Overview

Yes, that does in fact seem to be the correct spelling of the plural form! I like to think that there also exists a collective term, like those describing groups of particular animals, for a collection of Slinkys. What’s that coming down the stairs? Why, it’s a flock of Slinkys! (Of course, someone will remind you that once the Slinkys come to rest, they are more appropriately referred to as a “gaggle”.)

Theory

Mechanical waves need a medium to propagate in (as opposed to electromagnetic waves, which do not). In this activity, the Slinky is the medium that the waves travels through. Waves carry energy, and cause points along the Slinky (the medium) to be displaced from their equilibrium positions in a predictable pattern. A longitudinal wave causes the Slinky to be displaced along the same axis that the wave is traveling in — it stretches and compresses the Slinky. Sound is an example of a longitudinal wave. Transverse waves, such as those that exist at the surfaces of oceans and lakes, are what most people think of when they think of waves: they cause the Slinky to be displaced along an axis that’s perpendicular to the one the wave is traveling in (side-to-side or up-and-down motion). When two waves (transverse or longitudinal) that are displacing a medium in the same direction interact with one another, they undergo constructive interference: they add together. When two waves that are displacing a medium in opposite directions interact with one another, they undergo destructive interference: they cancel out. It’s important to keep in mind that no matter the type of interference, both waves emerge from the interaction unchanged, each traveling in the same direction as they were before colliding.

Both transverse and longitudinal waves are traveling waves: They start in one place and head off to another. When a traveling wave gets “stuck” between two boundaries, a standing wave is set up. When the front of a traveling wave hits a boundary, the wave reflects off the boundary. As the reflected wave travels back in the opposite direction of the initial wave, the reflected and initial waves can interfere with one another in certain ways, creating specific patterns of constructive and destructive interference. The allowable patterns, which are referred to as modes, depend on the system the wave exists within. We generally work with two basic standing wave models: a standing wave on a string with two fixed ends (e.g., a guitar string, or a Slinky with one person holding each end), and a standing sound wave in a tube. A tube can be open at both ends (e.g., a flute), closed at both ends (we won’t do much with this), or open at one end and closed at the other (e.g., a basic vocal tract situation — closed at the diaphragm and open at the mouth). In all of these cases, the allowable wavelengths are determined by the length of the system, and the allowable frequencies are determined by both the wave speed and the length of the system.

Doing the activity

Students generally need a bit of time to just play with the Slinkies, which makes sense, because Slinkys are pretty great. At some point, though, you’ll probably want to get to using them for making transverse and longitudinal waves. If students understand the distinction between these two types of waves, they will often come up with solutions for creating each type with some gentle prompting. Pair your students up and give each pair a Slinky. The pair should stretch the Slinky out on a long, smooth floor area (avoid stretching the

Necessary materials:

- Well… Slinkys. Extra-long metal ones are best.
- long, smooth area of floor (such as a gym or little-used hallway)
Slinky too tight; this could damage it), then test out some wave-making techniques. (We’ve had good luck making transverse waves by quickly pulling one end of the Slinky to the side with a sort of flicking motion, and making longitudinal waves by giving one end of the Slinky a sharp push toward one’s partner, but students may discover additional interesting techniques.) Encourage students to observe thoughtfully, using multiple senses — this activity provides good tactile feedback on wave behavior. Make sure that students take turns being the wave-maker.

Once students have had some time to explore and have the basics of transverse and longitudinal waves down, you are ready to transition into exploring wave interference. We strongly recommend starting this exploration with transverse waves, as the interaction will be much easier to observe.

1. Wave interference requires two waves, so each member of the pair will need to make a wave at the same time. Left and right are opposite for pair members, so each pair will need to decide on a system for coordinating which direction they’ll be making a transverse wave in (e.g., if only one side of a hallway has windows, the system could be “toward windows” and “away from windows”).

2. Each pair will also need a system for making a wave at the same moment. A simple countdown often works well, but your students may come up with a creative alternative.

3. When pairs have their systems in place, each member of the pair should make a transverse wave in the same direction at the same time.

4. Closely observe what happens in the middle of the Slinky, where the waves meet. (*The waves will add together, displacing the medium to a greater degree than either individual wave — this is constructive interference.*) Why do students think this occurs?

5. Now, pairs should repeat step 3, but focus their observation on what happens to each wave after it passes the center of the Slinky. Did the interaction change the wave? (*The waves should emerge from the interaction more or less unchanged.*)

6. Try making waves in opposite directions at the same time. Now what happens in the middle? (*The waves will “cancel out” — destructive interference.*) Do the waves still emerge from the interaction unchanged? (Yes!)

With an understanding of wave interference, students are ready to explore standing waves. Some students will likely have already set up a standing wave or two; this tends to be a pretty natural way to explore with theSlinky. It’s tricky to set up a standing wave using just reflection from a boundary with a Slinky, so we’ll take a slightly different approach that still produces a good experience with fundamental standing wave properties.

1. Both students in each pair will need to work together to create standing waves. Have both students oscillate their ends of the Slinky side-to-side at varying frequencies until they find one that creates a standing wave at the system’s fundamental frequency (first mode); the pace will
be relatively slow, and the midpoint of the Slinky will consistently be the point of greatest side-to-side displacement.

• Note: It can be challenging to oscillate the Slinky at its fundamental frequency! If students are having trouble, encourage them to coordinate more closely with their partner, move slower, and/or stretch the Slinky a bit tighter. Be aware that some pairs will likely create the second, third, and/or higher modes before creating the first mode. That’s completely OK! Just encourage them to re-create these, working up in order, once they sort out the first mode.

2. Now, have the students try to move up to the next allowable standing-wave pattern (second mode). In this pattern, the middle of the Slinky will be more or less stationary, and there will be two areas of large displacement to either side of it. How much faster does the wave-maker need to oscillate the Slinky to make this pattern? (This will be just about twice as fast as the fundamental frequency!)

3. Encourage the pair to try to create wave patterns with more peaks. This can get a bit challenging again, as the students will have to move pretty fast! The necessary frequency to make three wave peaks will be three times higher than the fundamental frequency; the frequency for four wave peaks will be four times higher, and so on.

Summing up

Slinky’s are an easy and entertaining way to see, feel, and even hear key wave properties. They can be used to explore two sets of fundamental categories of waves: transverse and longitudinal, and traveling and standing.

For more information

Little Shop of Physics: https://www.lsop.colostate.edu

Colorado State University College of Natural Sciences: https://www.natsci.colostate.edu