Master Teacher Bonnie Magura demonstrates S waves using two metal slinkies taped together. Attach a small paper "flag" to the taped joint to emphasize the movement directions.

NOTE that when a metal slinky is taped to a plastic slinky, the P waves both travels across the boundary and is reflected at the boundary due to the change in material response.
SEE question 2 on **Page 82** *on the worksheet for this activity.*

Activity–Seismic Slinky©

Slinkies prove to be a good tool for modeling the behavior of compressional P waves and shearing S waves. We recommend reading about the behavior of seismic waves and watching the variety of animations below to understand how they travel and how the P, S, and surface waves differ from each other.

NGSS Science Standards

- From Molecules to Organisms—Structures and Processes: MS-LS1-8
- Motion and Stability—Forces and Interactions: HS-PS2-1, MS-PS2-2
- Energy: MS-PS3-1, MS-PS3-2, HS-PS3-2, MS-PS3-5
- Waves and Their Applications in Technologies for Information Transfer: MS-PS4-1, HS-PS4-1, MS-PS4-2, HS-PS4-5

Resources on this DVD & Internet relevant to Seismic Slinky

VIDEOS—Demonstrations using the Slinky© are in the **2. Earthquakes & Tsunamis** folder on this DVD:

3. VIDEOS_Earthquake & Tsunami > **DEMO_SlinkySeismicWaves_Groom.mov**

Roger Groom's class demo: **http://www.iris.edu/hq/programs/education_and_outreach/videos#PS**

ANIMATIONS—Watch the following groups of animations in the **2. Earthquakes & Tsunamis** folder :

2. ANIMATIONS_Earthquake & Tsunami > **Seismic Wave Behavior_1station**
Seismic Wave Behavior-Travel time
Seismic Wave Motion-Brailes

INTERNET—Other descriptions of this activity:
http://www.exo.net/~pauld/summer_institute/summer_day10waves/wavetypes.html
Exploratorium: **http://www.exploratorium.edu/faultline/activezone/slinky.html**

Seismic Waves Training Simulation—Try the interactive **3D Primary, Secondary, and Surface Waves Simulator**
http://www.forgefx.com/casestudies/prenticehall/ph/seismic/seismic-waves-simulator.htm

Used with permission from Larry Braile's "**Seismic Waves and the Slinky: A Guide For Teachers**."

Seismic Slinky Classroom Demonstration and Student Worksheet

Time: 5-10 Minutes for demonstration;
15-30 min for classroom participation.

Target Grade Level: Any level

Content Objective

Students will produce P and S waves using a slinky to understand how seismic waves travel through the Earth.

Introduction

When an earthquake occurs it generates different types of seismic waves, each characterized by speed and direction. P and S waves that emanate from the hypocenter of the quake, inside the Earth are called body waves. The P and S waves have distinctive particle motions and travel at different speeds (figures on next page). By using a slinky as an analogy for the waves, you can see the difference between compressive P waves and S, or shear waves. In the Earth, P waves zip along at over 225 miles per hour (360 km/hr) through solid rock, compressing and dilating the Earth in the direction of travel (Table 1).

Procedure**

1. **PARTNER METHOD:** Hold one end of the slinky and have your partner stretch the slinky about 2ñ3 meters apart across the floor. Entire slinky touches floor.
   FIXED-END METHOD: Attach one end of slinky to a fixed object and one person stretches it out along floor or long table. Experiment with best distance.
2. Create P waves (compressional waves) Note that the motion of each coil is either compressional or extensional with the movement parallel to the direction of propagation. Because the other person is holding the slinky firmly, the P wave will reflect at that end and travel back along the slinky. The propagation and reflection will continue until the wave energy dies out.

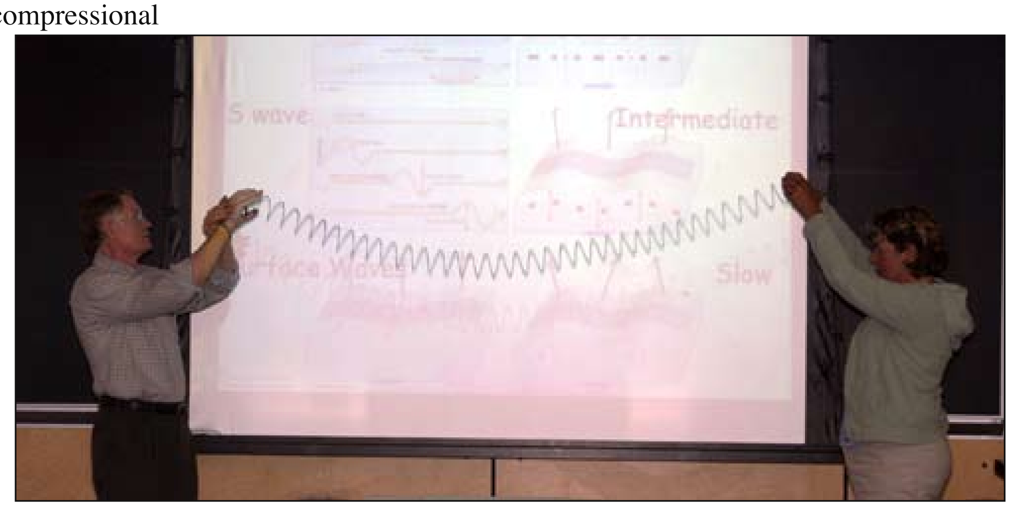
Materials

- 2-4 slinkies; metal is best, but plastic OK. (Two taped together gives best showing. If you do parallel P & S waves, step 4 next page, you will need four).
- string or tape
- metric ruler
- colored pencils or pens
- student data sheet (on 4th page of this activity).

METHOD 1: Tightly gather ten coils of the slinky into your hand and release the coil. Watch the coils compress and dilate until they reach the other end. Draw your results showing the movement of the wave through the slinky in the table on the following page.

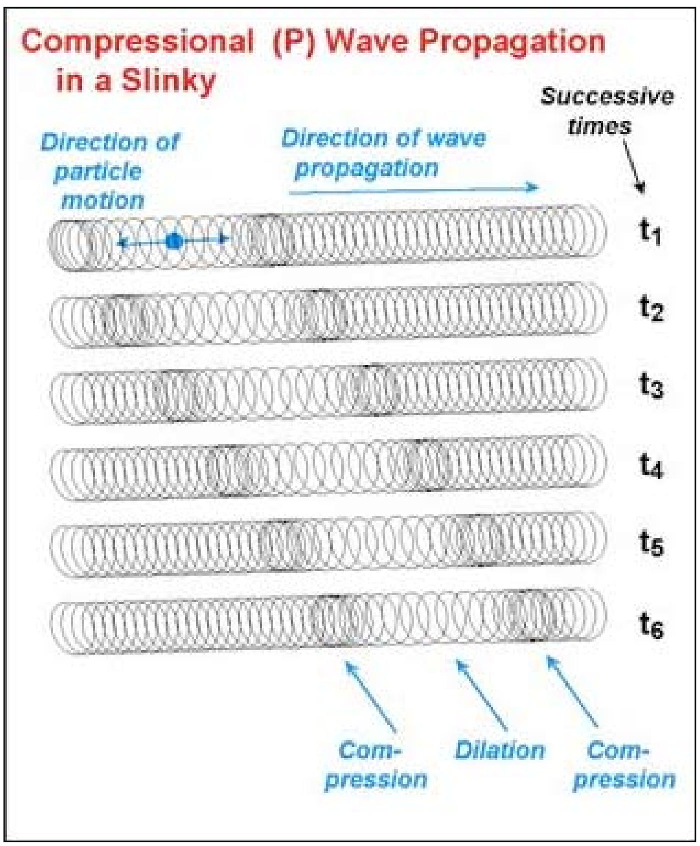
METHOD 2: One person should cup his or her hand over the last 3-4 coils of the slinky and, when the slinky is nearly at rest, hit that hand with the fist of the other hand. The compressional disturbance that is transmitted to the slinky will propagate along the slinky to the other person.

METHOD 3: Have rapid-push hand motion generate compression as shown in the animation opposite. 3. Create S waves (shearing waves) by quickly moving one end of the slinky to the left and back to the center in a quick whip-like motion (animation below). The S wave is more similar to a plucked guitar string than to compressive sound waves.

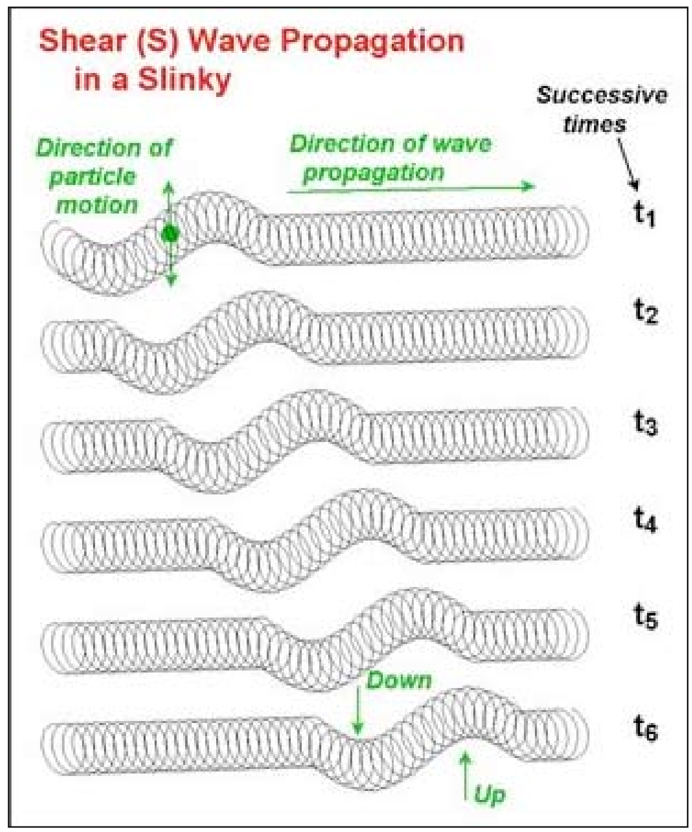


Bob Butler taps the back of his hand to generate a compressional P wave through the suspended slinky.

VIDEO: Watch this short video demonstration of a Slinky © generating P and S waves. The stand-alone animation is in the **RESOURCES** *folder for the Seismic Slinky Activity:* **DEMO_SlinkySeismicWaves_Groom** and on the web at **http://www.iris.edu/hq/programs/education_and_outreach/videos#PS**



Compressional (P) wave propagation in a slinky. A disturbance at one end results in a compression of the coils followed by dilation (extension), and then another compression. With time (successive times are shown by the diagrams of the slinky at times t1 through t6), the disturbance propagates along the slinky. After the energy passes, the coils of the slinky return to their original, undisturbed position. The direction of particle motion is in the direction of propagation.



Shear (S) wave propagation in a slinky. A disturbance at one end results in an up motion of the coils followed by a down motion of the coils. With time (successive times are shown by the diagrams of the slinky at times t1 through t6), the disturbance propagates along the slinky. After the energy passes, the coils of the slinky return to their original, undisturbed position. The direction of particle motion is perpendicular (for example, up and down or side to side) to the direction of propagation.

Animations *of these images can be found in the folder noted on the first page of this activity:* **Seismic Wave Motion-Braile**

Name ________________________

Seismic Slinky

Analysis: Answer the following questions using complete sentences.

1. Contrast the movement of P and S waves in the slinky?

2. How did the density of the slinky affect the speed of the waves?

3. What happened to the wave when it reached the boundary between the plastic and metal slinkies?

Conclusion: Communicate your findings using complete sentences. Remember to include the problem you were investigating, the results of your investigation, and the accuracy of your predictions.

A Comparison of P and S Waves		
	P Wave	**S Wave**
Description		
Drawing **Comparison of Speed of P and S waves**		
Comparison of Speed in Different Densities		
Description of the Waves between the plastic and metal slinkies		

Seismologist John Lahr demonstrates how seismic waves go in all directions from an earthquake source. (image from http://www.exo.net/~pauld/

Thoughts on Further Development of this Activity

Needs a student "worksheet" or suggested discussion questions to go along with the activity—suggest that at least a few evaluate the components of the model (what each step represents, similarities and differences of the model and the advantages and disadvantages of using it as a model), calculating the speed of the wave (d/t=r) and discussion of the forces involved and how kinetic energy is transferred by the wave.

Extension Idea

Grades 9-12 should evaluate wavelength, amplitude and frequency. They could also investigate the effect of different amplitudes on the frequency of the wave.