6TH GRADE
STUDYING HEAT, LIGHT, AND SOUND ENERGY WAVES

Summary: Students create transverse and longitudinal waves by using a slinky, spring, and rope. They explore the frequency, wavelength, and amplitude of the waves they make. Sound waves are studied by using tuning forks to explore how pitch and frequency are related.

Intended Learning Outcomes for 6th Grade:
1a. Observe simple objects, patterns, and events, and report their observations.
1b. Sort and sequence data according to criteria given.
1d. Compare things, processes, and events.
1i. Use data to construct a reasonable conclusion.
3a. Know and explain science information specified for the grade level.
4a. Record data accurately when given the appropriate form.
4b. Describe or explain observations carefully and report with pictures, sentences, and models.
4c. Use scientific language in oral and written communication.

Utah State Core Curriculum Tie:
Standard VI Objective 3:
a. Describe how sound is made from vibration and moves in all directions from the source in waves.
b. Explain the relationship of the size and shape of a vibrating object to the pitch of the sound produced.
c. Relate the volume of a sound to the amount of energy used to create the vibration of the object producing the sound.

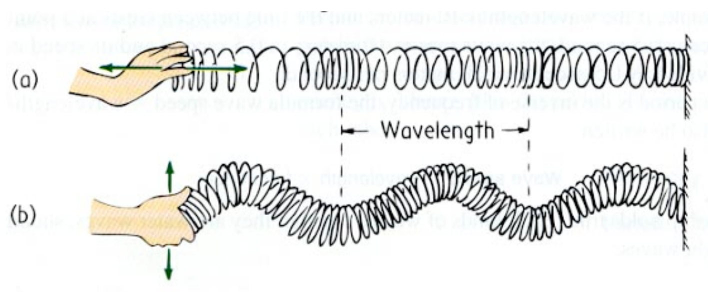
Preparation time: 20 min
Lesson time: 60 min
Small group size: works best in small groups with one adult for every 5 students

Materials: Fewer materials are needed if the lab is performed as stations.
1. slinky, extra long, hometrainingtools.com, item# MC-Slinky2, $5.95
2. snakey spring, pasco.com, item# SE-7331, $18.00
3. flexible rope, about 1" in width and 12' long, can be found at hardware stores, tie a knot in the end so that it doesn't become unwound
4. tuning forks in various sizes, enasco.com, product # SB48580M, $16.95
5. beaker or tall glass
6. assortment of small, different size boxes (approximately 3" to 6" in length)
7. assortment of available musical instruments: recorder, glockenspiel bars, guitar, or glasses filled with different amounts of water

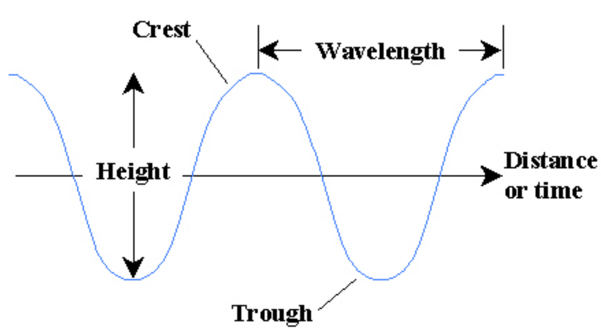
Background information:

Heat, light, and sound energy travel in a wave pattern. A **wave** is a disturbance that travels from one place to another. For heat, the wave disturbance is created by a difference in temperature that causes a heat wave to transfer from a higher temperature object to a lower temperature object. For light, electrons moving from higher energy to lower energy create the wave of electrical and magnetic fields. For sound, a vibration of particles causes the wave disturbance.

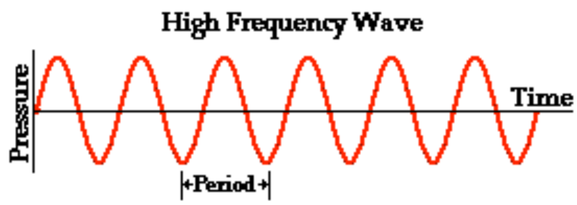
Energy waves can be either longitudinal waves or transverse waves. **Longitudinal waves** occur when the disturbance is in the same direction as the motion of the wave, or along the length. Sound waves travel in longitudinal waves. See example (a) below. **Transverse waves** occur when the disturbance is at a right angle to the direction the wave is moving or it is seen as an up and down movement. Heat and light travel in transverse waves. See example (b) below.

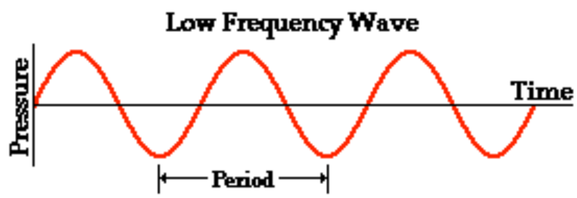


A transverse wave has a predictable shape and terminology associated with it. The **crest** of the wave is the highest point of the wave above the middle position. The **trough** is the lowest point of the wave below the middle position. The **amplitude** is the **height** of the wave above the middle position. The **wavelength** is the distance between one crest of a wave and the next or this is also called one wave cycle.

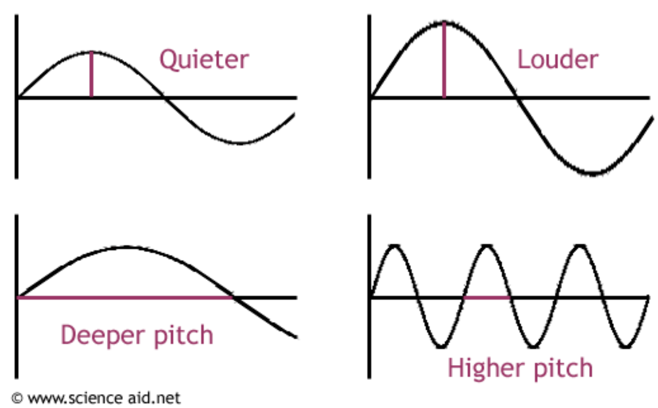


Waves also have a frequency. **Frequency** is how often a wave goes by a given point. A high frequency wave has many wavelengths down its length. A low frequency wave has fewer wavelengths down its length. A high frequency wave also has higher energy than a low frequency wave.





Pitch and frequency are related. High musical notes are **high pitch** sounds caused by a high frequency wave. Low or deep musical notes are **low pitch** sounds caused by a low frequency wave. Amplitude is related to how loud we hear a sound. A **high amplitude** sound wave seems loud and a **low amplitude** sound wave seems soft.



Vibrations carry sound through a longitudinal wave. When someone yells to you, they disturb or vibrate the particles near their mouth and then those particles vibrate the next particles and so on until the vibrations reach your ear. When the disturbed particles reach your ear they then vibrate the small bones in your ear and those bones tell your brain that a sound was made. When the wave stops there is no more sound. Sound waves can only move through a medium. There must be particles present in the air to carry the vibrations. That is why there is no sound in a vacuum or in space. Heat and light do not need particles to propel the wave so there is light and heat in space.

Pre-lab discussion:

Ask the students if they have ever done the 'wave' at a stadium. Have them do a wave now through the classroom. Did the wave move? Did they move? Explain that a wave is energy and it can move throughout the room but the particles (the students) that created the wave do not. Using the slinky have two students hold the ends and demonstrate a wave moving down the slinky. Explain to them the same principle. Wave energy moves from one end of the slinky to the other but the slinky tines do not. Are there more waves they can think of? Does this always work? It should.

Draw the diagram of a wave cycle on the board. Be sure and label: crest, trough, amplitude, and distance. Explain all the parts as well as the term frequency and demonstrate this to the students using a slinky.

Discuss how we hear sound vibrations. Using any musical instrument available to you (a glockenspiel is great), play a high pitch note and a low pitch note. Show them what causes the higher and lower pitch on the instrument. For example: string width on a string instrument, bar length on a glockenspiel, hole width on a wind instrument, glasses filled with different amounts of water, etc. Explain that high frequency sound waves cause high pitch notes and low frequency sound waves cause low pitch notes. Show them a tuning fork and explain how it will be used to study sound.

Instructional Procedure:

ACTIVITY 1: SPRING, ROPE, AND SLINKY WAVE MAKERS Have students hold the ends of each wave maker tightly as they lay the spring, rope, or slinky on the floor during each experiment.

1. Stretch the spring but do not overstretch it. With the spring lying on the floor, shake it once from right to left to send a wave or pulse down the spring. This is a transverse wave. What happens when the wave reaches the end of the spring being held by the other student? Does it reflect back? Reflection of a wave occurs when a wave hitting a solid object is bounced back to its origin. Record this on the student sheet.

2. Have one student send waves down the spring. First, try only one wave cycle in the spring, then two, and see how many can fit down the length of the spring at a time. Have students identify the crest, trough, amplitude, and wavelength of their wave. Have a student estimate the maximum number of wave cycles that can be achieved in the spring. Remember a wave cycle occurs from one crest to the next crest of the wave. Record this on the student sheet.

3. When sending high frequency waves, have a student estimate, in cm, the shortest wavelength that can be created with the spring. Have a ruler nearby to help students estimate the wavelength. Record this on the student sheet.
4. Ask the students to send the following types of waves:
High frequency, low amplitude
Low frequency, low amplitude
High frequency, high amplitude
Low frequency, high amplitude
Short wavelength. What is the frequency?
Long wavelength. What is the frequency?

5. Does frequency affect how many wavelengths you fit on the spring? Yes, a high frequency causes a short wavelength. Does frequency affect the amplitude of the wave? No, you can send high frequency low or high amplitude waves. Does it take more energy to increase frequency? Yes, ask students how tired their arms are when they send a high frequency wave.

6. Perform the activity on all three of the wave makers.

7. For the slinky, have students send a longitudinal wave as well. This can be achieved by having the student holding one end of the slinky push the slinky towards the student holding the other end. Does this longitudinal wave reflect back? Yes, for a slinky longitudinal waves bounce back as well. This is similar to a sound wave bouncing off a wall.

ACTIVITY 2: Tuning forks

1. Students should gently hit the tines of a tuning fork against the edge of a table or desk and hold it to their ear. Have them describe what they hear and explain why they are hearing it. Most tuning forks vibrate between 128 Hz (large tuning fork) and 1280 Hz (small tuning fork) or vibrations per second.

2. Students should compare a small hit (disturbance) of the tines vs. a larger disturbance of the tines. Be careful students do not break the tines. Less force produces less sound and more force produces more sound.

3. Strike the tuning fork tines and then dip the tip of the tines into a beaker of water. See the vibration ripples or waves in the water that occur in all directions from the tines. These waves are occurring in the air as well they just can't be seen. Do these waves travel faster in air or water? Sound travels faster in liquid than air. This occurs because molecules are closer together in a liquid and bump into each other more quickly. This propels the vibration faster because there is less distance between the molecules. What do you think this means about the speed of sound waves in a solid? It's even faster!

4. Try the different size tuning forks by hitting the tines and holding them to their ears. Which size tuning forks make lower pitch sounds and which size tuning forks make higher pitch sounds? Larger tuning forks cause lower frequency waves and this produces a lower pitch sound. Smaller tuning forks cause higher frequency waves and this produces a higher pitch sound.

5. Place the tuning fork base on top of a box after the tines have been struck. Describe what happens to the amplitude of the sound from the tuning fork. When you place the tuning fork on a box; the box and the air in the box start vibrating at the same frequency as the tuning fork and this amplifies the sound. The more molecules vibrating at the same frequency, the louder the sound heard. Since the box, air inside the box, and tuning fork are all vibrating at the same frequency the sound is louder.

6. Try and place the tuning fork on different size boxes and hear different amplitudes of sound. Which box creates the loudest sound? The larger the box (think of a stereo speaker) the louder the sound created.