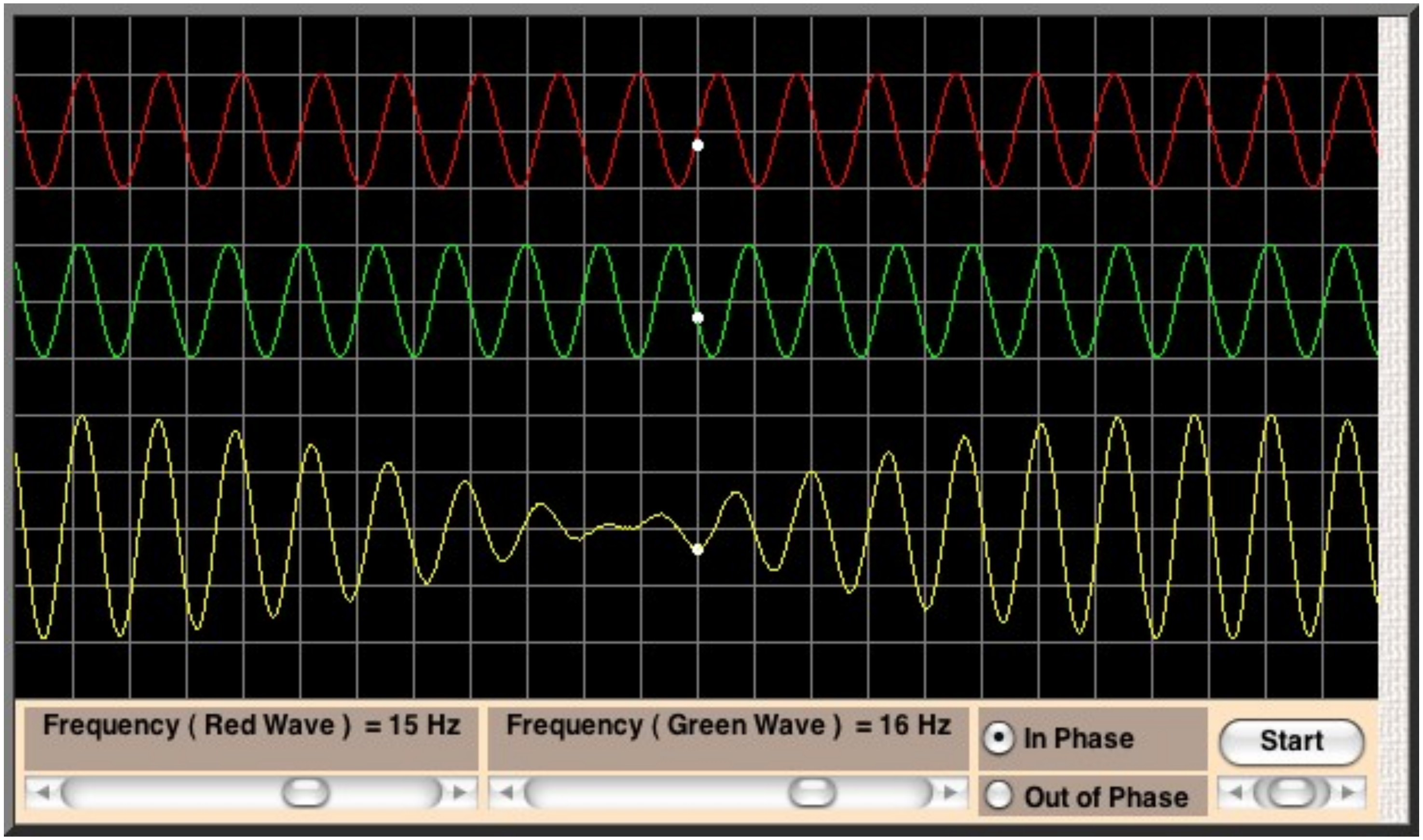
- **Theme Music:** **The Beach Boys**
  Good Vibrations
- **Cartoon:** **Bill Watterson**
  Calvin & Hobbes

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 <u>different frequencies</u> travel <u>in the same direction</u>, 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 <u>same frequency</u> travel in <u>opposite directions</u>, 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 (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.

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*)

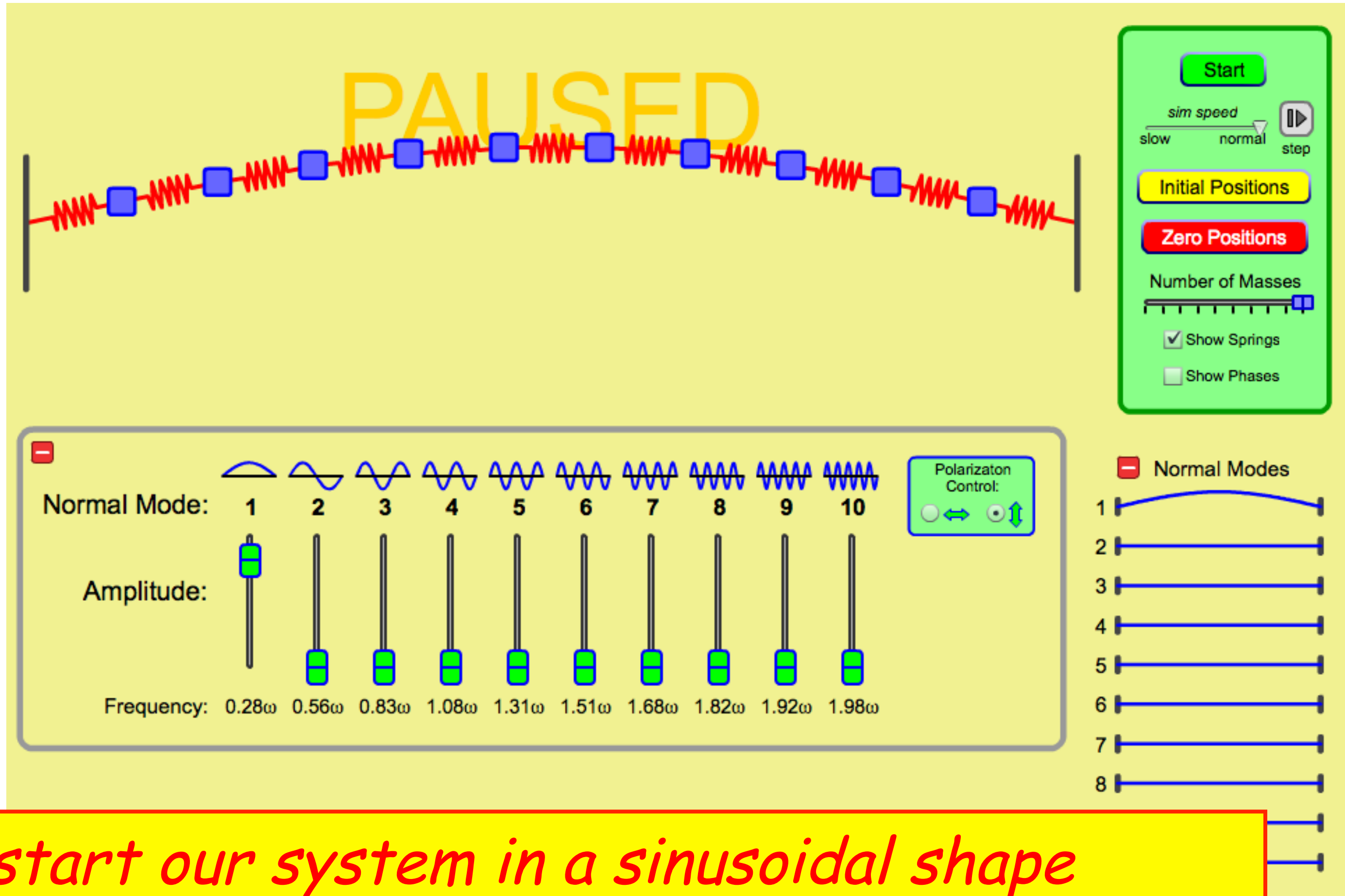
- We can tie the string down at these points and still let it wiggle in this shape. (*normal modes* or *harmonics*)
- To wiggle like this (all parts oscillating together) we need

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

- We still have

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

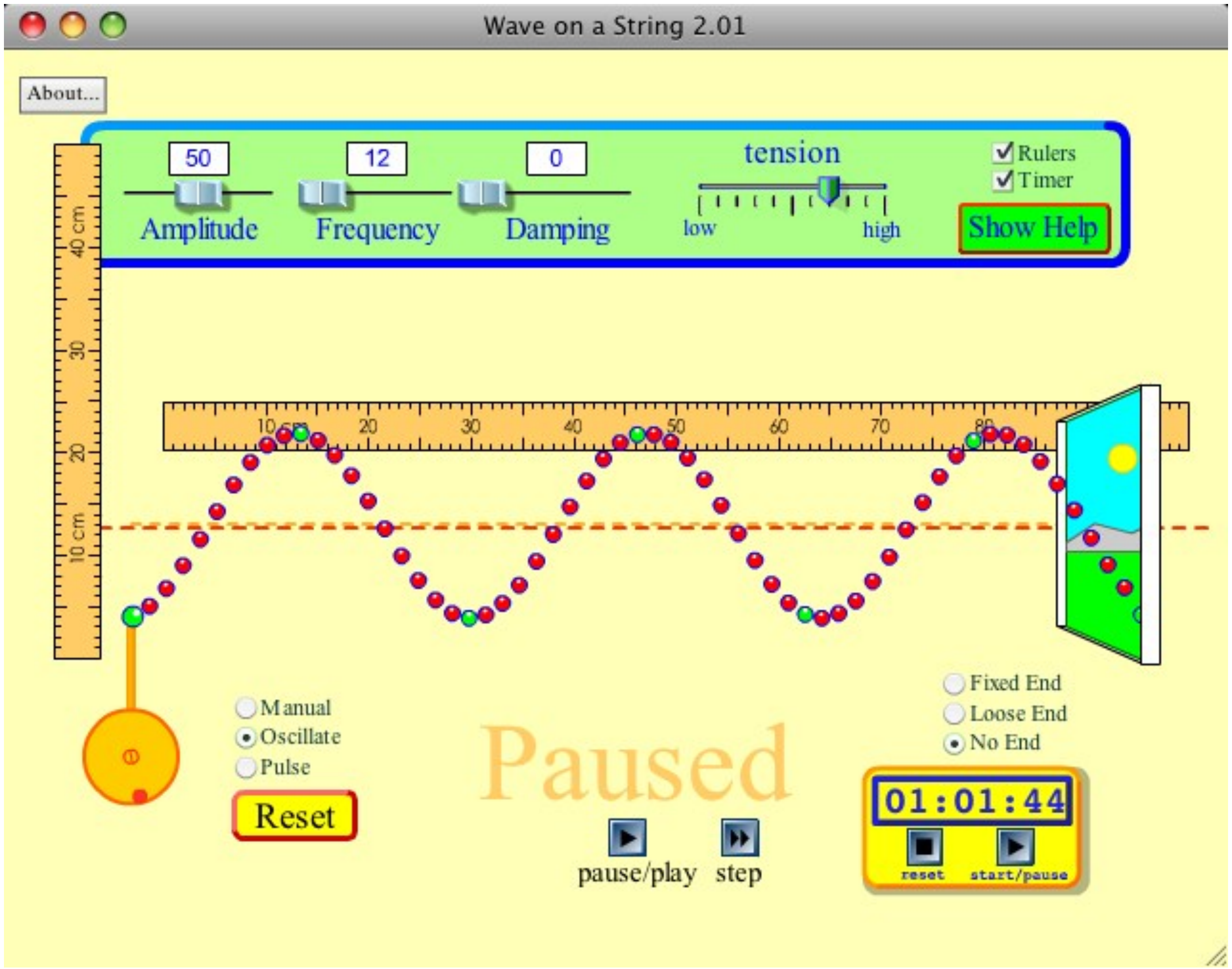
Explore with a simulation



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

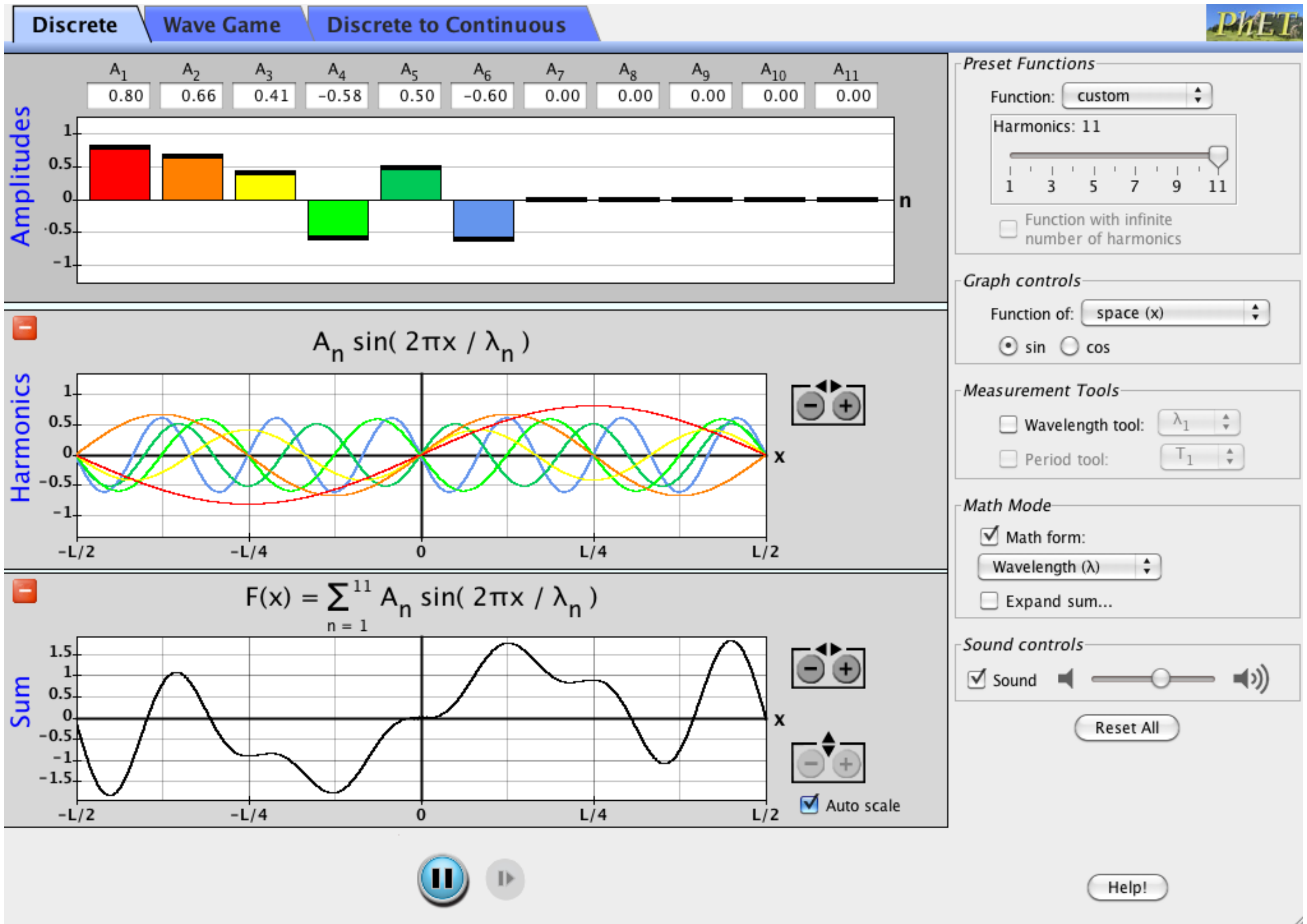
http://phet.colorado.edu/en/simulation/normal-modes

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