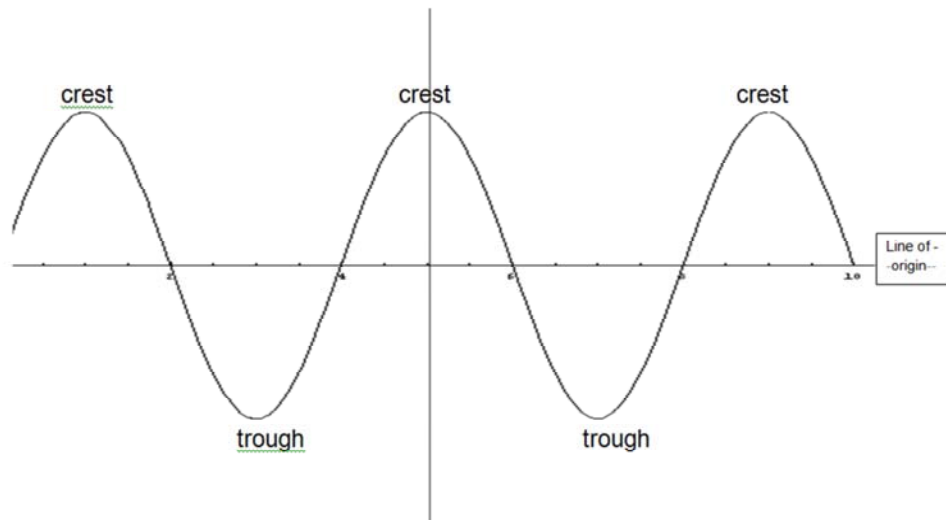
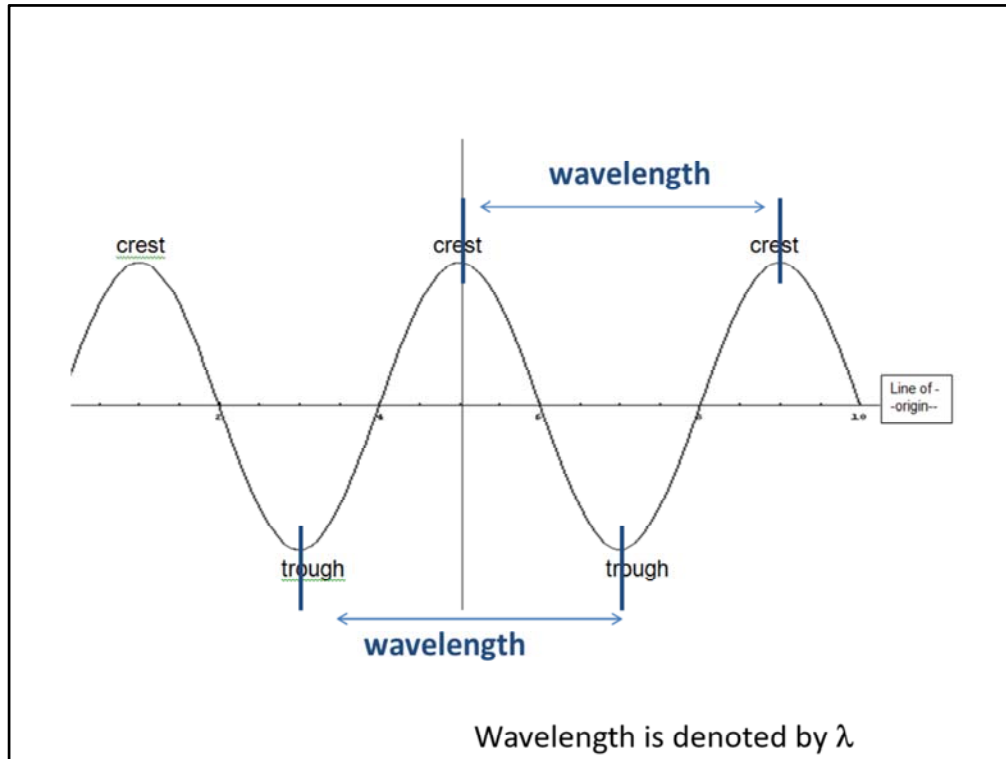


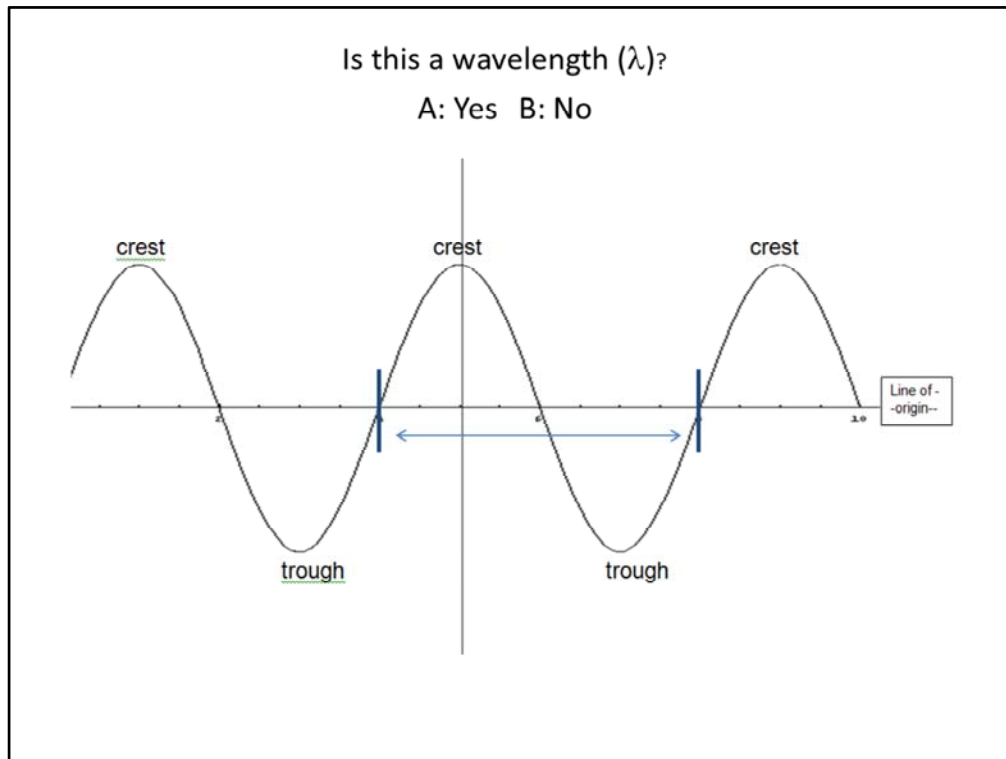
## Anatomy of a wave



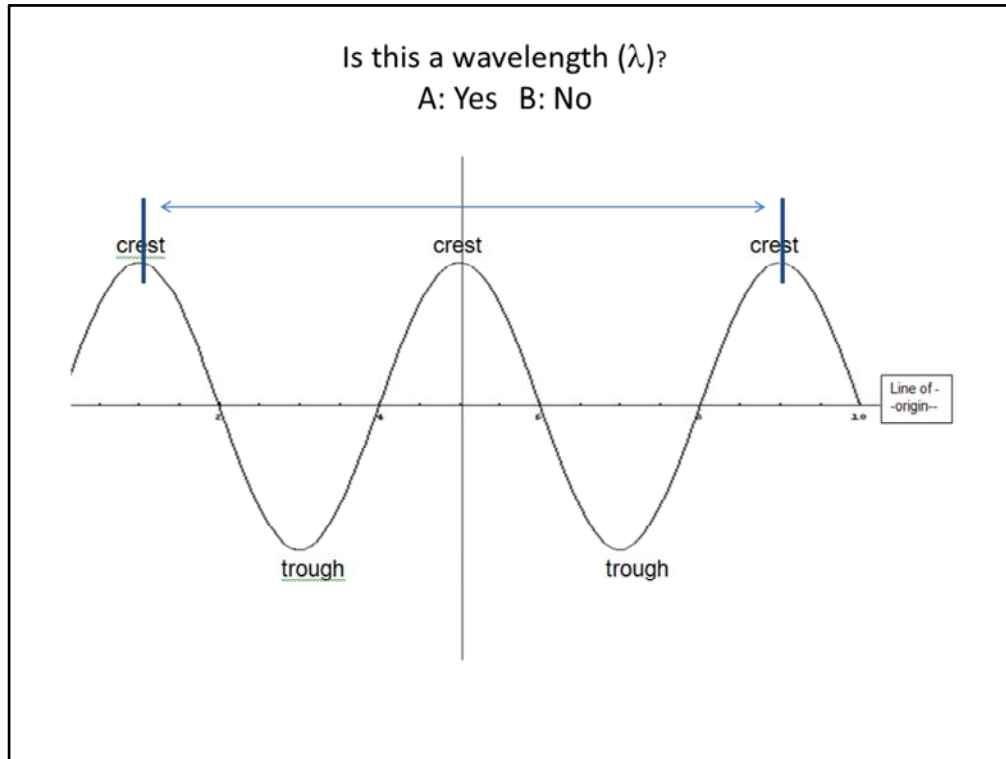
Anatomy of a wave partner activity: One person is a reporter and the other is the artist. The artist tries to draw what the reporter describes. Rules are important but the result is kids learn the parts of a wave and they learn how hard it is to use only a verbal description!



Define a wavelength as the length between adjacent crests. Show both the first two wavelengths on the slide.



Ask the class if this is also a wavelength? It is.

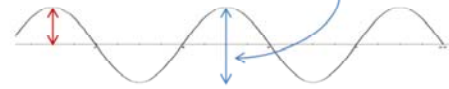


Ask the class if this is a wavelength. It is actually 2 wavelengths.

## What is

- **Amplitude (A)?**

- How high/low the crests/troughs are.

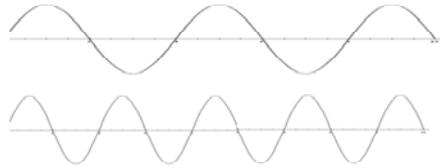


Sailors care about wave height – not amplitude!

Lower amplitude

- **Frequency (f)?**

- Rate of the oscillation



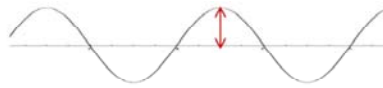
Higher frequency

Define amplitude then show the 1<sup>st</sup> wave. Ask students to describe what the same wave would look like with a smaller amplitude. If they've done the "Wave Basics" homework, they should be able to do this.

Next define frequency. Then show the wave and ask students what it would look like with a smaller frequency.

- **Amplitude (A)**

- m (meters)

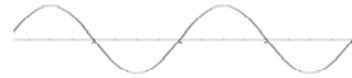


- **Frequency (f)**

- Number of oscillations per second

- 1/s or Hz (hertz)

2 Hz



- **Period (T)**

- Time for one oscillation

0.5 s



$$f = 1/T$$

$$2 \text{ Hz} = 1/0.5 \text{ s}$$

## Wave Speed

[Wave on a String](#) Homework:

Does the speed of the wave depend on

- Amplitude?    A – Yes, B – No
- Frequency?    A – Yes, B – No
- Damping?    A – Yes, B – No
- Tension?    A – Yes, B – No

# Imagine a concert

- What if wave speed depended on *frequency*?

- high notes would arrive before low notes
  - or vice versa



- What if wave speed depended on *amplitude*?

- louder notes would arrive before quieter notes
  - or vice versa



- What if wave speed depended on *tension*?

- That's how you tune stringed instruments



## Wave Speed

[Wave on a String](#) Homework:

Does the speed of the wave depend on

- Amplitude? A – Yes, B – **No**
- Frequency? A – Yes, B – **No**
- Damping? A – Yes, B – **No**
- Tension? A – **Yes**, B – No

Have to change the characteristics of the string

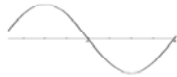
## Wave Speed

Wave speed is constant for a given medium.

$$v = \Delta x / \Delta t$$

$$v = \lambda / T$$

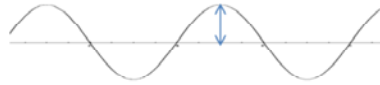
and we know  $1/T = f$



wavelength / Period

- **Amplitude (A)**

- m (meters)



- **Frequency (f)**

- Number of oscillations per second

- 1/s or Hz (hertz)

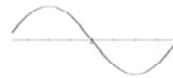
2 Hz



- **Period (T)**

- Time for one oscillation

0.5 s



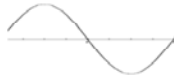
$$f = 1/T$$

$$2 \text{ Hz} = 1/0.5 \text{ s}$$

## Wave Speed

Wave speed is constant for a given medium.

$$v = \Delta x / \Delta t$$



$$v = \lambda / T = \lambda \cdot 1/T \text{ wavelength / Period}$$

and we know  $1/T = f$

So  $v = \lambda f$

So  $\lambda = v/f$  or  $f = v/\lambda$

## Wave Speed

Wave speed is constant for a given medium.

$$\lambda = v/f \quad \text{or} \quad f = v/\lambda$$

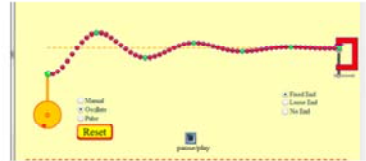
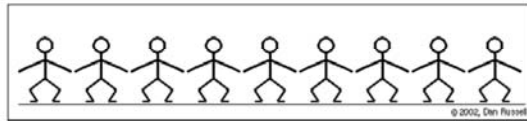
Can get *wavelength* from *frequency*

Or

*Frequency* from the *wavelength*

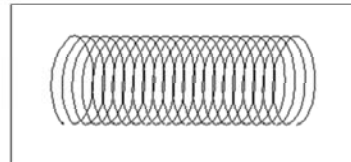
# Types of Waves

## Transverse Waves



## Longitudinal Waves

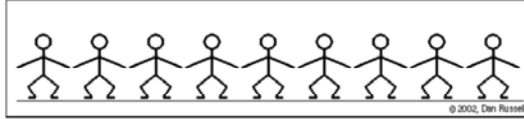
[Transverse, Longitudinal, and Periodic Waves](#)



The link at the bottom is a site that has very nice animations. However, it requires Apple Quicktime to run. These animations are simpler and easier to grasp than a slinky wave so I show the slinky after I show the animation.

## Source, Receiver & Medium

- People Wave



**What is the *Source*?**

first person

**What is the *Receiver*?**

last person

**What is the *Medium*?**

all the people

Ask what the source, receiver and medium is for each of these types of waves. You can show the PhET Interactive Simulations “Wave Interference” simulation as a visual of water waves if desired.

## Source, Receiver & Medium

- Wave on a String

**What is the *Source*?**

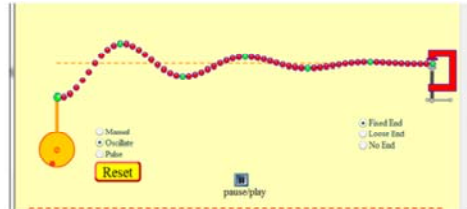
Orange Pump

**What is the *Receiver*?**

Clamp

**What is the *Medium*?**

The string of red beads

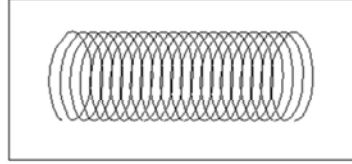


Ask what the source, receiver and medium is for each of these types of waves. You can show the PhET Interactive Simulations “Wave Interference” simulation as a visual of water waves if desired.



## Source, Receiver & Medium

- Longitudinal slinky wave



**What is the *Source*?**

start of slinky

**What is the *Receiver*?**

start of slinky

**What is the *Medium*?**

The slinky

Ask what the source, receiver and medium is for each of these types of waves. You can show the PhET Interactive Simulations “Wave Interference” simulation as a visual of water waves if desired.

## **How do waves add?**

Use the PhET Wave on a String simulation: [Phet.colorado.edu](https://phet.colorado.edu) and asked how the waves add? Example on next slide. It helps to show the Wave on a String simulation first. Show one pulse and how it travels back and forth along the string. Then ask the question on the following slide. You could show both pulses shown on the next slide separately but not together or that will give it away!

# Interference of Waves

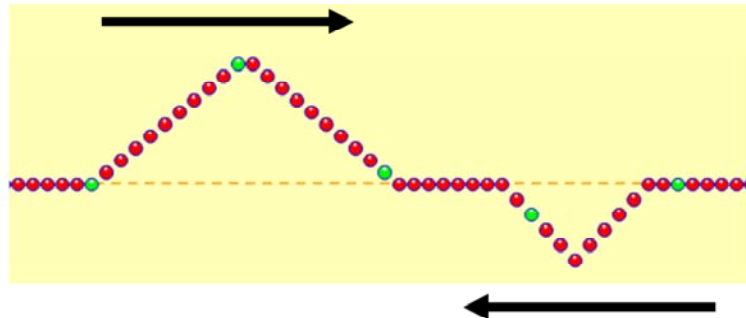
## Superposition Principle

When two or more traveling waves encounter each other while moving through a medium, the resultant wave is found by adding together the displacements of the individual waves point by point.

- Constructive Interference
- Destructive Interference

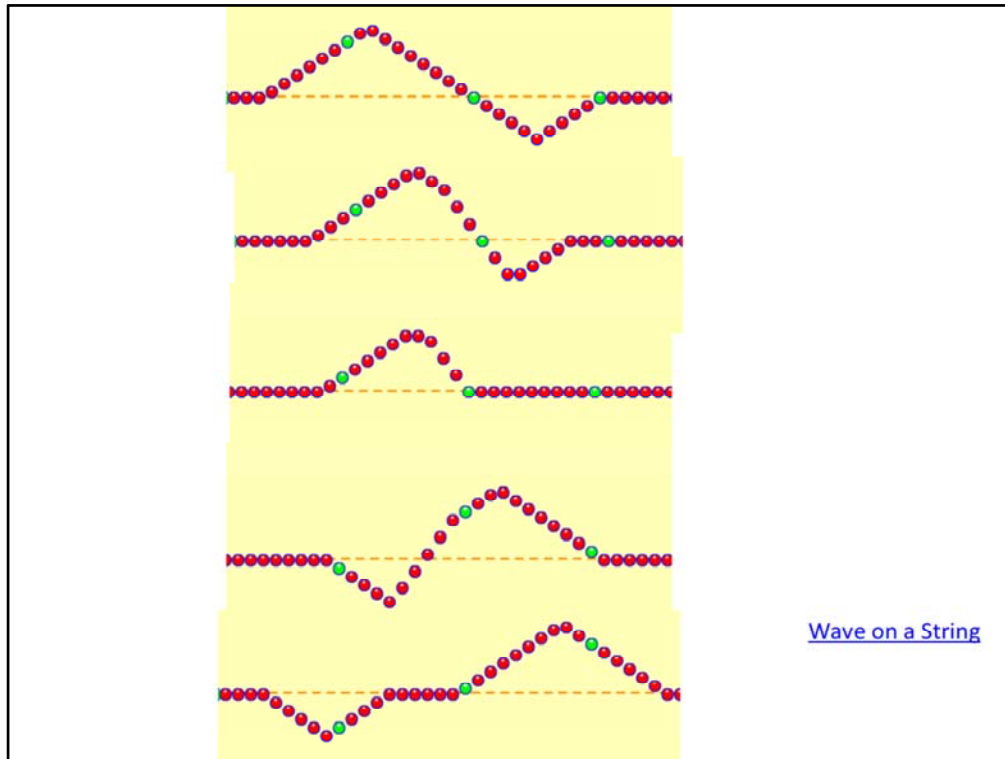
[Transverse, Longitudinal, and Periodic Waves](#)

Sketch what you think the pattern will look like



After students draw their predictions, ask for them to share with the class. Then show the results on the simulation. Click the snapshot to open the sim.

To demonstrate: I used the Pulse feature with Zero damping. First I set the wave characteristics to  $A = 50$ ,  $PW = 50$ , Damping = 0, Tension high, then pulsed and paused quickly. Then I reset the characteristics and sent another pulse. Quickly, I paused again and used the Step feature for slow motion. You can cycle through the waves interactions many times by stepping.



You can see that the lower wave is moving to the left. In shot 3 it's under the top wave. So the top wave is shorter and the lower wave isn't showing. When you add them up the top wave plus the negative bottom wave, you get a smaller but still positive number. On shot 4 you can see the lower wave emerge on the left and the top wave is bigger again. Finally shot 5 they are separate again and no different than they were to start with.

# **Resonance**

The natural frequency of an object

# Resonance

## •Swinging

<http://www.youtube.com/watch?v=I4FPK1oKddQ>

The swing has a natural frequency that is determined by its length. If the swing is given a small push at the right time in each cycle, its amplitude gradually increases. This is an example of *resonance*. The swing receives a small amount of energy during each push, but provided this amount is larger than the energy lost during each cycle (due to friction and air drag), the *amplitude* of swing increases.



Watch the swing example and explain how your push has to be just right. If it is, each time you push it adds to how high the person is going. If you try to push with different timing than the swings Natural frequency, it just doesn't work!

Show the pasta raisin demo.

# Resonance

- Pasta/raisin demonstration

The frequency an object likes to  
vibrate at



Show the pasta raisin demo. In this picture can you see the middle pasta and how fast it is moving?!



# Resonance

The frequency an object likes to vibrate at

- [Wave on a String](#) (A=3, f=50, Damp = 0, Tension = high)

Use the settings given above to show resonance with the Wave on a String simulation. It's really NEAT.

# Resonance

The frequency an object likes to vibrate at

- [Tall vs. Short Building damage](#)



This is a very clear video of resonance. It's designed to demonstrate earthquake damage but works beautifully for resonance in general. It shows different height objects resonating at different frequencies. I stop the video at the points where the speaker says he asks his students to predict, then I ask my students to predict.