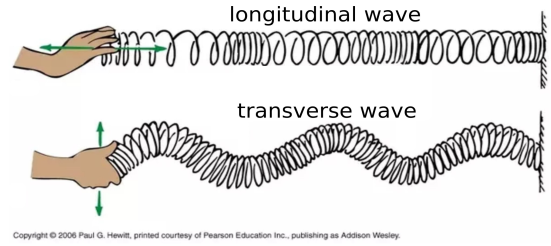
Waves, Sound, and Resonant Frequencies



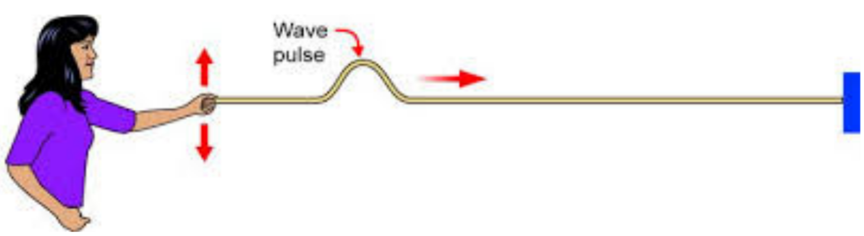
- Waves are vibrations that move through a material
- **Frequency:** how often a piece of material moves back and forth.
- Waves can be **longitudinal** (back-and-forth motion) or **transverse** (up-and-down motion).
- **Sound** is a longitudinal wave that moves through air and other materials. In a sound wave the molecules jiggle back and forth, getting closer and further apart.
- When a wave is caught in between walls, it will bounce back and forth to create a **standing wave**, but only if its frequency is just right! Waves with these **resonant** frequencies are **amplified** (become very big with only a little input energy).

Making Waves with a Slinky

Work in groups of 2 or 3.

Take turns being the "wall" (hold end steady) and the slinky mover.

1. Each of you should hold one end of the slinky. Stand far enough apart that the slinky is slightly stretched.
2. Try making a **transverse wave pulse** by having one partner move a slinky end up and down while the other holds their end fixed.



What happens to the wave pulse when it reaches the fixed end of the slinky? Does it return upside down or the same way up?

Try moving the end up and down once, faster:

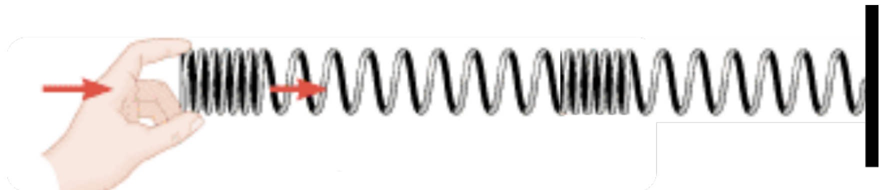
Does the wave pulse get narrower or wider?

Does the wave pulse reach the other partner noticeably faster?

3. Without moving further apart, pull the slinky tighter, so it is more stretched (scrunch up some of the slinky in your hand. Be gentle!). Make a transverse wave pulse again.

Does the wave pulse reach the end faster or slower if the slinky is more stretched?

4. Try making a **longitudinal wave pulse** by folding some of the slinky into your hand and then letting go.



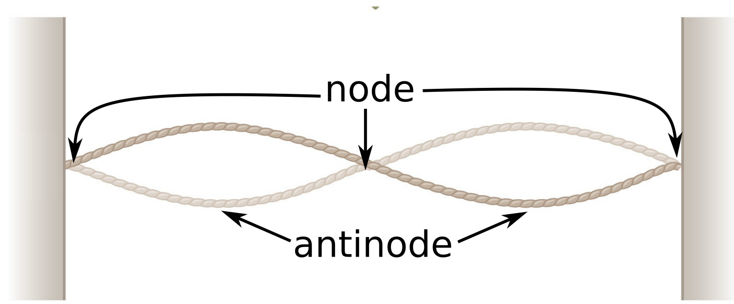
Slinky Standing Waves

1. Have one partner make a **transverse wave** by shaking the slinky end up and down with an even rhythm, while the other partner holds their end fixed.

2. Try shaking with different **frequencies** (faster or slower). Do not shake very hard – make small movements of your hand.

Can you find a frequency such that small movements of your hand make a large wave in the slinky?

This wave will look like it is standing still, with some parts of the slinky (the anti-nodes) moving a lot while others (the nodes) barely move. The special frequency you're shaking with is called a **resonant frequency** of your slinky.



How many anti-nodes does your standing wave have?

3. Can you find other frequencies that make different numbers of anti-nodes?

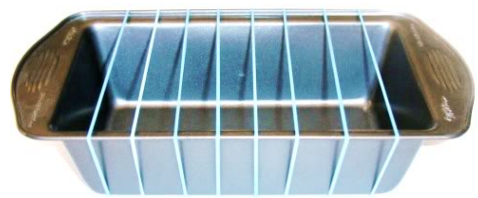
How many anti-nodes were you able to make?

4. If you pull the slinky tighter, do you have to shake with a higher or lower frequency to make a standing wave with one node in the middle?

When a string instrument (violin or guitar) makes a note, the string vibrates and makes a **standing wave** with certain resonant frequencies. The frequency of the vibrating string determines the frequency of the sound produced. We hear this as different pitches (high and low).

Rubber Band Guitars

1. Put several rubber bands of different thicknesses onto your box or can or cup so that the rubber band is stretched across the open end of the container.



2. Pluck the different rubber bands.

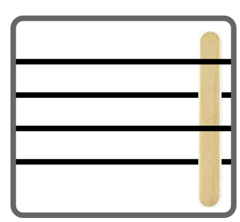
Do the thinner bands make a higher or lower pitched sound?

3. Based on what you learned with the slinky, make a prediction:

If you pull a rubber band tighter do you expect it to make a higher or lower pitch?

Try the experiment. Was your prediction correct?

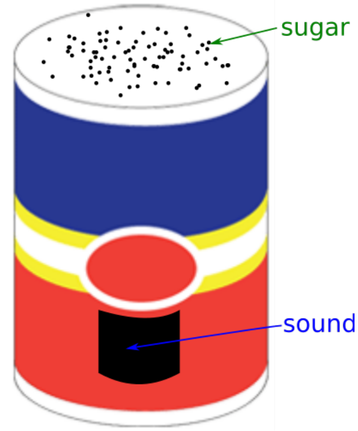
This is how violin and guitar strings are tuned: by changing the tension!



4. Try inserting a craft stick through the bands towards one end of the container. This lets you make the strings shorter.

Do the shorter strings make higher or lower pitched sound?

“Seeing” Sound



1. Cut a square hole (about 2” across) in the side of a cylindrical oatmeal container (about 2” from the bottom).
2. Stretch a piece of plastic-wrap over the top of an empty oatmeal can. Use a rubber band to hold it in place.
3. Sprinkle some sprinkles on top of the plastic wrap.
4. Strike a tuning fork with your pencil, and hold it near the sugar.

What happens if you touch the tuning fork to the plastic wrap?

Can you make the sugar jump by holding the fork nearby, **without** touching it or the plastic wrap?

Sound is a **wave** that travels through the air. Sounds are made by vibrating objects (like the tuning fork) which push air back and forth. When sound waves hit the plastic wrap, they make it vibrate in turn, making the sugar dance.

5. Have one partner hum into the hole on the side, while the other observes the sugar on the lid. Try humming at different pitches (low vs high sounds). Then trade places.

What did the sugar do?

Was humming at some pitches more effective than others?

If the frequency of the hum is just right it will set up a **standing wave** in the container. Just like with the slinky, a small disturbance (quiet hum) can become amplified into a strong (loud) wave. A container that amplifies specific frequencies of sound waves is called a “**resonance chamber**”.

More “Instruments”

Musical instruments all work on the same principle:

1) Something vibrates (string, reed, your lips, …)
2) The instrument has a resonance chamber that amplifies some frequencies of standing sound waves.
3) The amplified sound waves travel through the air to your ear. You hear a musical note.

Try making these toy instruments:

1. **The Musical Balloon**

https://stevespanglerscience.com

a) Put a hex nut in a balloon
b) Blow up the balloon and tie it off.
c) Swirl the balloon in circles to make the nut spin around the inside.

What causes the vibration? ________________________________
What is vibrating? ____

What forms the resonance chamber?

____

What happens to the pitch of the note as the nut slows down?

____

2. **The Duck-in-a-Cup**

ScienceBob.com

a) Poke a hole in the bottom of a plastic cup
b) Thread a string through the hole. Tie one end of the string to a paper clip.
c) Slide a wet paper towel along the string, pulling away from the cup.

What causes the vibration?

____

What is vibrating? ____

Why do you need the cup? ____

3. **The "Laser Gun"**

a) Wedge the bottom of a large cup into the slinky.
b) Wiggle the slinky around

What do you hear?
How does the cup change the sound compared to the slinky alone?