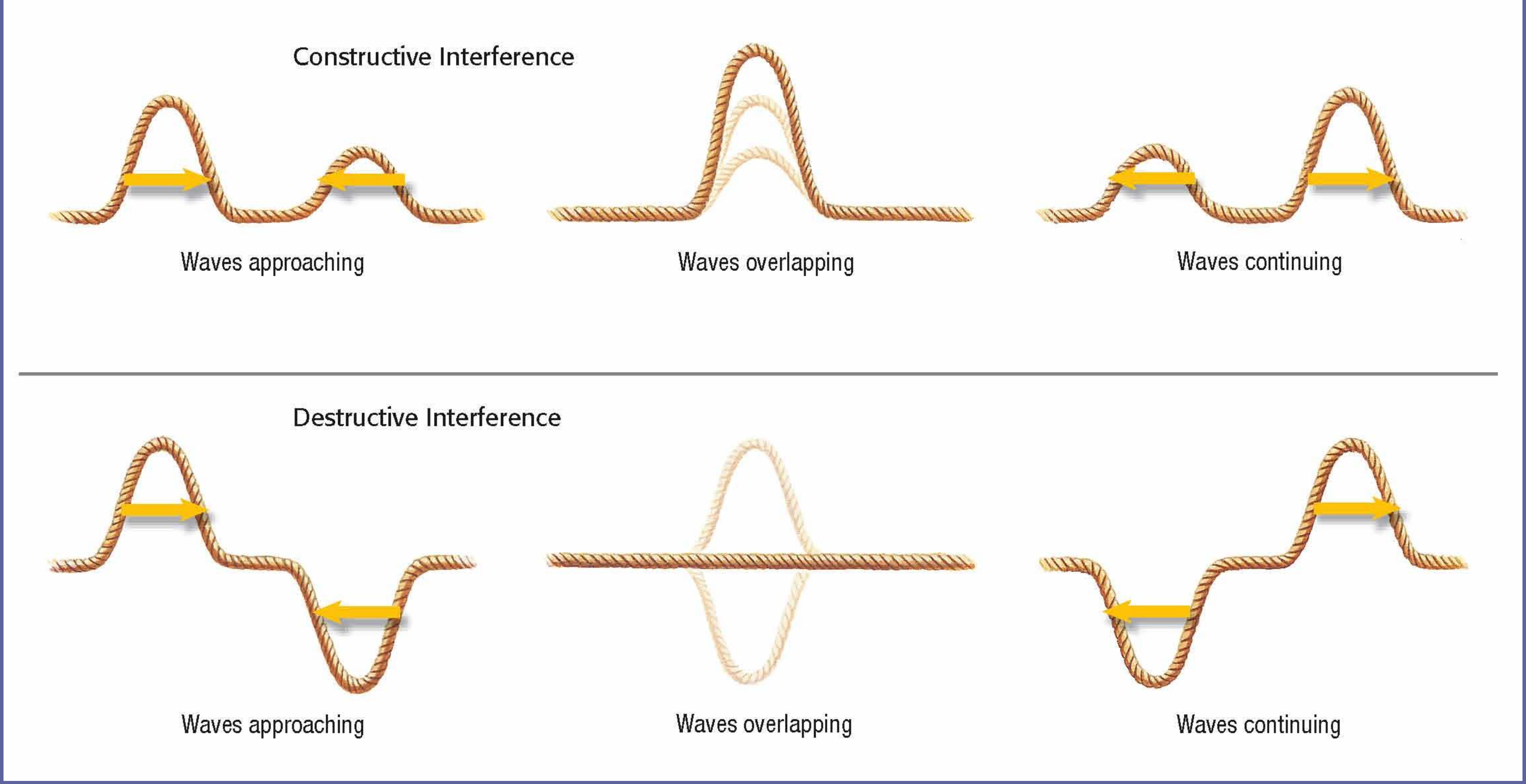
- **interference:** the combination of two or more waves that results in a single wave

Interference, *continued*

- Constructive interference increases amplitude.
  - **constructive interference:** a superposition of two or more waves that produces an intensity equal to the sum of the intensities of the individual waves

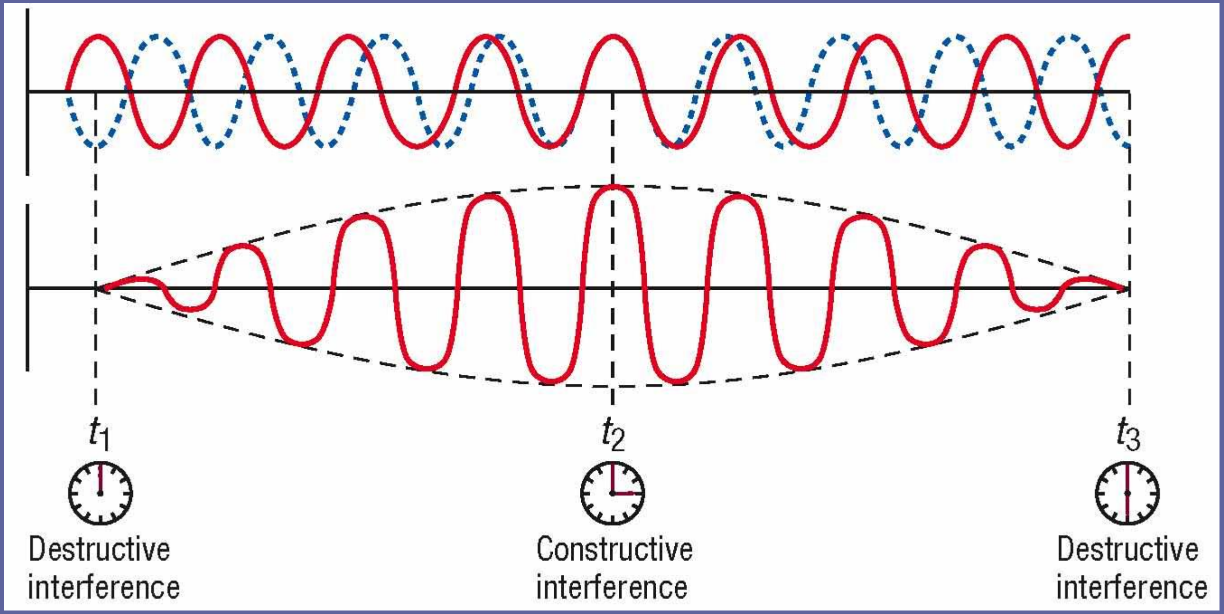
- Destructive interference decreases amplitude.
  - **destructive interference:** a superposition of two or more waves that produce an intensity equal to the difference of the intensities of the individual waves

Interference, *continued*



Interference, *continued*

- Interference of light waves creates colorful displays.
- When two waves of slightly different frequencies interfere with each other, they produce *beats.*



Standing Waves

- How are standing waves formed?

- A standing wave causes the medium to vibrate in a stationary pattern that resembles a loop or a series of loops.

- **standing wave:** a pattern of vibration that simulates a wave that is standing still

Standing Waves, *continued*

- Standing waves have nodes and antinodes.
  - Each loop of a standing wave is separated from the next loop by points that have no vibration, called *nodes.*
  - Midway between the nodes lie points of maximum vibration, called *antinodes.*