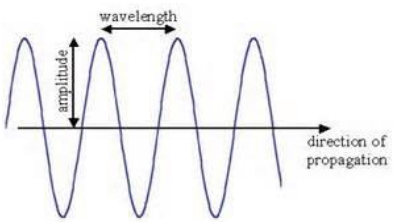
The Wave Exercise

Teacher Lesson Plan

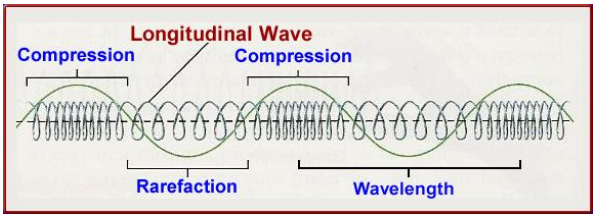
Background Information

This exercise is designed to create a kinesthetic learning activity for students to understand wave theory. In it, the students model waves.

- A wave is the transfer of energy through space or matter.
- Light waves travel as transverse waves in empty space in a straight line. Light travels at a speed of 186,000 miles per second. Compared to sound, light travels extremely fast. It takes less than 8 ½ minutes for light from the sun to reach the Earth which is 93,000,000 miles away.
- Sound waves need a medium in which to move by transferring the energy from one particle of matter to the next. The medium in which the wave is traveling does not move but the energy does.
- The speed of sound depends on the type of medium in which the energy is traveling. Sound travels fastest in solids, slower in liquids and slowest in gases. The temperature of the medium also effects the speed of the sound waves with the energy transferred fastest in high temperatures and slower at lower temperatures.
- Waves are characterized by their wavelength, frequency and amplitude.
    - Wavelength is the distance between two corresponding points between neighboring waves. This is typically crest to crest or trough to trough. Wavelength determines the type of light based on the electromagnetic spectrum.
    - Frequency is the number of waves passing a given point every second. Frequency and wavelength determine the pitch in sound. Different frequencies in visible light waves produce different colors.
    - Amplitude refers to the height of a wave. In light, it refers to the intensity or brightness. In sound, it refers to the volume or loudness.
- There are two types of waves.
    - In transverse waves, the displacement of the particles is perpendicular to the direction of the propagation of the wave. A ripple on a pond and shaking a rope are examples of transverse waves. Light waves are transverse waves.



- In longitudinal waves the displacement of the medium is parallel to the propagation of the wave. These are also called compression waves. A wave in a "slinky" is a good visualization. Sound waves are longitudinal waves.



Content Standards

- Physical Science
  - Light and sound are forms of energy that behave in predictable ways.

Student Activities

LESSON 1: The Wave Exercise

Lesson Materials: None. Depending on the number of students and the size of your room, you may want to do two separate lines facing each other.

Activity #1 Human Wave Procedure:

- Together we will do "The Wave" like you have seen people do in stadiums.
- Line up shoulder to shoulder. Placing toes on a line on the floor is helpful.
- You move ONLY after the person to your next to you moves.
- Keep your feet in the SAME PLACE. Students are the particles in the medium. Students don't travel but the energy moves through them.
- The teacher should start the "The Wave". Every wave needs an energy source. The teacher is the source.

Student Discussion Questions:

- What is the definition of a wave? *A wave is the transfer of energy from one place to another. The students stay in place but the energy moves down the line.*
- Where did the energy come from? T*he teacher generated the energy to start the wave. Energy cannot be created or destroyed but can be transferred.*

Activity #2 Amplitude Procedure:

- Next, we will repeat our wave but just move our hands a few inches up and down. This represents a whisper.
- Repeat, but only move our arms up and down. This represents talking.
- Repeat, but move your whole body up and down. This represents shouting.

Student Discussion Questions:

- What is changing in the wave? *The wave height is changing.*
- What is the name of this wave characteristic? *Wave amplitude. It is measured from the centerline of the wave to the highest or lowest point.*
- In light and sound waves, what characteristic does amplitude represent? *Light-brightness; Sound-loudness or softness*.

Activity #3 Transverse Wave Definitions Procedure

- Have the line of students hook elbows.
- Remind them that the energy moves down the wave but the particles remain in the same place. They can move up and down like a fishing bobber in a pond.
- The teacher is the source of energy. The teacher should hook elbows at the end of the line of students. The teacher should take one large step forward, return to the starting spot and take one large step backward and return to original position. Allow the wave to travel through the line.
- Repeat the above action 2 times in row. This represents frequency.
- Repeat again but tell the students during this action, you will say, "FREEZE". They need to stop right where they are. Point out the crest, trough and wavelength of the human wave.

Student Discussion Questions:

- What kind of wave is occurring? *It represents a transverse wave.* Explain why? *The particles are moving perpendicular to the direction that the wave is moving.*
- Define the parts of the wave. Crest is the highest part of the wave. The trough is the lowest part of the wave. The wavelength is the distance between successive crests of a wave.
- What is frequency? *Frequency (Hertz) equals the number of waves that passes a given point per second.*

Activity #4 Transverse and Longitudinal Waves using a Slinky Procedure

- Chose a student to hold the end of the slinky. Send a transverse wave down the slinky by moving your hand perpendicular to the student at the end.
- Move your hand up and down keeping the slinky on the floor at a faster rate. What are you changing in this wave? *You are changing the frequency*.
- Ask another student to hold one end of the slinky on the floor in front of the line of students.
- Grab a handful of coils of the slinky or push the slinky toward the student holding it.
- This demonstrates a longitudinal or compression wave. Sound waves travel as longitudinal waves.

Student Discussion Questions:

- What are the areas of the wave called where the coils are close together? *Compressions*
- What are the areas of the wave called where the coils are far apart? *Rarefactions*
- How can I change the frequency of a longitudinal wave? *Send the pulses (energy input) faster into the slinky.*
- What is the relationship between the energy input and the way the energy in a transverse wave travels? *The energy input is perpendicular to the direction of the wave.*

Activity #5 Longitudinal Waves Procedure:

- Waves also move parallel to the direction of the energy. These are called LONGITUDINAL waves. Sound waves are longitudinal waves.
- Line up shoulder to shoulder. Remind the students to not move their feet and remind them that the energy is transferred in the wave not the particles (students). The teacher should start and one end and give a gentle push to the line of students. (Option: the students can hold hands and pass a squeeze down the line.)
- REMINDER: Energy can not be created or destroyed. There should not be more energy at the end of the line than at the beginning.

Activity #6 Wave Speed Procedure:

- Adjust your line so that the students are arm's length apart. The teacher should generate a longitudinal wave by gently pushing on a student's shoulder. Describe the speed of the wave with a large space between the students. Using a stopwatch, time the wave from start to finish.
- Adjust your line so that the students are elbow's distance apart. The teacher should generate a longitudinal wave. Describe the speed of the wave with this space between the students. Using a stopwatch, time the wave from start to finish.
- Adjust your line so that the students' shoulders are touching. The teacher should generate a longitudinal wave. Describe the speed of the wave in this demonstration. Using a stopwatch, time the wave from start to finish.

Student Discussion Questions:

- Waves move at different speeds through different kinds of matter. Matter that is solid has particles packed tightly together so the energy moves fastest through the solids. In a gas, the particles are farther apart from each other so it would take longer to pass the energy. Liquids represent the middle speed.
- Compare the times of the three waves. *The wave where the student's shoulders were touching was the fastest time.*
- Explain what this activity demonstrates. *Waves travel fastest in a solid. This was represented by the trial where the student's shoulders were touching. They travel slowest in a gas represented where the student's shoulders*
- You are scuba diving and hear the song of a humpback whale. Who would hear it first, the captain of your dive boat or you in the water? *The scuba diver would hear it before the boat captain.* Why? *Sound waves travel faster in liquids than they do in a gas.*

Activity #7 Wave Reflection Procedure:

- Students MUST keep their feet in the same place. Stand shoulder to shoulder with the last student in line standing next to a wall. The teacher should pass a longitudinal wave down the line. The student at the end of the line should bump the wall, then pass the impulse back to the person next to him. It should travel until it gets back to the teacher. This demonstrates a wave reflection.

Student Discussion Questions:

- What is a sound reflection called? *Echo*