April 17, 2013 Physics 132 Prof. E. F. Redish

- **Theme Music:** **The Beach Boys**
  Good Vibrations
- **Cartoon:** **Bill Watterson**
  Calvin & Hobbes

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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.

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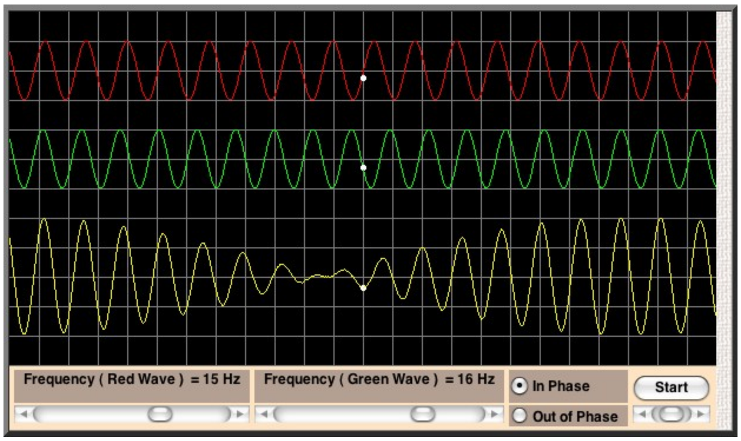
Beats



http://www.mta.ca/faculty/science/physics/suren/Beats/Beats.html

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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 (sc+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.

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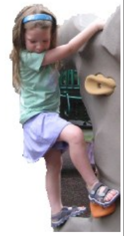
Foothold principles: Standing Waves



- 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

$$kL = n\pi \quad \text{or} \quad L = n\frac{\lambda}{2}$$

- We still have

$$v_0 = \omega/k \quad \text{that is} \quad v_0 = \lambda f$$

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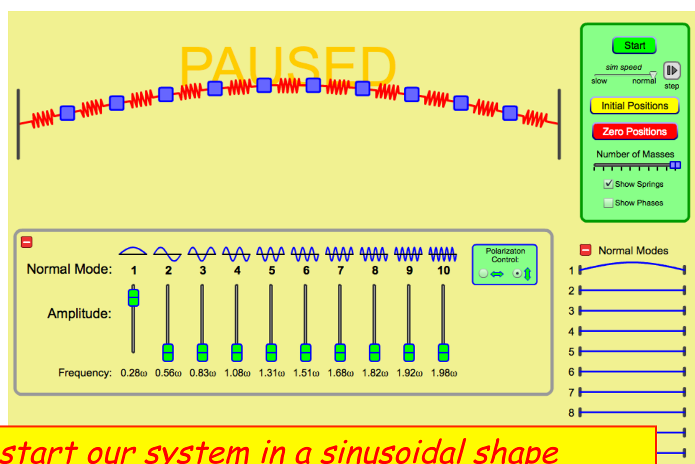
Explore with a simulation



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

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

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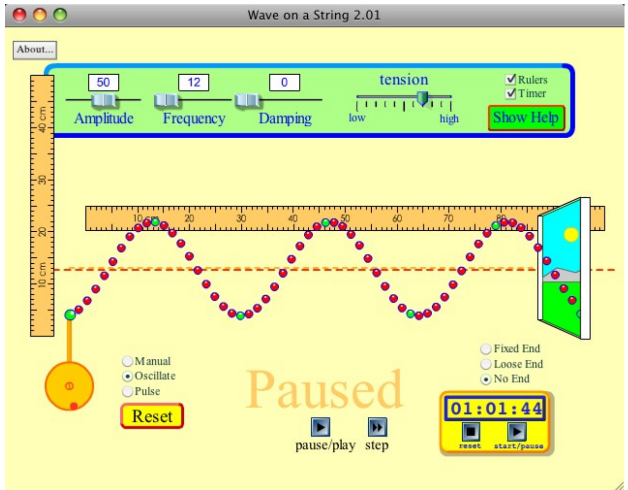
Explore with a simulation



http://phet.colorado.edu/simulations/sims.php?sim=Wave_on_a_String

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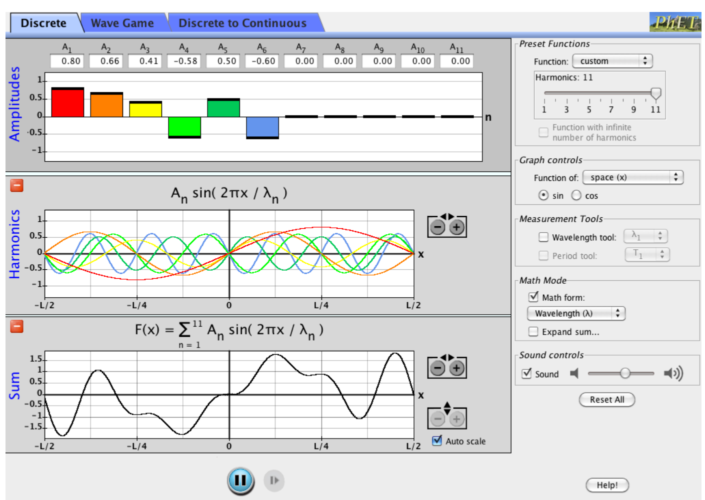
Explore with a simulation



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

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