Ch 16: Waves I

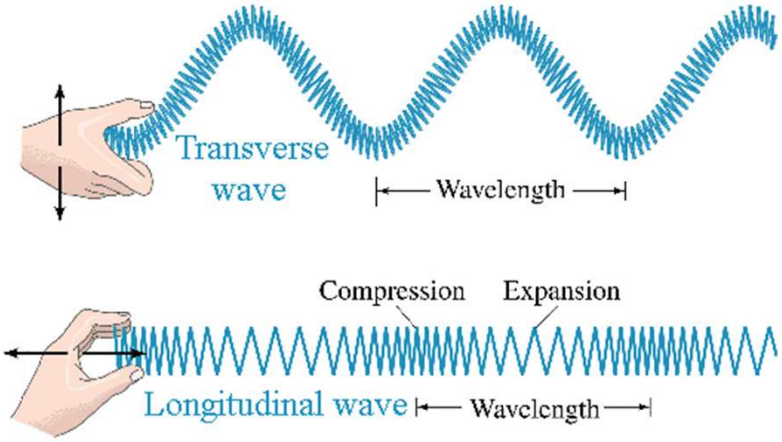
More Details About Transverse Waves

Today's Quest is to Explore:

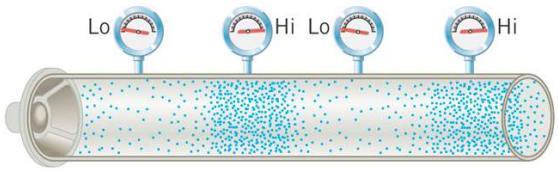
- What are the two main types of Mechanical Waves?
- What is the function that describes both amplitude and position of a wave?
- What happens when you have more than one wave in the same space at the same time?
- What happens when a wave flips back on itself?

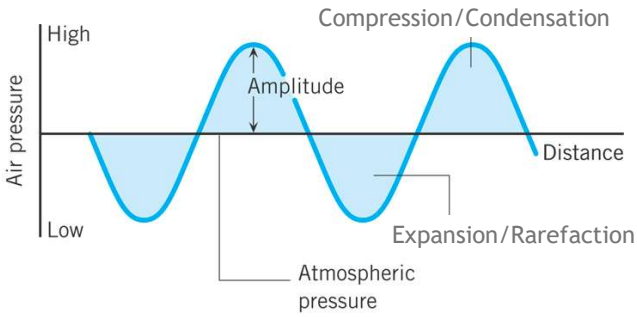
Transverse & Longitudinal Waves

- It's all about the direction of the vibrations (oscillations) that create the wave compared to the direction the wave travels.



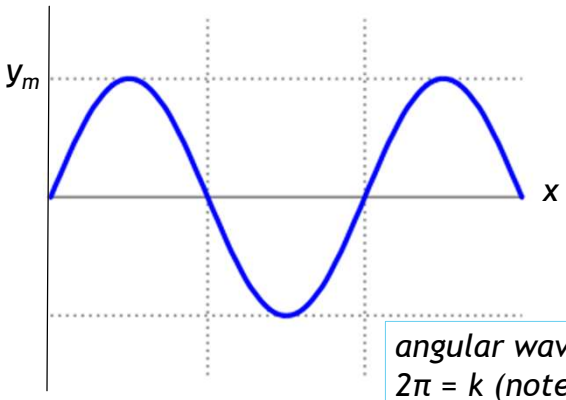
All Wave Variables Apply to Both





Traveling Waves in Space and Time

- A wave is an entity that moves in both space and time, so the function has to describe the amplitude (size) of the wave both in terms of *x* and *t*.
- Let's start with what the wave looks like as a function of position.



General equation

$$y(x)=y_m \sin(x)$$

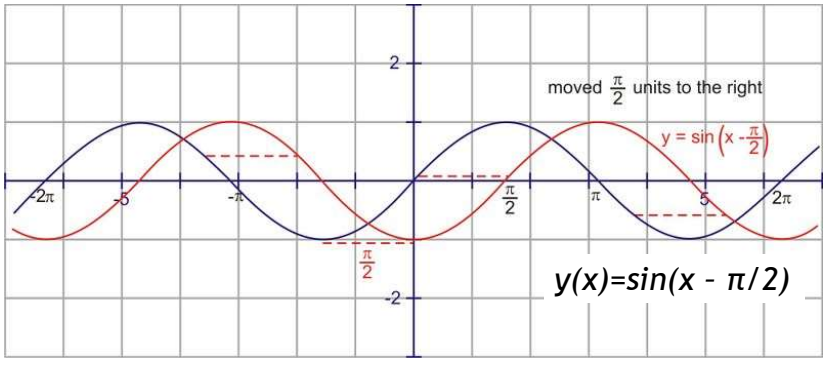
The sine function resets (repeats) every 2π, so from a position point of view the function is really:

$$y(x)=y_m \sin\left(\frac{2\pi}{\lambda} x\right)$$

angular wave number

$$\frac{2\pi}{\lambda} = k \text{ (note: } k \text{ also } = \omega/v)$$

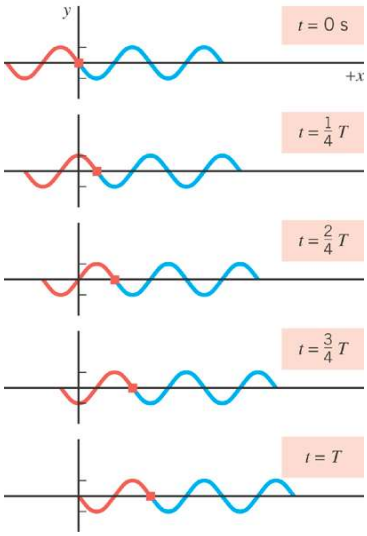
Shifting Waves



$$y(x)=\sin(x - \pi/2)$$

$$y(x,t)=y_m \sin\left(\frac{2\pi}{\lambda} x - \frac{2\pi}{T} t\right)$$

Cleaning Up the Equation

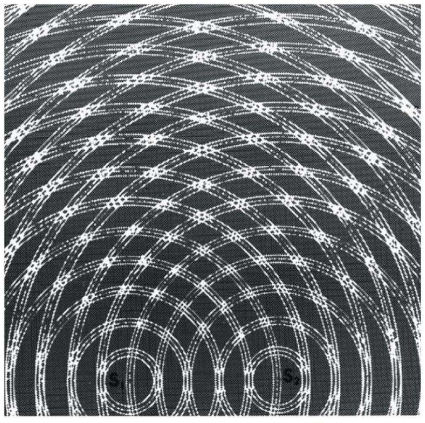


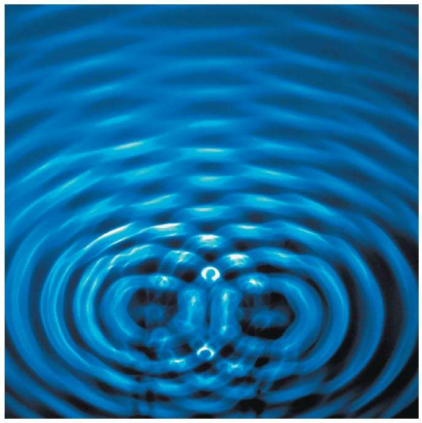
$$y(x,t)=y_m \sin\left(\frac{2\pi}{\lambda}x - \frac{2\pi}{T}t\right)$$

$\frac{2\pi}{\lambda} = k$ $\quad \frac{2\pi}{T} = 2\pi f = \omega$

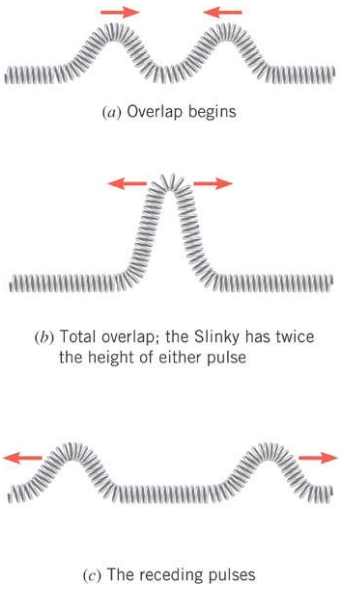
$$y(x,t)=y_m \sin(kx - \omega t)$$

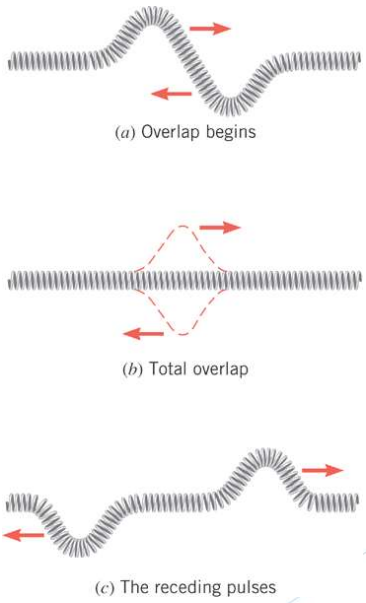
Waves Sharing Space: Interference





Principle of Linear Superposition



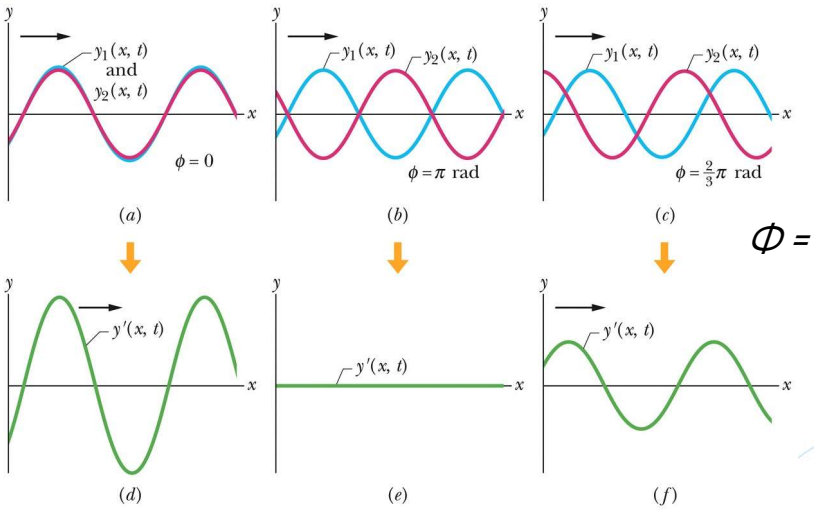


Constructive & Destructive Interference

Being exactly in phase, the waves produce a large resultant wave.

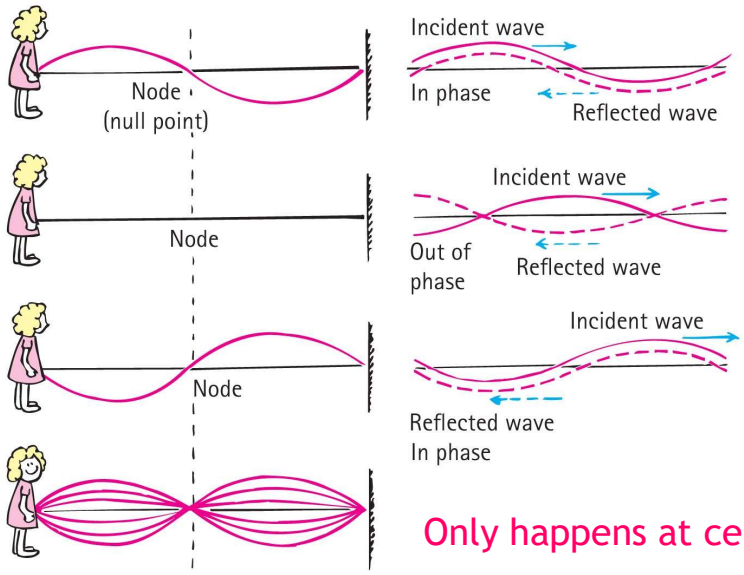
Being exactly out of phase, they produce a flat string.

This is an intermediate situation, with an intermediate result.



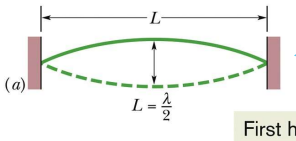
Φ = phase difference

Flipped Waves: Standing Waves



Only happens at certain frequencies!

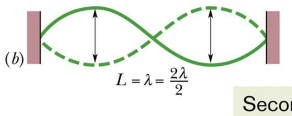
Harmonics



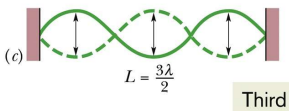
L = length of the string

λ = 2L

First harmonic

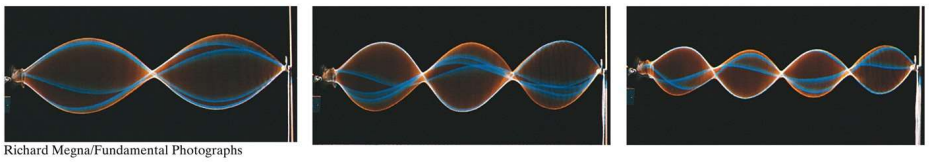


Second harmonic



Third harmonic

$$f = \frac{v}{\lambda} = n\frac{v}{2L}, \quad \text{for } n = 1, 2, 3, \ldots$$



Richard Megna/Fundamental Photographs