SECTION 1 (PP. 489-495): WAVES TRANSFER ENERGY.

Georgia Standards: S8P4a – *Identify the characteristics of electromagnetic and mechanical waves.*

1. **A wave is a disturbance.**
   A **wave** is a disturbance that transfers energy from one place to another. **Mechanical waves** travel through a material, called a medium, transferring energy.

   When a mechanical wave travels through a medium (such as water, ground, or air) the medium moves as the wave passes through it. However, it is not permanently moved. After the wave has passed, the medium returns to its former state.

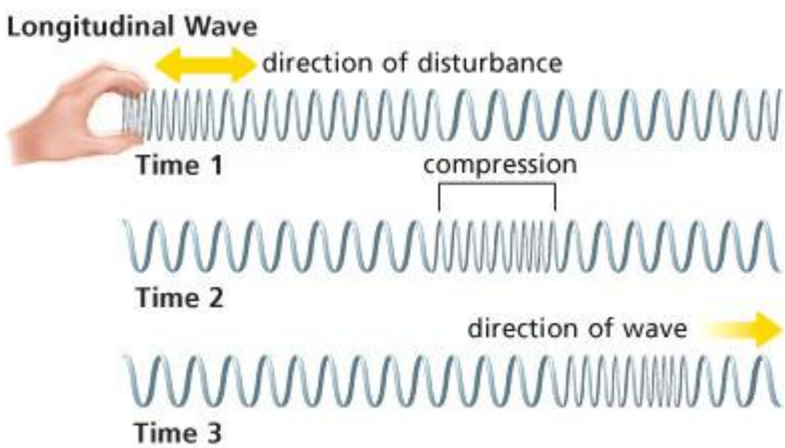
   The waves caused by an earthquake are good examples of energy transfer. The disturbed ground shakes from side to side and up and down as the waves move through it. Such waves can travel kilometers away from their source. The ground does not travel kilometers away from where it began; it is the energy that travels in a wave. In the case of an earthquake, it is kinetic energy, or the energy of motion, that is transferred.

This photograph was taken after a 1995 earthquake in Japan. A seismic wave transferred enough energy through the ground to bend the railroad tracks, leaving them in the shape of a wave.

2. **Waves can be classified by how they move.**
   A **transverse wave** travels in the direction perpendicular to the disturbance that caused it. Think about snapping a rope with your hand. The action of your hand causes a vertical, or up-and-down, disturbance in the rope. However, the wave it sets off is horizontal, or forward. This type of wave is known as a transverse wave. In a **transverse wave,** the direction in which the wave travels is perpendicular, or at right angles, to the direction of the disturbance. *Transverse* means "across" or "crosswise." The wave itself moves crosswise as compared with the vertical motion of the medium.

Water waves are also transverse. The up-and-down motion of the water is the disturbance. The wave travels in a direction that is perpendicular to the direction of the disturbance. The medium is the water, and energy is transferred outward in all directions from the source.

Longitudinal waves travels in the same direction as the disturbance. A longitudinal wave can be started in a spring by moving it forward and backward. The coils of the spring move forward and bunch up and then move backward and spread out. This forward and backward motion is the disturbance. Longitudinal waves are sometimes called ***compressional waves*** because the bunched-up area is known as a compression. How is a longitudinal wave similar to a transverse wave? How is it different?



Sound waves are examples of longitudinal waves. Imagine a bell ringing. The clapper inside the bell strikes the side and makes it vibrate, or move back and forth rapidly. The vibrating bell pushes and pulls on nearby air molecules, causing them to move forward and backward. These air molecules, in turn, set more air molecules into motion. A sound wave pushes forward. In sound waves, the vibrations of the air molecules are in the same direction as the movement of the wave.

SECTION 2 (PP. 496-503): WAVES HAVE MEASURABLE PROPERTIES.

Georgia Standards: S8P4f – *Diagram the parts of the wave and explain how the parts are affected by changes in amplitude and pitch;* S8CS3f – *Use ratios and proportions, including constant rates, in appropriate problems.*

1. **Waves have amplitude, wavelength, and frequency.**

   Measuring Wave Properties

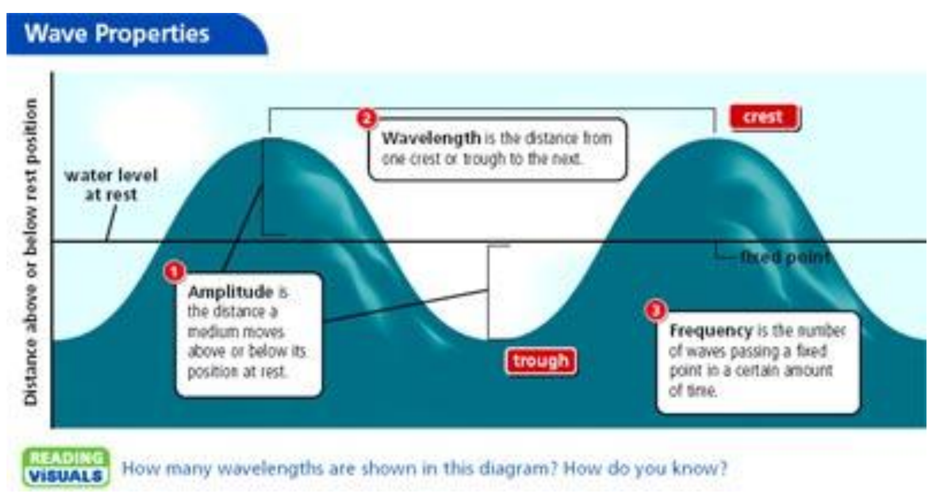
   A **crest** is the highest point, or peak, of a wave. A **trough** is the lowest point, or valley, of a wave. Suppose you are riding on a boat in rough water. When the boat points upward and rises, it is climbing to the crest of a wave. When it points downward and sinks, the boat is falling to the trough of the wave.

1 **Amplitude** for a transverse wave is the distance between a line through the middle of a wave and a crest or trough. In an ocean wave, amplitude measures how far the wave rises above, or dips below, its original position, or rest position.

Amplitude is an important measurement, because it indicates how much energy a wave is carrying. The bigger the amplitude, the more energy the wave has. Find amplitude on the diagram below.

2 The distance from one wave crest to the very next crest is called the **wavelength.** Wavelength can also be measured from trough to trough. Find wavelength on the diagram below.

3 The number of waves passing a fixed point in a certain amount of time is called the **frequency.** The word *frequent* means "often," so frequency measures how often a wave occurs. Frequency is often measured by counting the number of crests or troughs that pass by a given point in one second. Find frequency on the diagram below.



2. **Wave speed can be measured.**
One way to find the speed of a wave is to time how long it takes for a wave to get from one point to another. Another way to find the speed of a wave is to calculate it. The speed of any wave can be determined when both the frequency and the wavelength are known, using the following formula:

$$\text{Speed} = \text{wavelength} \cdot \text{frequency}$$
$$S = \lambda f$$

Different types of waves travel at very different speeds. For example, light waves travel through air almost a million times faster than sound waves travel through air. You have experienced the difference in wave speeds if you have ever seen lightning and heard the thunder that comes with it in a thunderstorm. When lightning strikes far away, you see the light seconds before you hear the clap of its thunder. The light waves reach you while the sound waves are still on their way.

Calculating Wave Speed

Sample Problem

An ocean wave has a wavelength of 16 meters and a frequency of 0.31 waves per second. What is the speed of the wave?

What do you know? wavelength = 16 m, frequency = $0.31 \frac{\text{(wave)}}{\text{s}}$

What do you want to find out? Speed

Write the formula: $S = \lambda f$

Substitute into the formula: $S = 16 \frac{\text{m}}{\text{(wave)}} \cdot 0.31 \frac{\text{(wave)}}{\text{s}}$

Calculate and simplify: $16 \frac{\text{m}}{\cancel{\text{(wave)}}} \cdot 0.31 \frac{\cancel{\text{(wave)}}}{\text{s}} = 5 \frac{\text{m}}{\text{s}}$

Check that your units agree: Unit is m/s. Unit for speed is m/s. Units agree.

Answer: $S = 5$ m/s

Click to enlarge

Practice the Math

1. In a stormy sea, 2 waves pass a fixed point every second, and the waves are 10 m apart. What is the speed of the waves?
2. In a ripple tank, the wavelength is 0.1 cm, and 10 waves occur each second. What is the speed of the waves (in cm/s)?

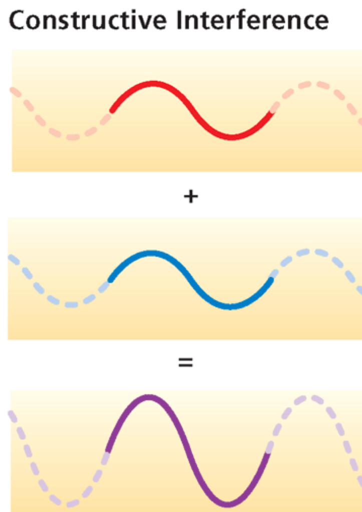
SECTION 3 (PP. 504-509): WAVES BEHAVE IN PREDICTABLE WAYS.

Georgia Standards: S8P84b – ***Describe how the behavior of light waves is manipulated causing reflection, refraction, diffraction, and absorption;*** **S8P4d –** ***Describe how the behavior of waves is affected by a medium (such as air, water, and solids).***

1. **Waves interact with materials.**
   Waves behave predictably when they interact with barriers or other obstacles. Waves can undergo reflection, refraction, or diffraction.
   - In **reflection**, waves meet a solid barrier and bounce back. For example, an echo occurs when a sound wave meets a wall and bounces back to the source of the sound.
   - In **refraction**, waves move from one medium to another and bend, or refract. An example is a glass of water with a straw. Where the straw passes into the water, it looks broken. However, the break is an illusion caused by refraction of light waves as they pass from air to water.

- In **diffraction**, waves interact with a partial barrier and a portion of the waves pass through and spread out. An example is the way sound waves spread around corners.

2. **Waves interact with other waves.**
   In **constructive interference**, two waves combine in phase, so that a crest meets a crest or a trough meets a trough.



In **destructive interference**, two waves of the same frequency meet up such that the trough of one wave joins with the crests of the other. If the amplitudes of the two original waves are equal, the two waves cancel each other out.