Physics 132 Prof. W. Losert

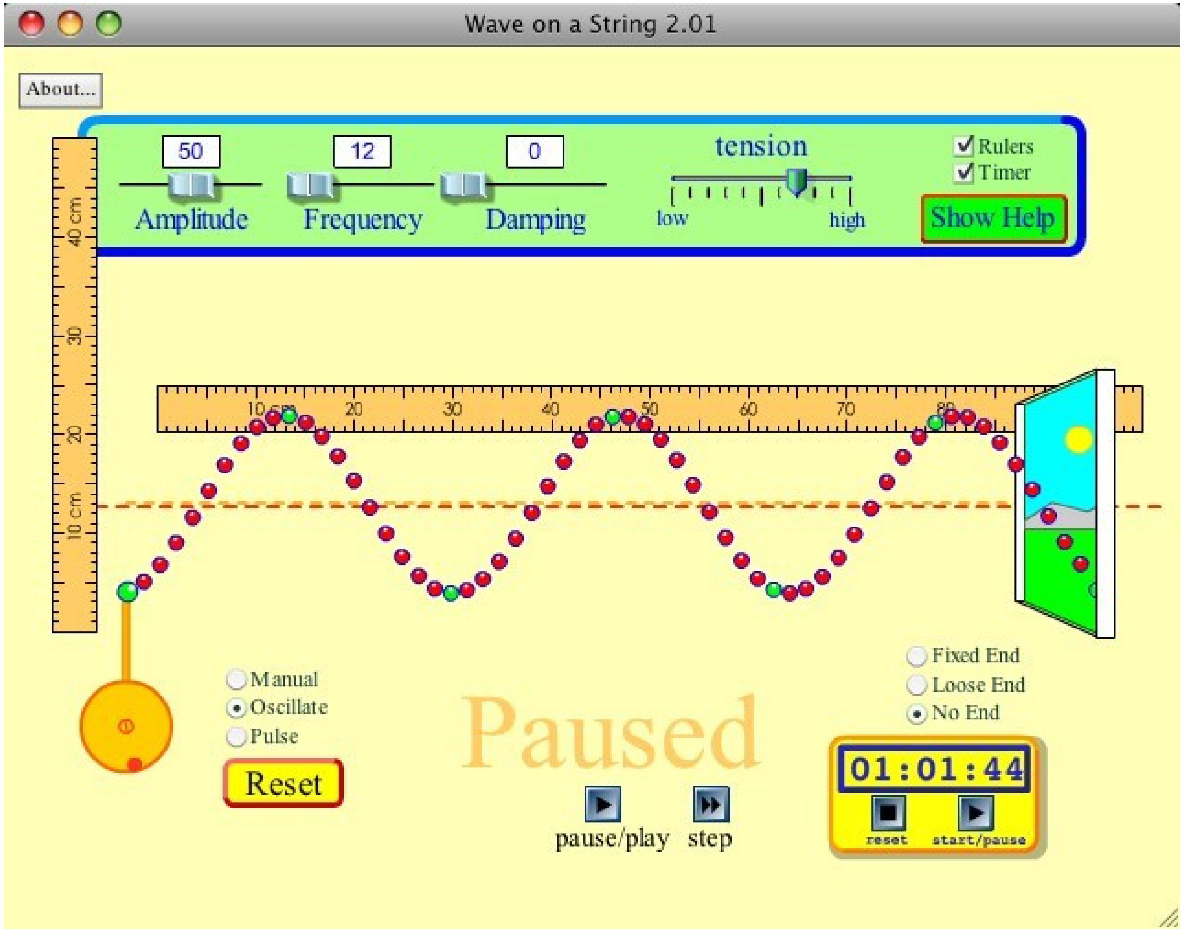
Outline

Standing Waves

Midterm II Makeup FRIDAY 3pm

Office hours in Course Center Thursday 11.30-1

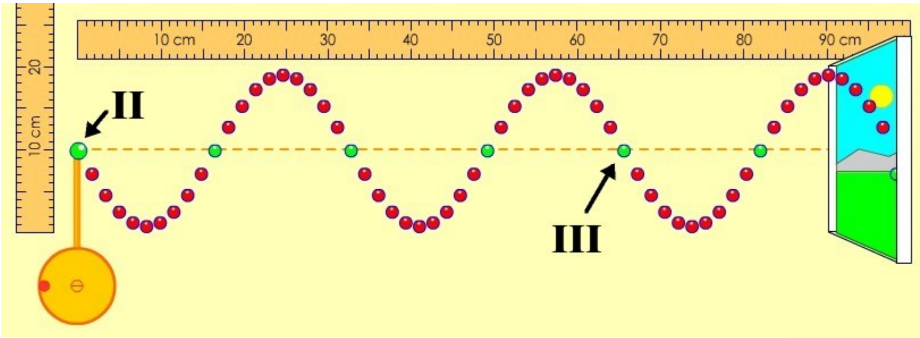
Sinusoidal Waves: $y(x,t) = A\sin k(x - v_0 t)$

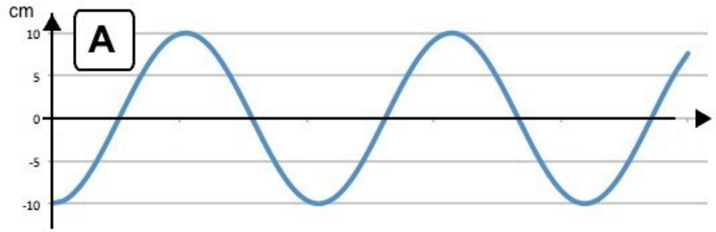


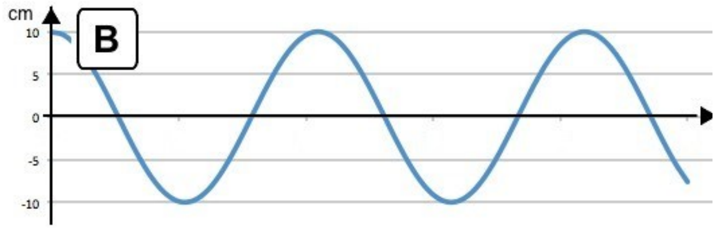
http://phet.colorado.edu/simulations/sims.php?sim=Wave_on_a_String

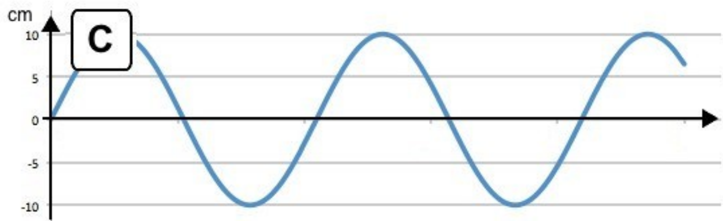
An elastic string (modeled as a series of beads) driven by a wheel driving one of the beads up and down sinusoidally. . The driving wheel has generated a traveling wave of amplitude 10 cm moving to the right. (The string continues on for a long way to the right as indicated by its going “out the window.”) The figure shows t = 0, when the green bead marked “II” is passing through its equilibrium point.

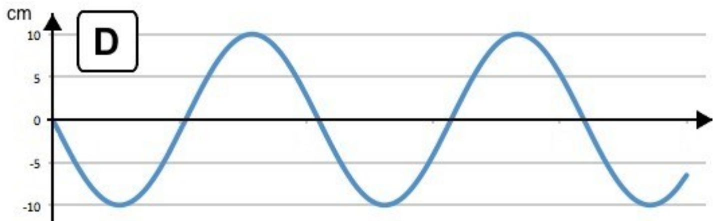
Which of the graphs could serve as the graph of **the vertical displacement of bead II** as a function of **time**?





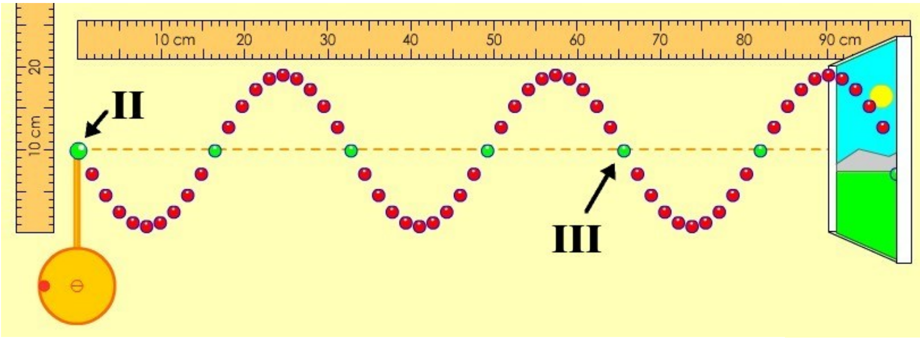


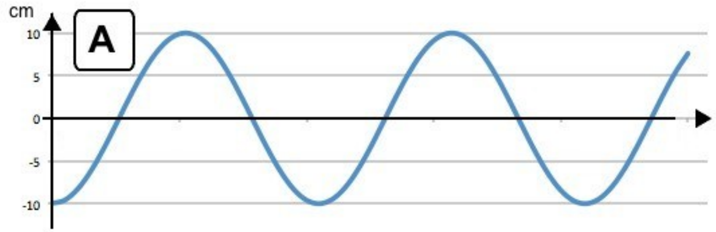


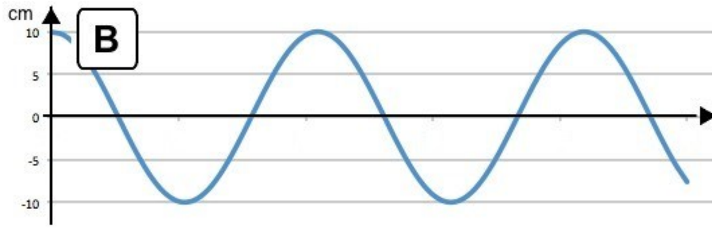


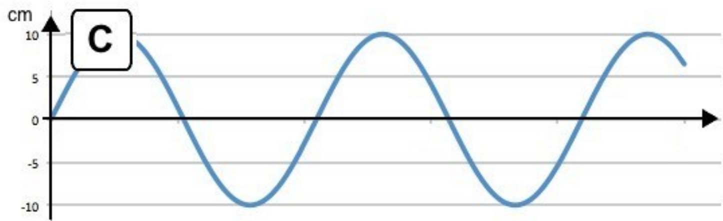
An elastic string (modeled as a series of beads) driven by a wheel driving one of the beads up and down sinusoidally. . The driving wheel has generated a traveling wave of amplitude 10 cm moving to the right. (The string continues on for a long way to the right as indicated by its going "out the window.") The figure shows t = 0, when the green bead marked "II" is passing through its equilibrium point.

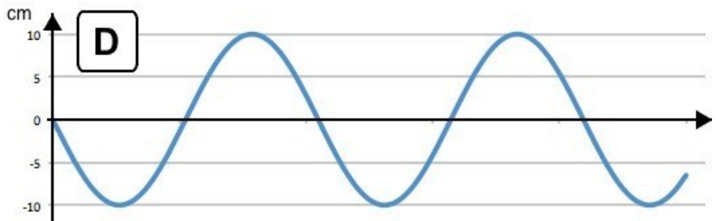
Which of the graphs could serve as a graph of **the vertical displacement of bead III** as a function of **time**?

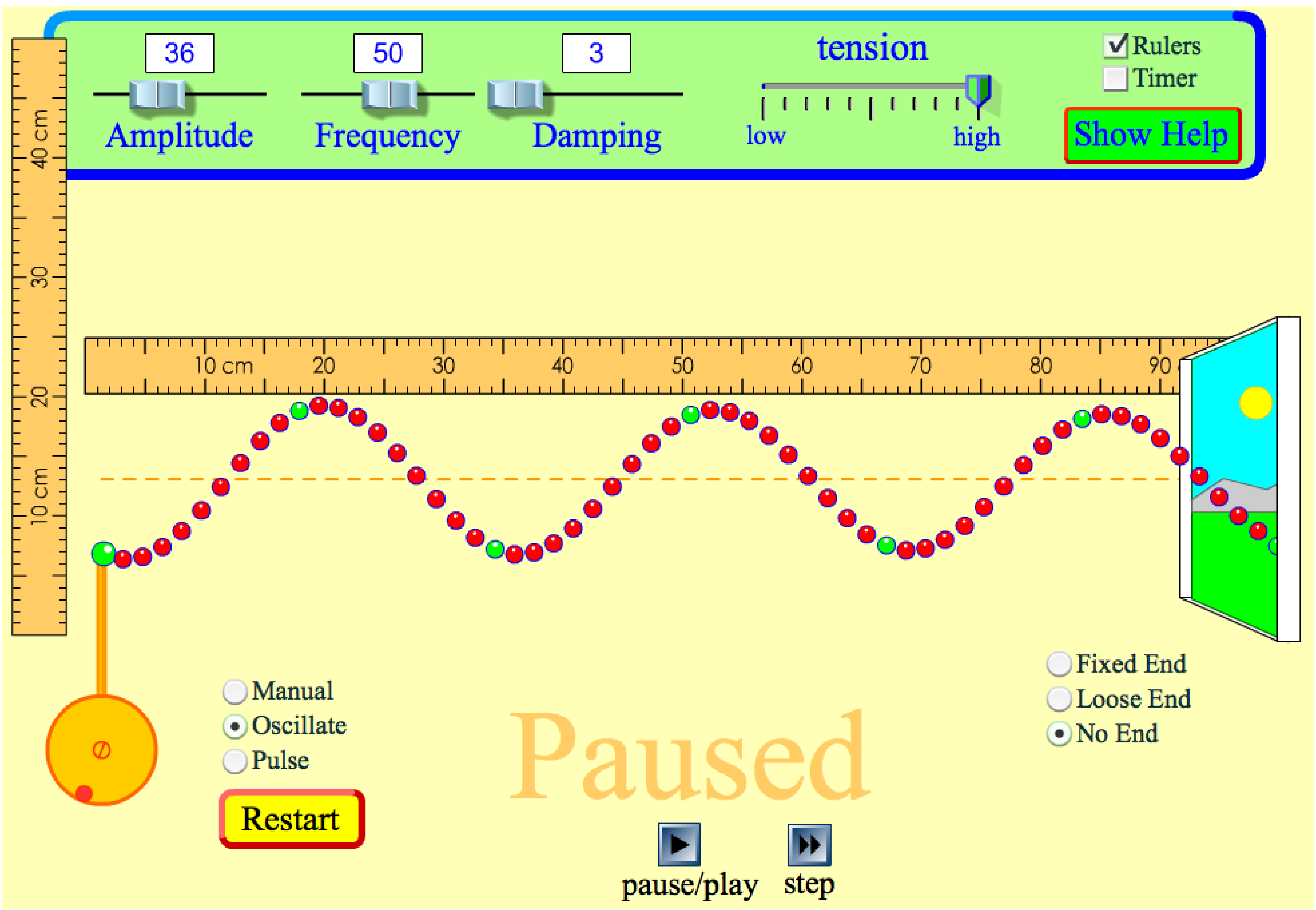


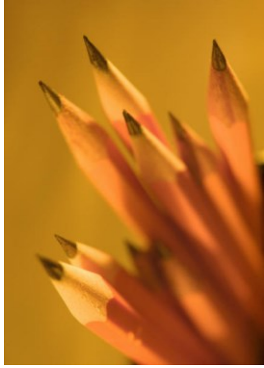












This is the state of the PhET wave-on-a-string simulation when the string is very long so reflection can be ignored. What is the speed of the wave (assuming that the frequency is given in cycles/min?

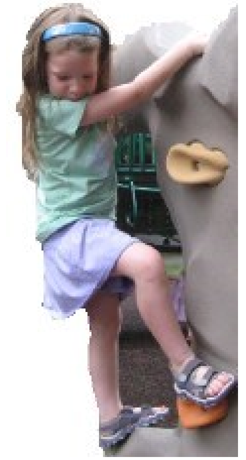
What happens at a fixed end?

1. Pass through like before
2. Stop and die
3. Bounce back right side up
4. Bounce back upside down
5. 3 but delayed
6. 4 but delayed

What happens at a loose end?

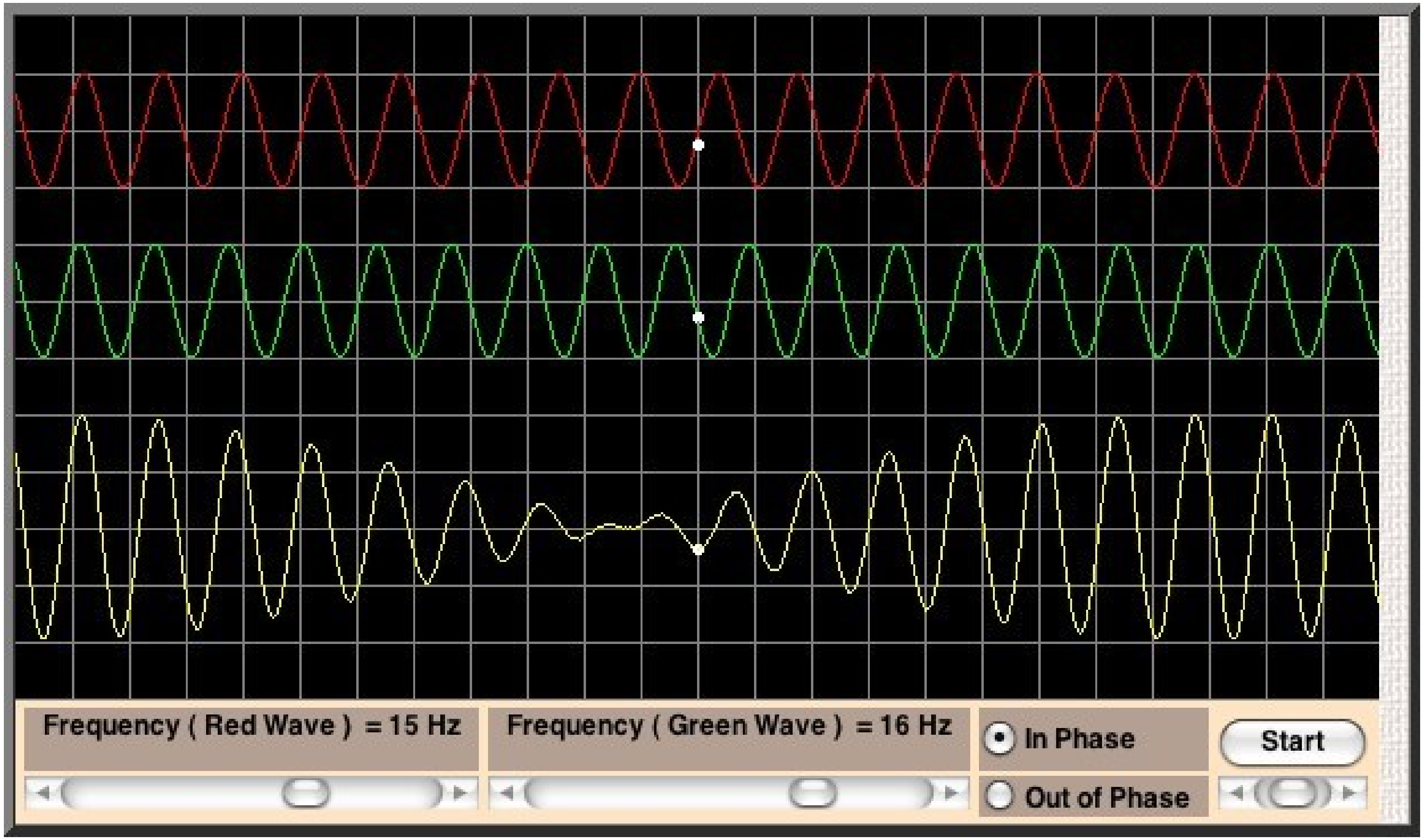
1. Pass through like before
2. Stop and die
3. Bounce back right side up
4. Bounce back upside down
5. 3 but delayed
6. 4 but delayed

Foothold principles: Superposition of Mechanical waves



- *Superposition*: when two or more waves (or pulses) 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</u> <u>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</u> <u>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

Standing waves: Sinusoidal Waves, same frequency, going in opposite directions

$$y(x,t) = A\sin(kx - \omega t) + A\sin(kx + \omega t)$$

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.

Adding Sinusoidal Waves – an example

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

$$y = 2A\sin(kx)\cos(\omega t)$$

Is there a position for which this function is zero at all times?

$$y(x = 0, t) = A\sin(-\omega t) + A\sin(\omega t)$$

$$y(kx = \pi, t) = A\sin(\pi - \omega t) + A\sin(\pi + \omega t)$$

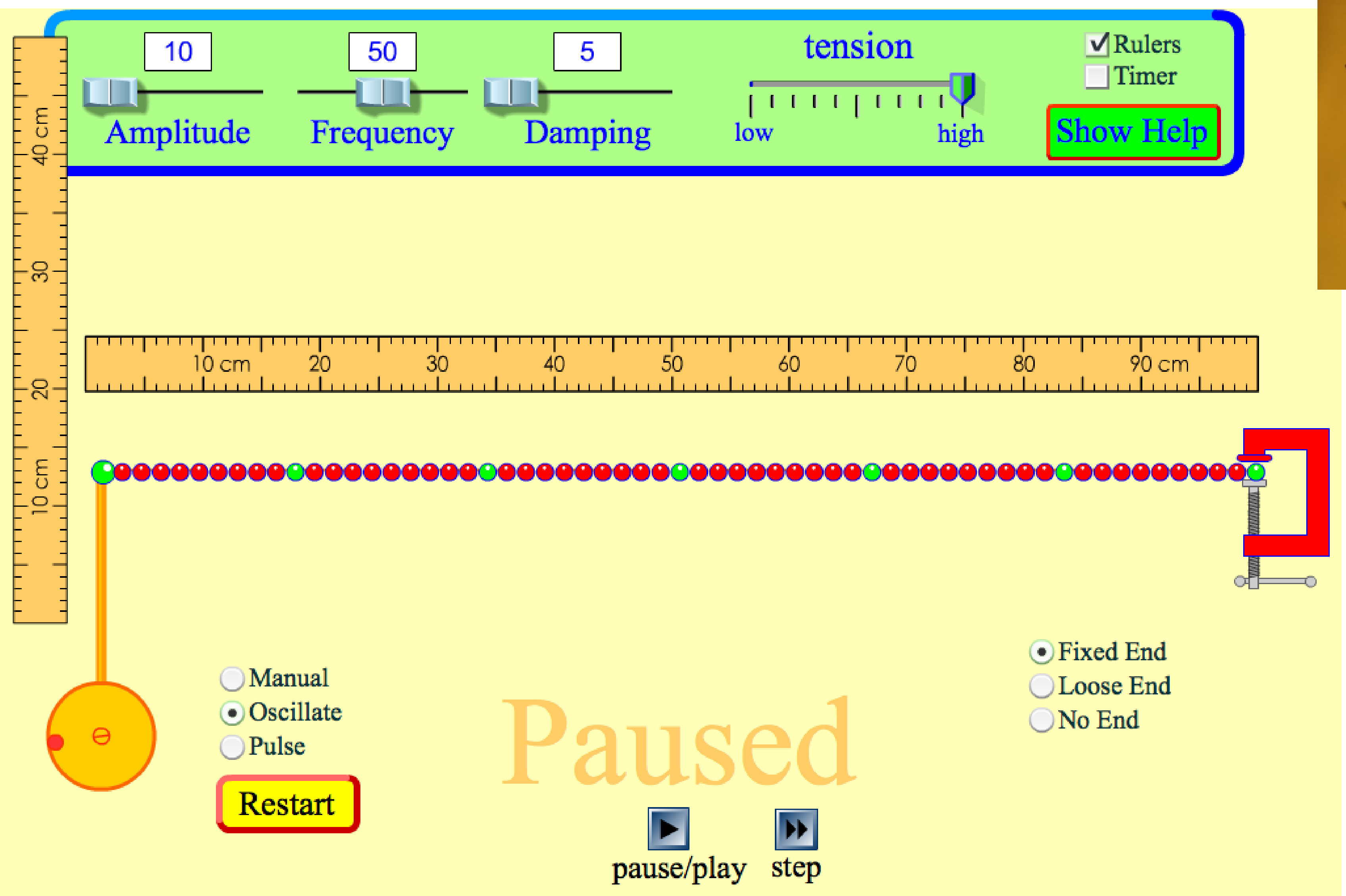
The function is also zero wherever kx is a multiple of π

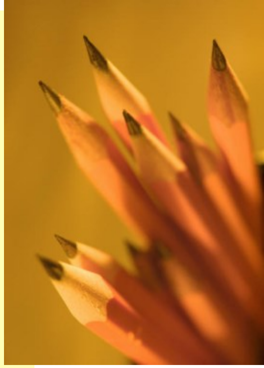
Standing Waves

- Some points in this pattern (values of *x* for which *kx* = nπ) are always 0. (NODES)
- To wiggle like this (all parts oscillating together in a "standing wave") we need to have the end fixed

$$L = n\frac{\lambda}{2}$$

- We still have $v_0 = \omega / k$ that is $v_0 = \lambda f$





For what frequencies will I generate a large (resonant) standing wave if I drive it with a small amplitude?