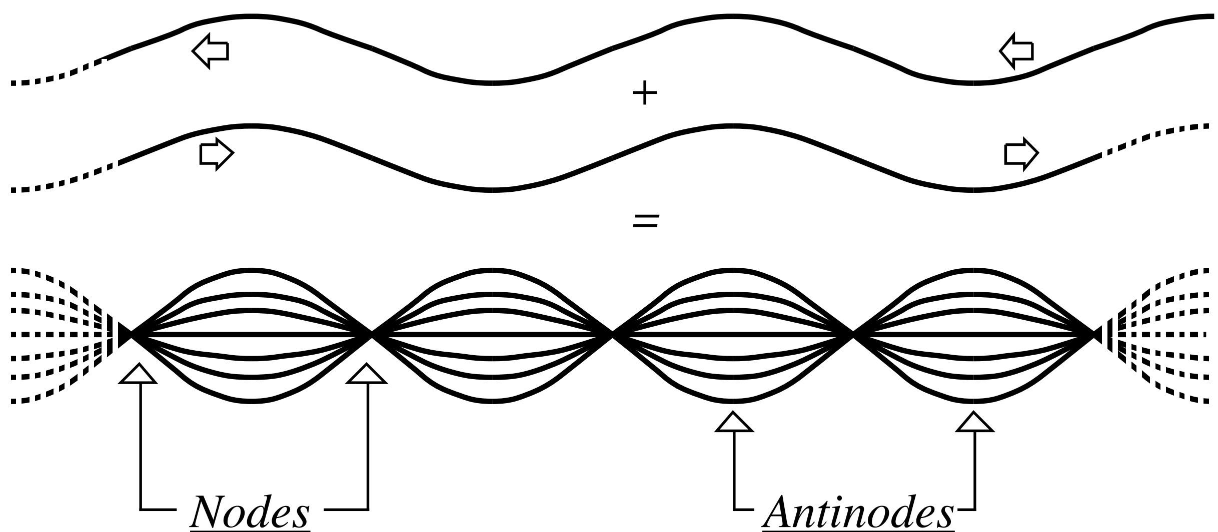
Name________________________

Standing waves

- A *standing wave* is *not* really a wave...
- A standing wave is a historical term for the stationary pattern of nodes and antinodes produced by the superposition of two waves with opposite directions.



Nodes
Where two oppositely traveling waves *always* destructively intefere.

Antinodes
Where two oppositely traveling waves *always* constructively intefere.

Properties of the two waves that are superposed to make a standing wave:

- These two waves must be traveling in opposite directions.
- These two waves must have the same wavelength.
- These two waves must have the same amplitude.
- If two waves are coming from sources at $\pm\infty$, then a standing wave can have any wavelength! In a finite medium, then the extent of the medium determines which wavelengths and hence which frequencies can be excited.

Media conditions determine whether boundaries are nodes or antinodes (relates to phase shift at a boundary)

Standing waves in ropes

1. Leave 2 meters of the spring free. With one person at each end, excite the lowest frequency, the **jump-rope mode**. Measure this frequency, then excite and measure 2 higher frequencies.

2. Draw pictures of the rope for the three frequencies that you produced. Mark the nodes and the antinodes. Record the wavelength, frequencies, and wave speeds

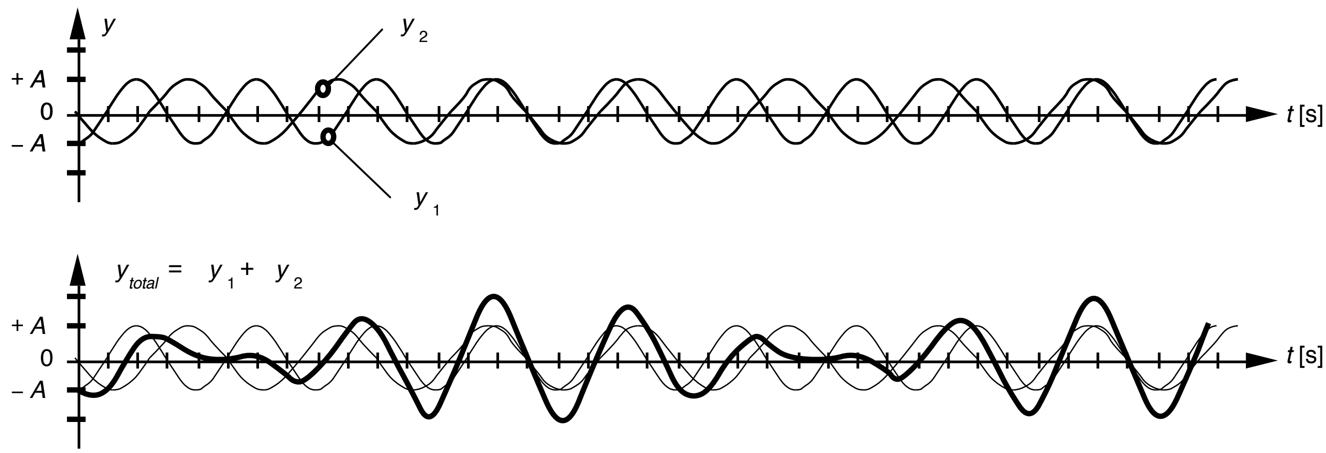
Lowest freq. (fundamental)		$\lambda =$ $f_1 =$ $v_{wave} =$
Middle freq. (2nd harmonic)		$\lambda =$ $f_2 =$ $v_{wave} =$
Highest freq. (3rd harmonic)		$\lambda =$ $f_3 =$ $v_{wave} =$

3. Now hang 120 cm of the spring vertically (with the bottom end free). Find the three lowest frequencies of vibration. Measure these frequencies and draw what these waves look like.

Lowest freq. (fundamental)		$\lambda =$ $f_1 =$ $v_{wave} =$
Middle freq. (2nd harmonic)		$\lambda =$ $f_2 =$ $v_{wave} =$
Highest freq. (3rd harmonic)		$\lambda =$ $f_3 =$ $v_{wave} =$

4. In which cases is there a phase change of 180° (or π) for the reflected wave at the end of the rope, and in which cases is there no phase change. *Think about what happens to the amplitude at the end if there is or isn't a phase change at the end. Remember we are adding two waves together.*

Consider these two waves. The bold line represents the superposition of these two waves.



1. Determine the frequencies f_1 and f_2, in Hz (as decimal values; don't use fraction values).

2. List the times where: (a) $\Delta\theta$ = even·π; (b) $\Delta\theta$ = odd·π. Then specify these times on the graphs above.

Determine the "beat" period and frequency of these waves.

3. How long (in sec) does it take for $\Delta\theta$ to go through one cycle of constructive-destructive-constructive interference on the graph? How frequently (in Hz) do these two waves go through constructive-destructive-constructive interference?

Determine the "pitch" period and frequency of these waves.

4. While these waves are superposing constructively, what is their period (in sec) on the graph? Their frequency (in Hz)? (This is "wiggliness" of the bold line—what your ear hears, after these waves add together.)