Waves
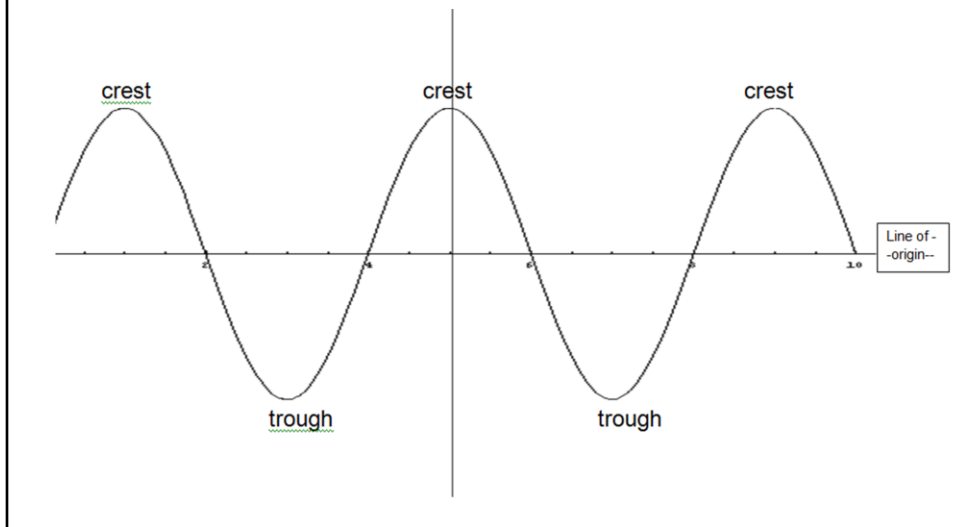
- Anatomy of a Wave
- Wave Speed
- Adding waves
- Natural Frequency
- Resonance

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!

Wavelength is denoted by λ
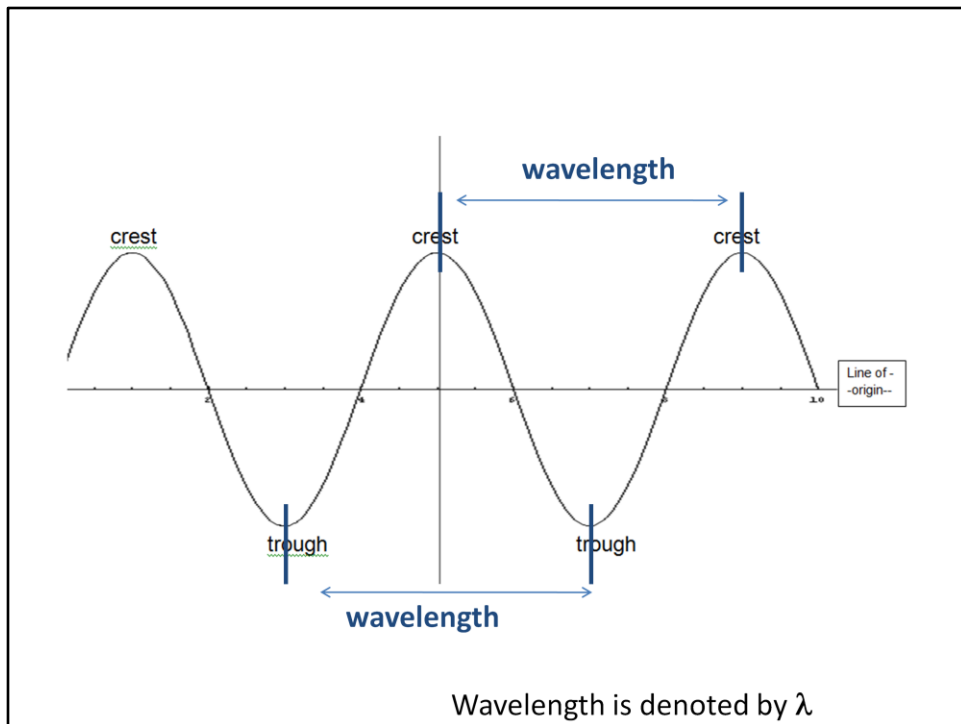
Define a wavelength as the length between adjacent crests. Show both the first two wavelengths on the slide.
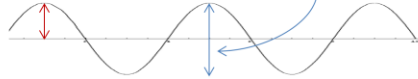
Is this a wavelength (λ)?
A: Yes   B: No
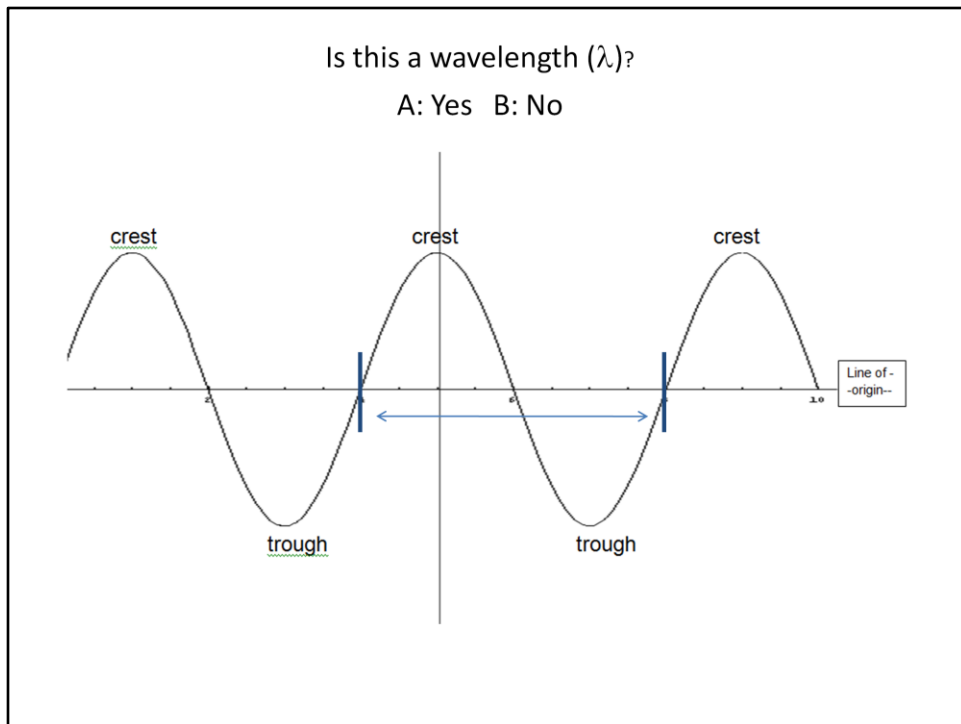
Ask the class if this is also a wavelength? It is.
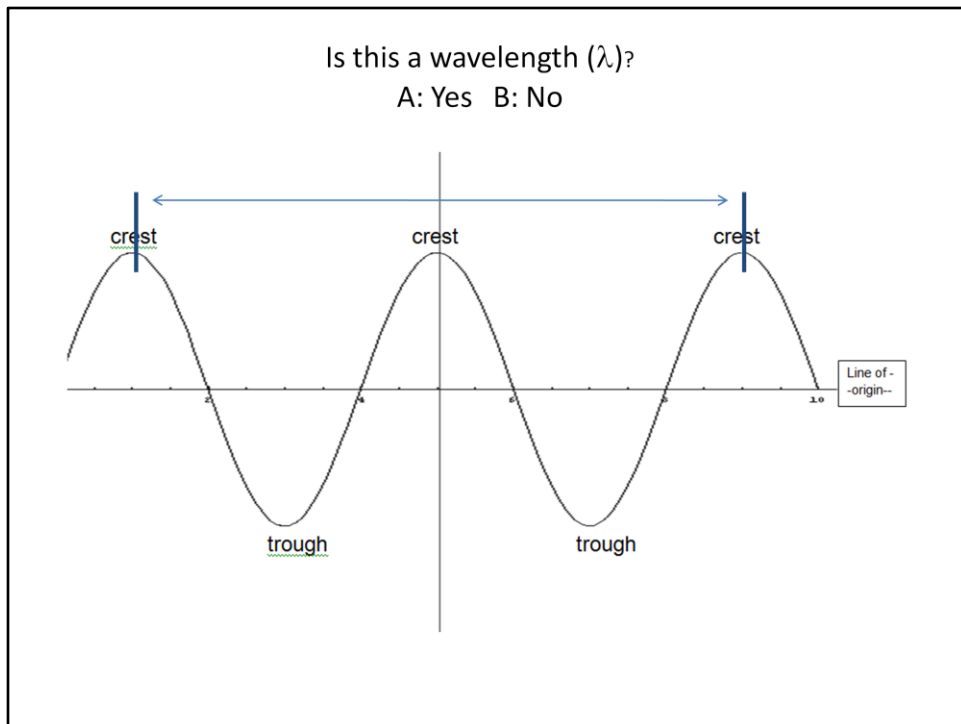
Ask the class if this is a wavelength. It is actually 2 wavelengths.

Define amplitude then show the 1st 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.

Which wave represents a smaller amplitude than the wave shown?
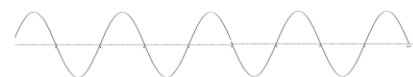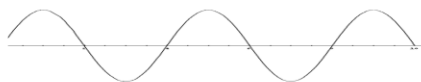

A

B

C

D

Which wave represents a smaller amplitude than the wave shown?

A
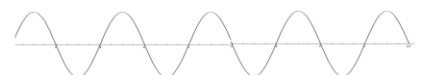
B

C

D

Which wave represents a smaller frequency than the wave shown?

A

B

C

D
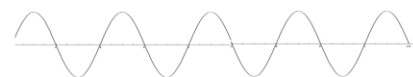
Which wave represents a smaller frequency than the wave shown?

A

B

C

D

- **Amplitude (A)**
  - m (meters)
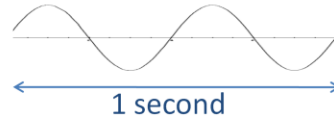
- **Frequency (_f_)**
  - Number of oscillations per second
  - 1/s or Hz (hertz)

1 second

Frequency of the above wave is

- A. ½ Hz
- B. 1 Hz
- C. 2 Hz
- D. Not enough Information

- **Amplitude (A)**
  - m (meters)

- **Frequency (f)**
  - Number of oscillations per second
  - 1/s or Hz (hertz)

1 second

Frequency of the above wave is
- A. ½ Hz
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- **Amplitude (A)**
  - – m (meters)

- **Frequency (_f_)**
  - – Number of oscillations per second
  - – 1/s or Hz (hertz)

2 Hz
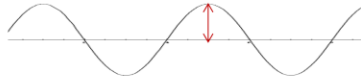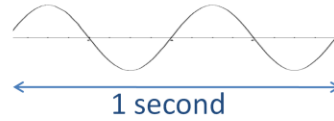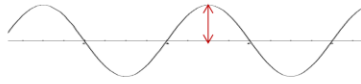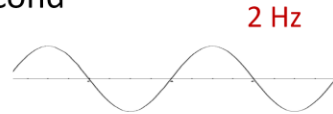
- **Period (T)**
  - – Time for one oscillation

  The period of the above wave is
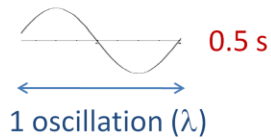
  A. ½ s
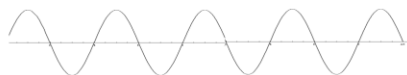
  B. 1 s

  C. 2 s

  D. Not enough information
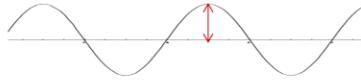
- **Amplitude (A)**
  - m (meters)

- **Frequency (f)**
  - Number of oscillations per second
  - 1/s or Hz (hertz)

  2 Hz

- **Period (T)**
  - Time for one oscillation

  0.5 s

  The period of the above wave is

  A. ½ s
  B. 1 s
  C. 2 s
  D. Not enough information

  1 oscillation (λ)

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

<u>Wave on a String</u> 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

Types of Waves

Transverse Waves
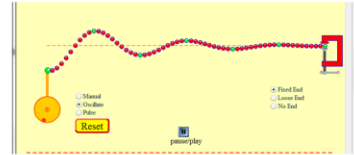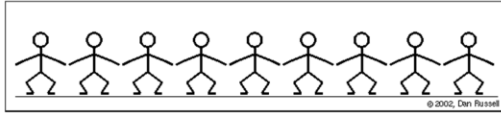
Longitudinal Waves

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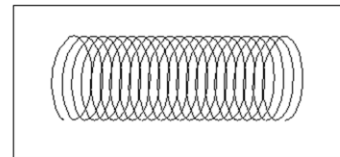
The link at the bottom is a site that has very nice animations. However, it requires Apple Quicktime to run. These animations are simpler and easier to grasp than a slinky wave so I show the slinky after I show the animation.

Source, Receiver & Medium

- People Wave
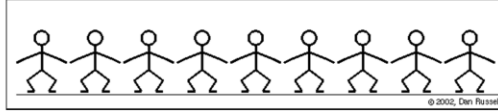
What is the *Source*?
first person

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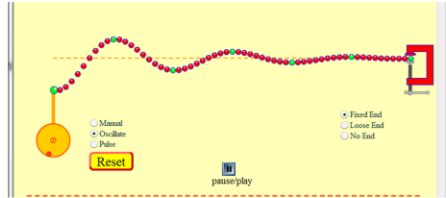
Ask what the source, receiver and medium is for each of these types of waves. You can show the PhET Interactive Simulations "Wave Interference" simulation as a visual of water waves if desired.

Source, Receiver & Medium

- Longitudinal slinky wave
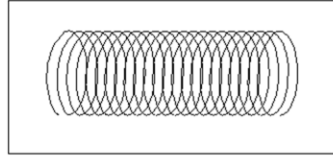
What is the *Source*?
start of slinky

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 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

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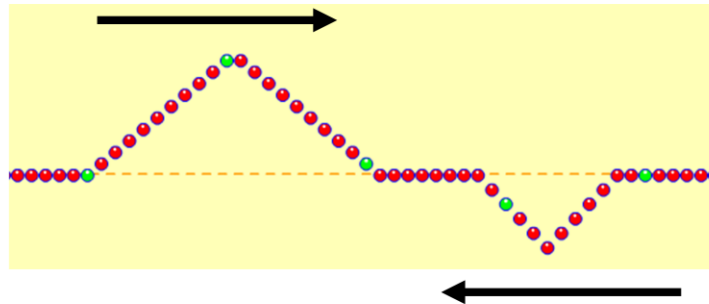
After students draw their predictions, ask for them to share with the class. Then show the results on the simulation. Click the snapshot to open the sim.

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.

Wave on a String
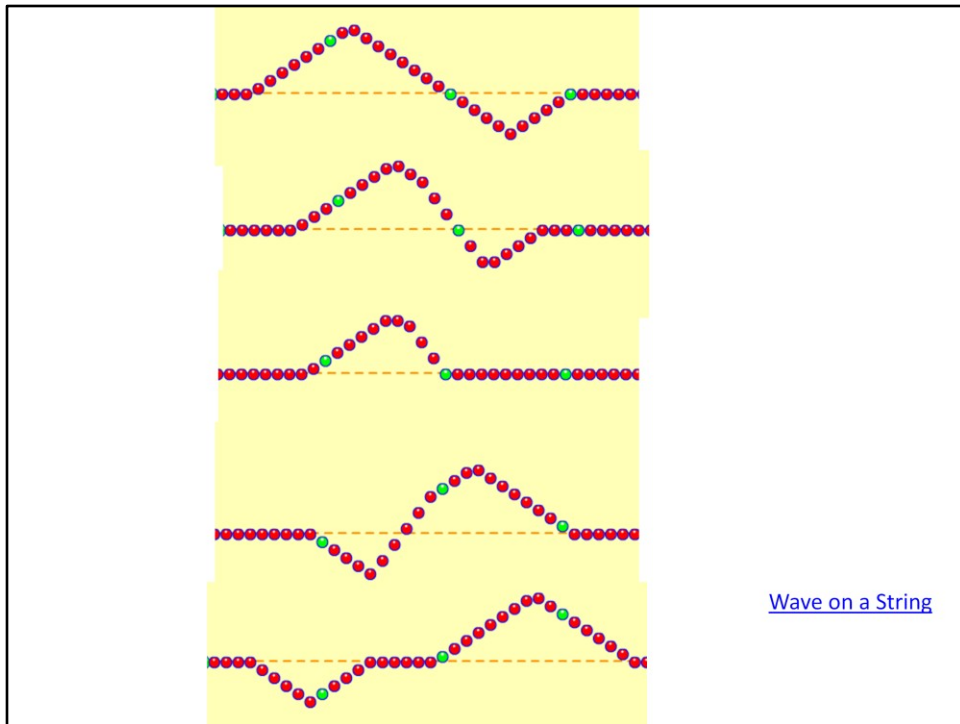
You can see that the lower wave is moving to the left. In shot 3 it's under the top wave. So the top wave is shorter and the lower wave isn't showing. When you add them up the top wave plus the negative bottom wave, you get a smaller but still positive number. On shot 4 you can see the lower wave emerge 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.

Natural Frequency

The frequency at which an object likes to vibrate

Resonance

When one object is vibrating and it is put in contact with another object, if the *frequency* of the first object is at the *natural* *frequency* for the second object, the second object will start vibrating vigorously at its *natural frequency*.

(pasta demo is an nice clean example of resonance

Or two tuning forks)

Tuning Fork example

If one tuning fork causes another to resonate,

A. both forks must be the same frequency

B. The forks can be any frequencies

C. The forks have to be the same note.

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Resonance

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(pasta demo is an nice clean example of resonance

Or two tuning forks of the same frequency)

Tuning Fork example

When one object is vibrating and it is put in contact with another object…

If the vibrating tuning fork #1 is held near but **not** touching the quiet fork #2 and causes fork #2 to begin vibrating,

A. Fork #1 is resonating with Fork #2
B. Technically #1 resonates with the *air* which in turn resonates with tuning fork #2.
C. The tuning forks must be in contact for one to cause the other to vibrate.
D. Other

2013 ran out of time here

Tuning Fork example

When one object is vibrating and it is put in contact with another object…

If the vibrating tuning fork #1 is held near but **not** touching the quiet fork #2 and causes fork #2 to begin vibrating,

A. Fork #1 is resonating with Fork #2

B. **Technically #1 resonates with the *air* which in turn resonates with tuning fork #2.**

C. The tuning forks must be in contact for one to cause the other to vibrate.

D. Other

Resonance

• Swinging
http://www.youtube.com/watch?v=I4FPK1oKddQ

In terms of energy, generate an explanation of why Dad's timing has to be just right for the Amplitude to increase.

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

•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.

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

Resonance

When a driving frequency causes an object to vibrate at its *natural frequency*.

- 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

When a driving frequency causes an object to vibrate at its *natural frequency*.

- [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.