Theme Music: The Beach Boys
Good Vibrations

Cartoon: Bill Watterson
Calvin & Hobbes
Foothold principles: Mechanical waves 2

- **Superposition**: when one or more disturbances overlap, the result is that each point displaces by the sum of the displacements it would have from the individual pulses. (signs matter)

- **Beats**: When sinusoidal waves of different frequencies travel in the same direction, you get variations in amplitude (when you fix either space or time) that happen at a rate that depends on the difference of the frequencies.

- **Standing waves**: When sinusoidal waves of the same frequency travel in opposite directions, you get a stationary oscillating pattern with fixed nodes.
Beats

http://www.mta.ca/faculty/science/physics/suren/Beats/Beats.html
Adding Sinusoidal Waves going in opposite directions

When we add two sinusoidal waves.

\[ y = A \sin(kx - \omega t) + A \sin(kx + \omega t) \]

Using trig identities \((\text{sc}+\text{cs}...\)) we can show

\[ y(x,t) = 2A \sin(kx) \cos(\omega t) \]

For each point on the string labeled “\(x\)” it oscillates with an amplitude that depends on where it is — but all parts of the string go up and down together.
Foothold principles: Standing Waves

- Some points in the pattern
  \[ y(x,t) = 2A \sin(kx) \cos(\omega t) \]
  (values of \(x\) for which \(kx = n\pi\) are always 0 (nodes)

- We can tie the string down at these points and still let it wiggle in this shape. (normal modes or harmonics)

- To wiggle like this (all parts oscillating together) we need
  \[ kL = n\pi \quad \text{or} \quad L = \frac{n\lambda}{2} \]

- We still have
  \[ v_0 = \frac{\omega}{k} \quad \text{that is} \quad v_0 = \frac{\lambda f}{2} \]
Explore with a simulation

If we start our system in a sinusoidal shape it will undergo period motion - repeat itself.

http://phet.colorado.edu/en/simulation/normal-modes
Explore with a simulation

http://phet.colorado.edu/simulations/sims.php?sim=Wave_on_a_String
Explore with a simulation

http://phet.colorado.edu/en/simulation/fourier