Transverse and Longitudinal Waves

Demonstration

This demonstration uses a slinky and tuning fork to explain two types of waveforms in our world: transverse and longitudinal. A discussion on sound waves is included and leads to categorizing sound waves as longitudinal waves.

Figure 1. Image of demonstration materials

Number of Participants: 5-10
Audience: All ages
Duration: 10-20 Minutes
Difficulty: Level 1
Materials Required:

- Long slinky – Longer the better
- Tuning fork
- Bowl/cup
- Water

Note: All materials are located in the 2020-21 SOCK.

Setup 1 – Longitudinal and Transverse Waves:

1. Begin by taking the long slinky to an open area, preferably a solid and flat floor with room to extend the slinky. Tables can be used but it will be hard for younger children to observe.
2. Place the long slinky on the desired surface and extend the slinky with two people on each end of the slinky. You want the slinky to be stretched, with space between the rings, but too much so that the slinky is not damaged as they can be permanently deformed.
    - Presenter(s) can decide whether the two people on each end of the slinky are presenters or participants.
3. Choose a person on one side of the slinky to push the slinky forward in a single pulse parallel to the direction of elongation (in and out), rapidly. Verify the waves in the slinky from the straight pulse are similar to figure 2a and 2b.
4. Choose a person on one side of the slinky to push the slinky perpendicular to the direction of elongation (side to side) in a pulse, rapidly. Verify the waves in the slinky from the sideways pulse are similar to figure 3a and 3b.

Setup 2 – Sound Waves Are Longitudinal Waves:

1. Fill a bowl with water and place on a flat surface as seen in figure 5.
2. Strike the tuning fork to produce a sound and vibrations.
3. Ask students to identify which part of the tuning fork makes sound. Have student touch the tuning fork to confirm where there are vibrations.

4. To visualize the tuning fork vibrations, partly submerge the vibrating tuning fork in the water bowl until visible vibrations or ripples form on the water's surface as seen in figure 6. Note: Depending on the tuning fork, water can splash more than a meter away.
5. Repeat steps 2-3 until all participants observe the ripples or vibrations in the water.

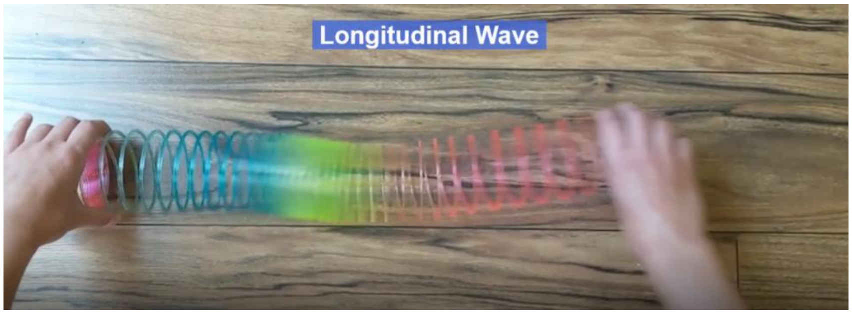

Figure 2a. Image of slinky demonstrating a longitudinal wave

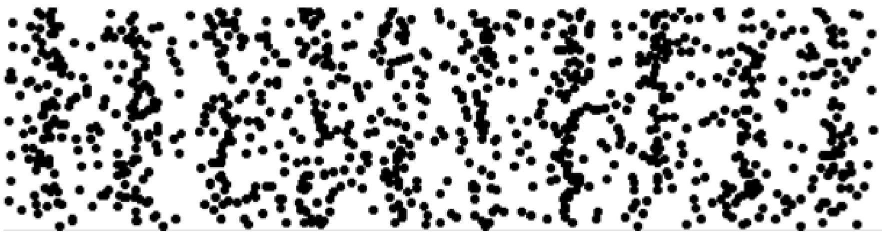

Figure 2b. Diagram of longitudinal waves by Dan Russel from Penn State

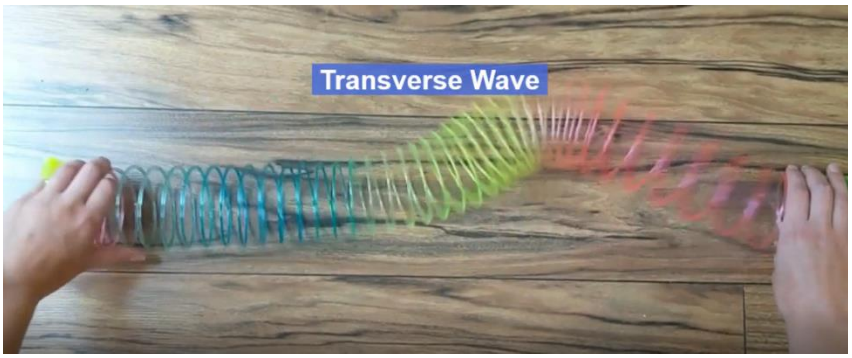

Figure 3a. Image of slinky demonstrating a transverse wave

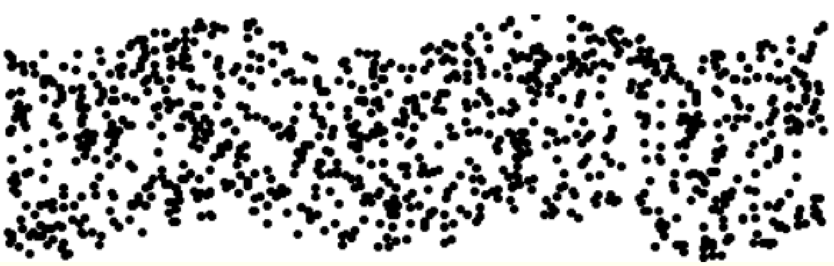

Figure 3b. Diagram of transverse waves by Dan Russel from Penn State

Figure 4-5. Images of demonstration Setup 2

Presenter Brief:

Be familiar with transverse and longitudinal waves. Be able to explain the motion of both transverse and longitudinal waves with the long slinky. Be familiar with sound waves and understand why sound waves are categorized as longitudinal waves. Look over the "Introduction to Sound" diagrams for each age group and be ready to reference the diagram during the physics explanation. Understand how tuning forks make sound.

Vocabulary:

Wave – a disturbance or change in physical quantity that transports energy or information from one point to the next.
Transverse Wave – a type of wave in which the vibrations travel perpendicular to the direction of propagation of the wave.
Longitudinal Wave – a type of wave in which the vibrations travel in the same direction or parallel to the direction of propagation of the wave.
Sound waves – longitudinal waves that travel through solids, liquids, and gases.

Physics and Explanation:

Elementary:

As the slinky is set on the ground, begin by asking for examples of a wave. There are many. After several are given, ask students to identify how we can make waves on a slinky. Wait until both types are given. Then begin to define longitudinal and transverse waves with the following discussion.

There are two common types of waves that exist in our world: longitudinal and transverse waves. Both types of waves can be demonstrated using a slinky. Longitudinal waves travel back and forth in a straight line, in the same direction it is stretched. Figure 2b shows the motion of a longitudinal wave as the dots or particles move from left to right without any up or down motion. A slinky will demonstrate the motion of a longitudinal wave by quickly jerking one end of an extended slinky in a forward motion (figure 2a). Relate this to sound waves and tuning fork arms moving back and forth.

Transverse waves travel in an up and down or side to side motion, which is NOT in the same direction it is stretched. Relate this to ocean waves. The motion of a transverse wave can be seen in figure 3b, and the slinky demonstration of a transverse wave is seen in figure 3a as the slinky is pulsed sideways. Common examples of transverse waves are ripples on the surface of water or a wiggling string.

- Longitudinal and transverse waves are two common types of waves in our world.
- Longitudinal waves move in a straight line, in the same direction as the stretch, and transverse waves move in a side to side motion, NOT in the same direction that the wave moves.

Once setup 1 and the first discussion are completed, move on to setup 2 and start the following discussion.

A common example of longitudinal waves is sound waves, which are pressure waves or vibrations that travel through materials, like air. Longitudinal waves can also travel through solid material, like water or even stone. Some of the waves from an earthquake are longitudinal. We can make longitudinal waves by making things vibrate very quickly. Tuning forks produce a single note, or a specific sound, when struck by making the arms move in and out very rapidly (hundreds or thousands of times a second). The tuning fork arms push air, making small longitudinal waves we can observe as a quiet sound. In the second part of the demonstration, a tuning fork is played while being placed in a bowl of water. The surface of the water then starts to vibrate from the sound, letting us see where the vibrations are coming from, turning the tuning fork longitudinal waves into transverse waves in the water.

Middle School and General Public:

As the slinky is set on the ground, begin by asking for examples of a wave. There are many. After several are given, ask students to identify how we can make waves on a slinky. Wait until both types are given. Then begin to define longitudinal and transverse waves with the following discussion.

There are two common types of waves that exist in our world: longitudinal and transverse waves. Both types of waves can be demonstrated using a slinky. Waves are disturbances of particles that can travel through different medium. Some waves have the particles oscillate in the same direction as the direction of wave propagation. These waves, called longitudinal waves, travel back and forth in a straight line without any side to side motion. In other words, the motion of the particles making up the wave is parallel to the direction the wave moves. A slinky will demonstrate the motion of a longitudinal wave by pushing one end of an extended slinky in a forward motion (figure 2a). Figure 2b also exhibits the motion of a longitudinal wave as the dots or particles move from left to right.

Transverse waves travel in a side to side motion so that the wave travels perpendicular to its velocity. The motion of a transverse wave can be seen in figure 3b, and the slinky demonstration of a transverse wave is seen in figure 3a as the slinky is pulsed sideways. Common examples of transverse waves are ripples on the surface of water or light waves.

- Longitudinal and transverse waves are two common types of waves in our world.
- Longitudinal waves move in a straight line, in the same direction as the stretch, and transverse waves move in a side to side motion, NOT in the same direction that the wave moves.

Once setup 1 and the first discussion are completed, move on to setup 2 and start the following discussion.

A common example of longitudinal waves is sound waves, which are pressure waves or vibrations that travel through air or other materials, like water. Tuning forks produce a single note, or a specific sound, when struck by making the arms move in and out <u>very</u> rapidly (hundreds or thousands of times a second). The tuning fork arms push air, making small longitudinal waves we can observe as a quiet sound. In the second part of the demonstration, a tuning fork is played while being placed in a bowl of water. The surface of the water then starts to vibrate from the sound, letting us see where the vibrations are coming from, turning the tuning fork longitudinal waves into transverse waves in the water.

References:

1. Rossing, Thomas D., et al. The Science of Sound. Pearson Education, 2014.

Additional Resources:

- “Introduction to Sound (K-7)” diagram
- “Introduction to Sounds (8-12) diagram
- “How Do We ‘See’ Sound?” diagram
- http://hyperphysics.phy-astr.gsu.edu/hbase/Waves/funhar.html#:~:text=A%20harmonic%20is%20defined%20as,all%20harmonics%20of%20the%20fundamental