GSC International
Phone: 417.374.7431
Fax: 417.374.7442
Toll Free: 888.756.4592
service@gosciencecrazy.com
2076 James River Court
Nixa, Missouri 65714

Simple Wave Demonstrations with Springs #SNAKY01, #SLINKY2, #SLINKYKT

Warning:

- **Not a toy; use only in a laboratory or educational setting.**
- **California Proposition 65 Warning: This product can expose you to chemicals including nickel and lead, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to www.P65Warnings.ca.gov.**

Introduction

Waves are an essential part of physics. They are a major means of energy transfer and can be categorized in two ways: **mechanical waves,** or waves that transmit energy through a medium, and **electromagnetic waves,** or waves that travel via charged particles and can transmit energy through a vacuum. Since their creation by naval engineer Richard James in 1943, slinkys have been popular with science teachers around the world in demonstrating the basics of mechanical waves. Our slinky wave series includes multiple ways to investigate them in a manner that is fun, interactive, and visually clear.

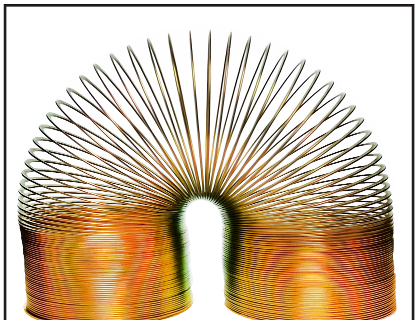
The demonstrations in this sheet can be observed with any of the products below. Experiment with all three mediums to observe how waves travel differently through each. Our wave demonstrations are designed to be used by two students holding opposite ends of either the snaky spring, the helix slinky, or the cotton cord, and then having one student introduce energy to create to medium in order to create and observe waves as they travel through it. The following pages will describe various wave concepts in more detail and lay out the steps for observing those specific concepts:

#SNAKY01 – Snaky Spring

- **Diameter:** 0.79 in. / 20mm
- **Rest Length:** 71 in. / 1800mm
- **Extension:** 16.4 ft. / 5m

#SLINKY2 – Helix Slinky

- **Diameter:** 3 in. / 76mm
- **Rest Length:** 4 in. / 102mm
- **Extension:** 16.4 ft. / 5m



#SLINKYKT – Wave Set

- **Helix Slinky**
- **Snaky Spring**
- **Cotton Cord –** 10 ft.

General Tips for Experimenting

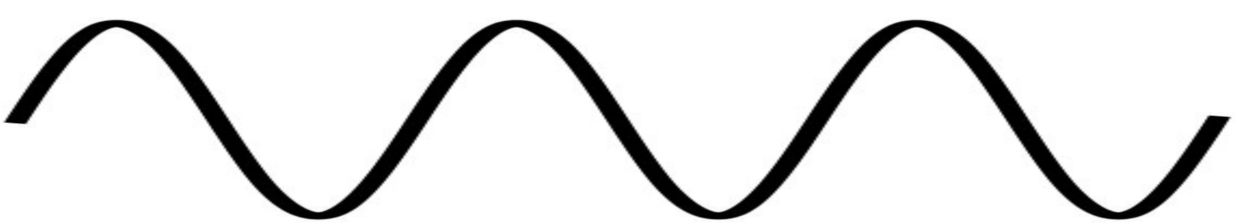
The following tips will help assure that your demonstrations are as clear and useful as possible:

- Demonstrations are best performed in a long hallway without carpet.
- Use the **helix slinky** on a **table** or on the **floor**, and use the **snaky spring** and **cotton cord** on the **floor** or **suspended** mostly-taut between the two standing students.
- Energy to produce transverse waves can be introduced as a **pulse** (single, discreet side-to-side movement) or **continuously** as a series of pulses.
- **Wave frequency** can be increased or decreased by adjusting how fast students move their end of the snaky spring, helix slinky, or cotton cord. In most cases, for clarity in observing the concept, demonstrations call for only one student introducing energy, while the other student holds the other end in a fixed position. However, students will likely want to experiment with moving both ends. This can be done when demonstrating concepts like standing waves but should generally be avoided.
- Make sure both ends of the spring being held are gripped tightly. This is to avoid any **possible injury** resulting from an end of the spring snapping back when released and hitting one of the experimenters.

Mechanical Waves

Mechanical waves are waves that require a medium such as water, air, earth, cords, springs, or another material to move energy. Examples of mechanical waves include sound waves, water waves, and the vibrations in a violin string. All waves created using the snaky spring, helix slinky, or cotton cord are mechanical waves. Follow the instructions below to observe basic mechanical waves:

1. Stretch the snaky spring, helix slinky, or cotton cord across the floor between two students.
2. Instruct one of the students holding the wave demonstration to introduce energy to the system by preforming one pulse (a quick, side-to-side motion) at their end of the demonstration. Make sure the other student holds his or her end in place.
3. Time how long it takes for the wave to travel to one end of the spring and back.
4. Experiment with different variable to see what can be done to make the wave move faster.
   - Does a larger pulse of energy (a more pronounced side-to-side motion) increase the speed that the wave travels through the demonstration?
   - Does stretching the spring more increase or decrease the speed of the wave? Does stretching the spring less increase or decrease the speed of the wave?



General Wave Terms

The following terms are essential to understanding waves and should be understood before trying to grasp the more complicated wave concepts explained later:

- **Equilibrium:** Equilibrium refers to the resting position of a medium without any waves transmitting energy through it. For example, when a spring or cord is stretched along a table between two students, its position before either student pulses energy through it is its equilibrium, or resting, position.

- **Wavelength:** The wavelength of a wave can be thought of as the distance it takes for a wave to repeat its shape.

- **Amplitude:** A wave's amplitude refers to the maximum distance along its wavelength that it displaces particles in its medium from the equilibrium position. The energy of a wave is proportional to its amplitude squared:

$$E \alpha A^2$$

- **Frequency:** Frequency refers to the number of times a wave passes through a single point in a given amount of time. Frequency is measured in Hertz (wave cycle per second).

Transverse and Longitudinal Waves

Mechanical waves can be described by comparing the direction energy is traveling through the medium to the direction the particles of the medium are being displaced by the energy traveling through it. In this way, waves can be described as either **transverse** or **longitudinal.**

Transverse waves refer to waves where the oscillations of the wave move perpendicularly to the direction of the energy carried by the wave. Create a transverse wave using the following instructions:
1. Stretch the snaky spring, helix slinky, or cotton cord across the floor (or table) between two students.
2. Instruct one student holding the wave medium to pulse energy into it by quickly moving their end side-to-side.

Longitudinal waves refer to waves where the oscillations of the wave move in parallel with the direction of the energy carried by the wave. Create a longitudinal wave using the following instructions:
1. Stretch a spring (the cord will not carry a visible longitudinal wave) across the floor (or table) between two students.
2. Instruct one student holding the wave medium to pulse energy into it by bunching up several coils into their hand (compressing the spring near where they are gripping it) and releasing them all at once.

Transverse and longitudinal waves are found everywhere in nature. For example, **sound waves** are longitudinal waves compressing and stretching the air before it reaches your ear. **Ocean waves** are transverse waves moving through the ocean as the tidal forces of the moon tug at the water. Events like earthquakes even produce both longitudinal waves and transverse waves in the forms of P waves and S waves, respectively. Can you think of other examples of transverse or longitudinal waves?

Turn to the next page to see a diagram of both a transverse wave and a longitudinal wave. On these diagrams, you will be able to find **wavelengths, amplitudes**, **crests** and **compressions**, **troughs** and **rarefactions**, and the directions of oscillation and energy transfer for each type of wave.

Diagram of a Transverse Wave

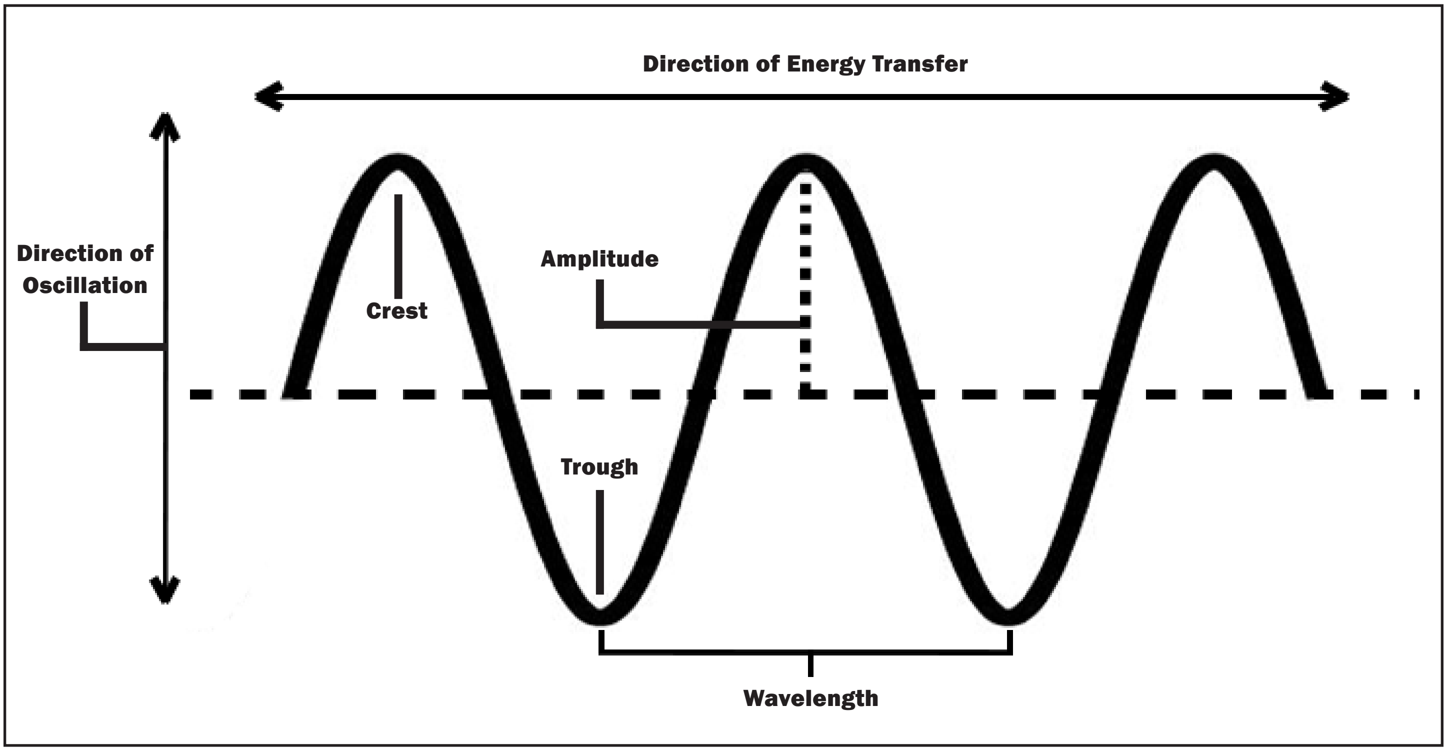
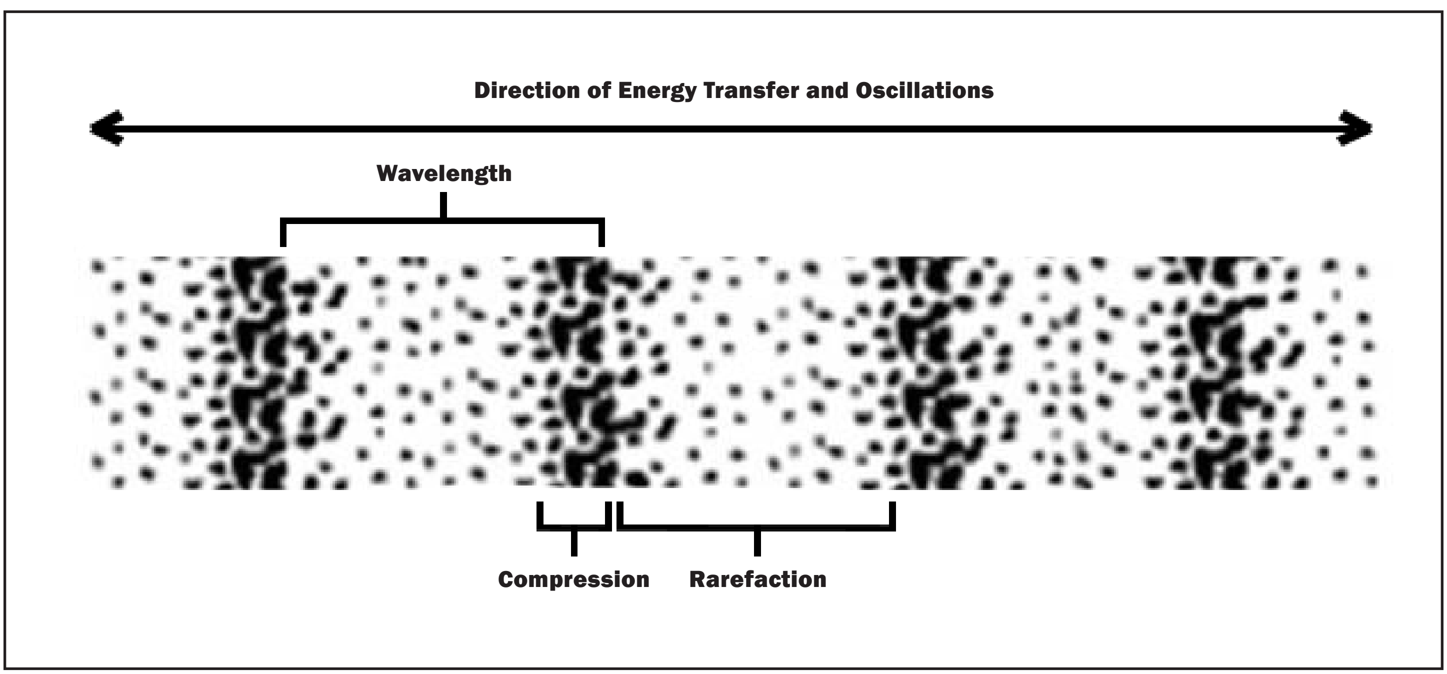


Diagram of a Logitudinal Wave



Interference and Fixed-End Reflected Waves

Interference is the phenomena that occurs when two waves collide in the same medium. Interference can be constructive or destructive. **Constructive interference** occurs when two or more waves displace the medium in the same direction, causing their amplitudes to add together. **Destructive interference** occurs when two or more waves displace the medium in opposite directions, causing their amplitudes to cancel each other out.

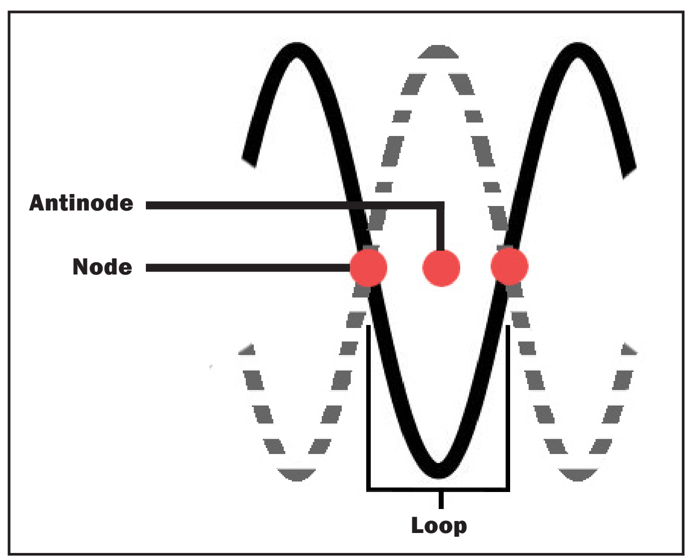
To observe **interference:**
1. Instruct each student holding on to the spring or cord to introduce a pulse of energy to the side they are holding.
2. Observe how the waves each student created interfere with each other when they meet in the middle.
3. Experiment with changing the directions and amplitudes of the waves you have created to see how you can change the interference patterns they create. Can you demonstrate constructive and destructive interference?

When a medium is attached to a fixed point (such as a partner holding one end of your spring in place), a wave produced at one end of the spring will **reflect** back in the opposite direction once it reaches the fixed point that obstructs it from continuing in the direction it started in. To observe this reflection:
1. With one student holding their end firmly in place, instruct the other student to introduce one pulse of energy.
2. Observe how this wave travels down the length of the spring or cord. When it reaches the end being held still, observe how the wave is reflected off of it.
3. Experiment with creating multiple waves. Observe the reflected waves interfering with the waves being created.

Standing Waves

One important type of wave interference results in what are known as **standing waves.** At the right frequency, reflected waves will interfere with new waves in a way that causes specific points along the medium the wave is traveling through to stand still. These points that appear to stand still are known as **nodes,** the spaces between them are **antinodes** surrounded by **loops,** and the frequencies that cause them are called **harmonic frequencies.**

To observe **standing waves:**
1. Stretch a spring across the floor between two students.
2. Have one student move their end of the spring from side to side slowly.
3. Experiment with increasing or decreasing the frequency until a wave with one antinode (in the spring's center) forms. Then, slowly increase frequency until two (then three or more) antinodes form. Refer to the diagram of a standing wave to see what you should be looking for.
4. Consider standing waves and how they relate to musical instruments. Standing waves with nodes on either end are representative of stringed instruments, while standing waves with an antinode on one end (which can be modeled by attaching one end of the spring to the cotton cord so that it is free to move) represent wind instruments.



Additional Wave Terms

Some other terms that you may run into in wave studies include **traveling waves** and **damped waves.**

Traveling waves are waves that appear to be moving the medium they are travelling through. Though the energy displaces the particles in the medium, the medium returns to its original location after the wave passes. All waves created with the products included in this manual will be traveling waves. This concept is also tied to the concept of **wave particle motion,** which refers to the idea that wave particles are displaced in their medium but they are not carried forward along the length of the medium.

To observe **traveling waves** and **wave particle motion:**
1. Attach a piece of tape along the length of the medium.
2. With two students stretching the medium across a table (or the floor), have one student generate a transverse or longitudinal wave.
3. Observe how the tape remains in the same place on the medium once the wave passes through it.

Damped waves are waves whose oscillations have decreased in amplitude over time. Damped waves will eventually fade completely, and the medium will return to equilibrium.

To observe **damped waves:**
1. With two students stretching the medium across a table (or the floor), have one student generate a single transverse or longitudinal wave with a single pulse of energy.
2. Without continuing to introduce any more energy to the medium, observe the amplitude of the wave you have created decrease over time until the entire medium has returned to equilibrium.