EXAM III

Physics 101: Lecture 21
Waves

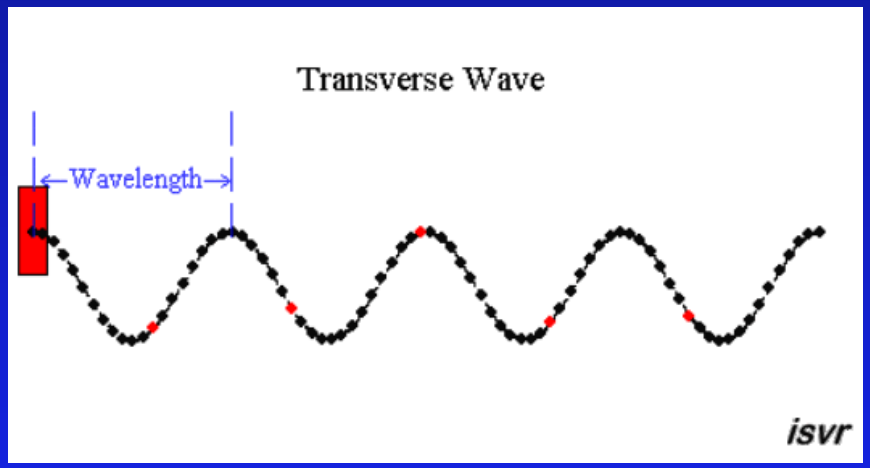
Today's lecture will cover Textbook Chapter 11

Waves Overview

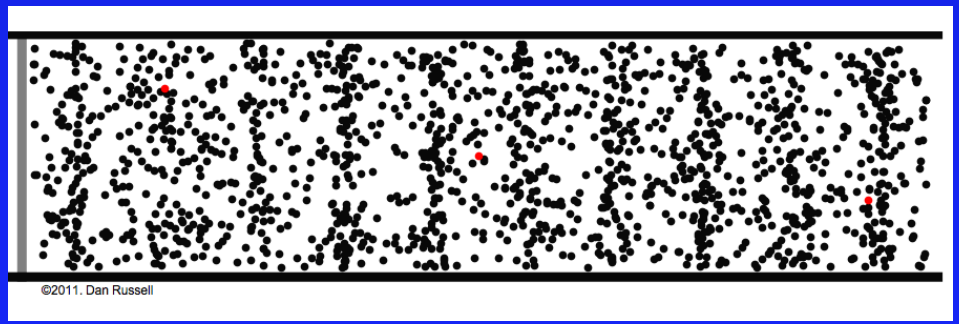
- Types
- Speed
- Harmonic
- Superposition and Interference
- Standing

Types of Waves

- **Transverse:** The medium oscillates perpendicularly to the direction the wave is moving.
  - ➔Water (more or less)
  - ➔Slinky demo



- **Longitudinal:** The medium oscillates in the same direction as the wave is moving
  - ➔Sound
  - ➔Slinky demo

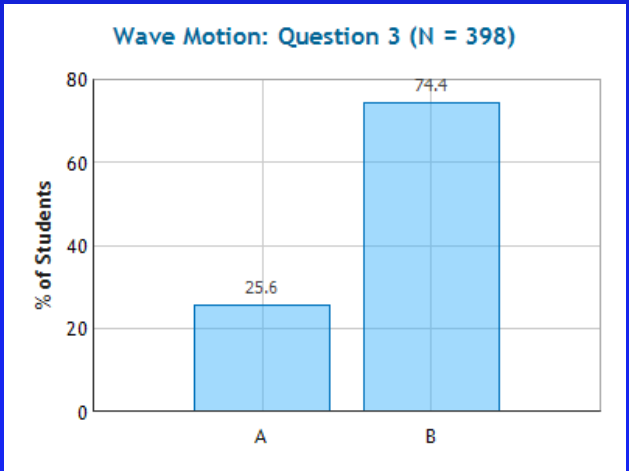


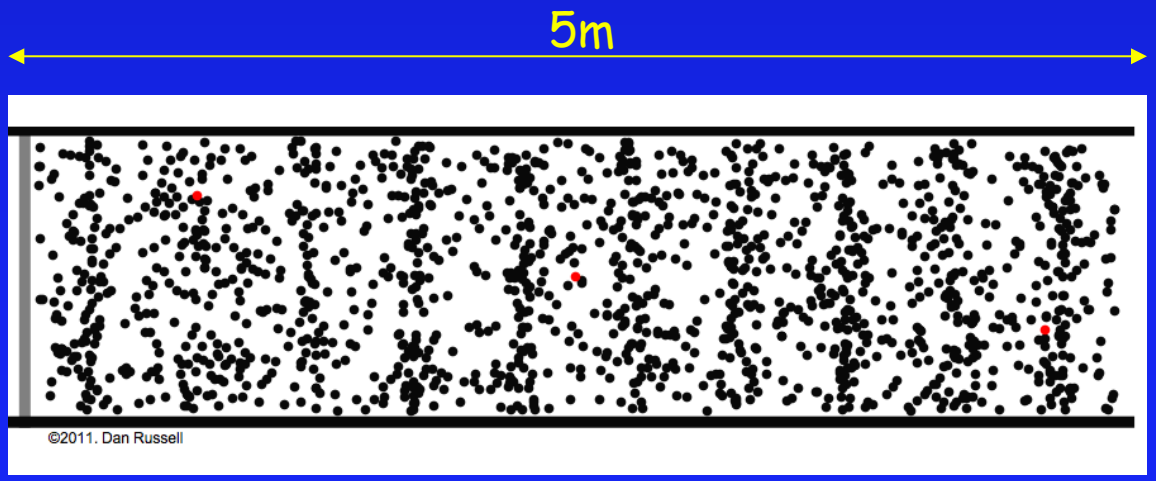
Slinky Checkpoint 3

Suppose that a longitudinal wave moves along a Slinky at a speed of 5 m/s. Does one coil of the slinky move through a distance of five meters in one second?

1. Yes
2. No ⟵ correct

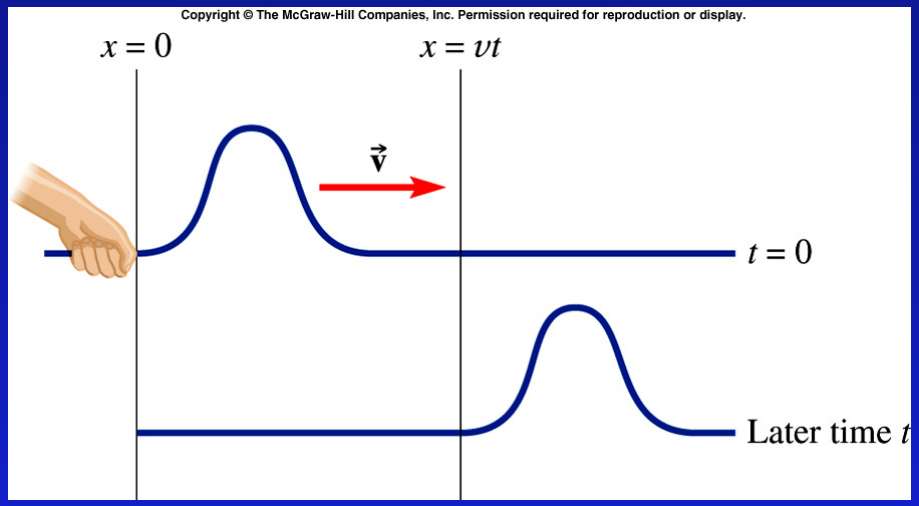
the coil won't move, 5m/s is the speed for wave propagation





Velocity of Waves Act

$$v = \sqrt{\frac{T_{ension}}{m/L}} = \sqrt{\frac{T_{ension}}{\mu}}$$



A spring and slinky are attached and stretched. Compare the speed of the wave pulse in the slinky with the speed of the wave pulse in the spring.

A) $v_{slinky} > v_{spring}$ B) $v_{slinky} = v_{spring}$ C) $v_{slinky} < v_{spring}$

Slinky stretches more, so it has a smaller mass/length μ.

Waves

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

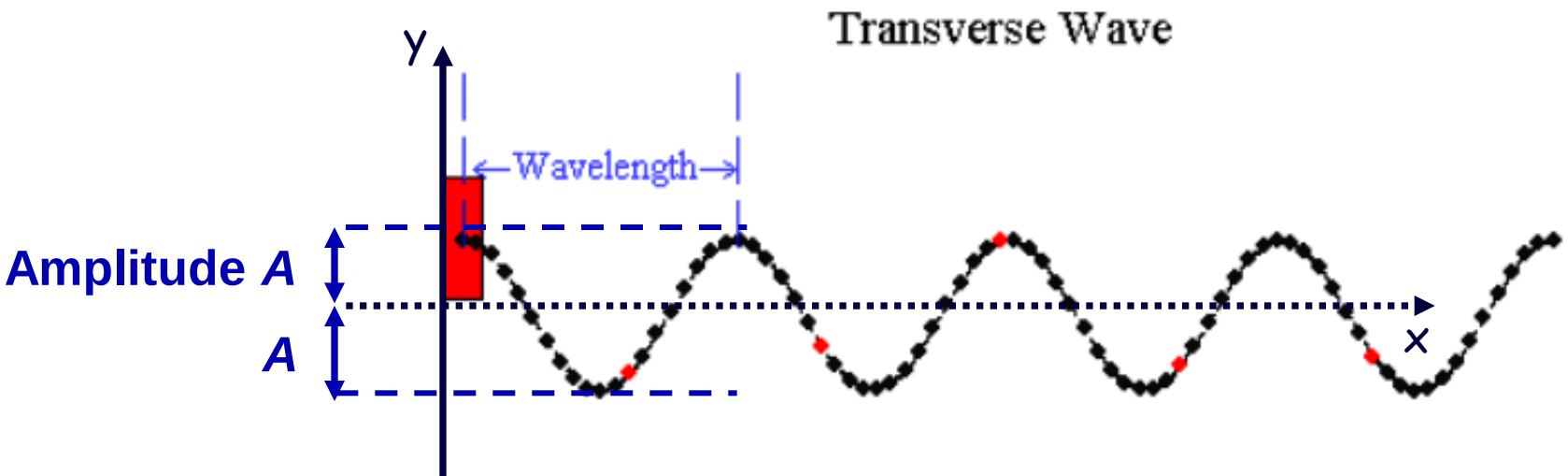
Wavelength: The distance λ between identical points on the wave.

Amplitude: The maximum displacement *A* of a point on the wave.

Angular Frequency ω: $\omega = 2\pi f$

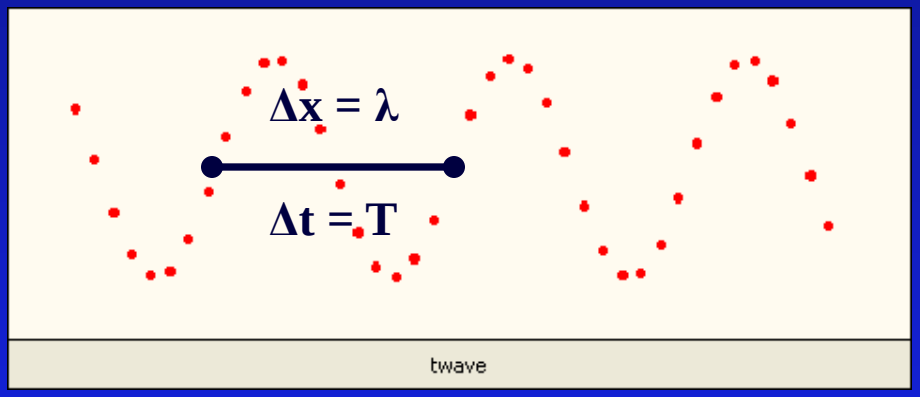
Wave Number k: $k = 2\pi / \lambda$

Remember: $f = v / \lambda$



Period and Velocity

- Period: The time *T* for a point on the wave to undergo one complete oscillation.



- Speed: The wave moves one wavelength λ in one period *T* so its speed is $v = \lambda / T$.

$$v = \frac{\lambda}{T} = \lambda f$$

Waves Exercise

Graph $y(x,t) = 2\cos(4t - 2x)$ at x=0.

Label axis and tic marks if the graph shows a snapshot of the wave

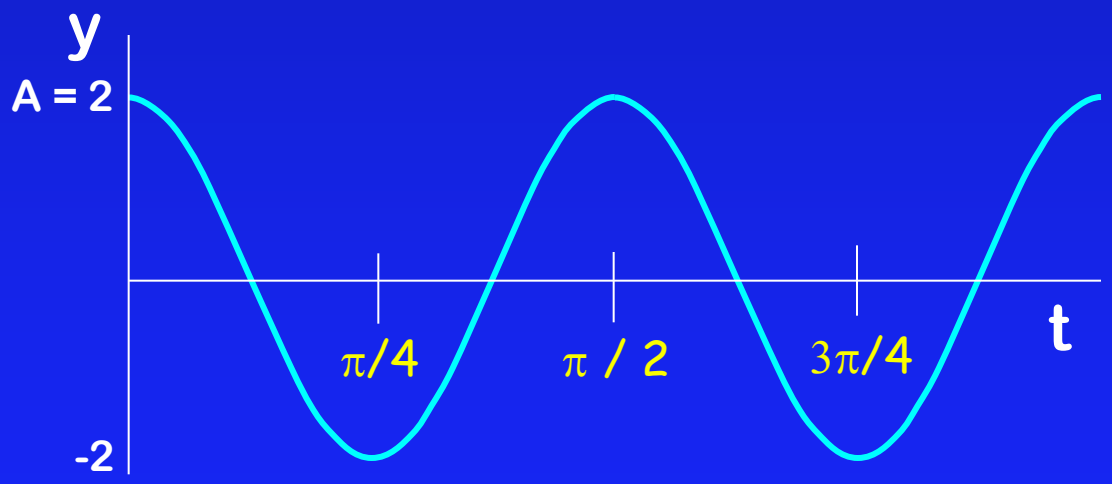
$$y(x,t) = A\cos(\omega t) \quad (x = 0)$$

Recall: $T = 2\pi/\omega$

$T = 2\pi / \omega$

$= 2\pi/4$

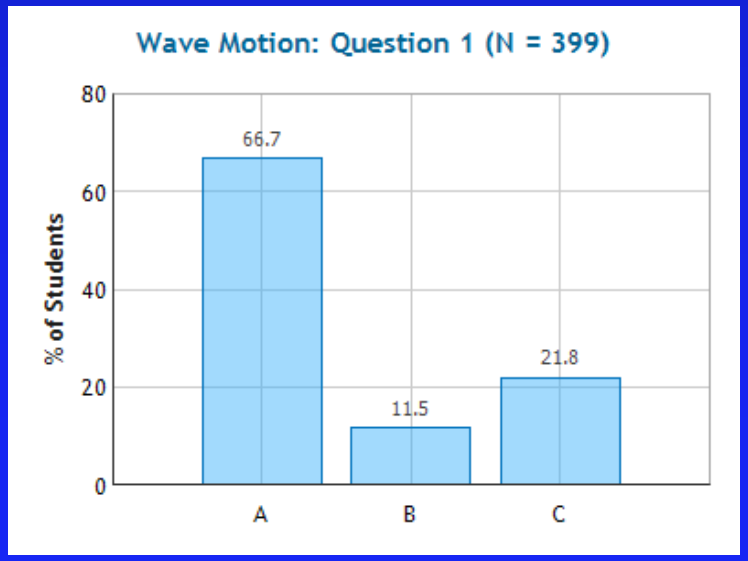
$= \pi/2$



Checkpoint 1+2

Suppose a periodic wave moves through some medium. If the period of the wave is increased, what happens to the wavelength assuming the speed remains the same?

1. The wavelength increases ⟵ correct
2. The wavelength remains the same
3. The wavelength decreases



$v = \lambda / T$

$\Rightarrow \quad \lambda = vT$

ACT

- The wavelength of microwaves generated by a microwave oven is about *3 cm*. At what frequency do these waves cause the water molecules in your burrito to vibrate ?

(a) *1 GHz* (b) *10 GHz* (c) *100 GHz*

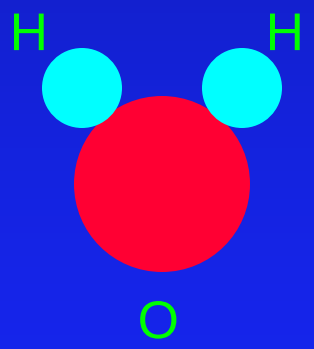
1 GHz = 10^9 cycles/sec

The speed of light is $v = 3x10^8$ *m/s*

ACT Solution

- Recall that $v = \lambda f$

$$f = \frac{v}{\lambda} = \frac{3 \times 10^8 \ m/s}{.03m} = 10^{10} \ Hz = 10GHz$$



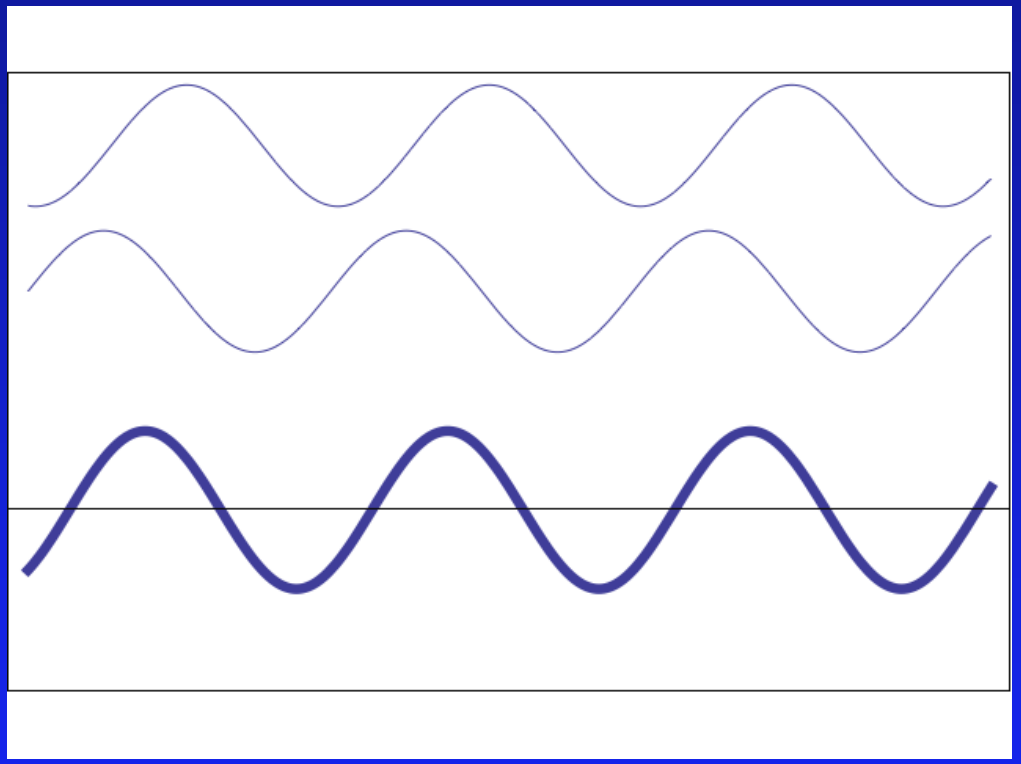
Makes water molecules wiggle

1 GHz = 10^9 cycles/sec

The speed of light is $c = 3x10^8$ *m/s*

Interference and Superposition

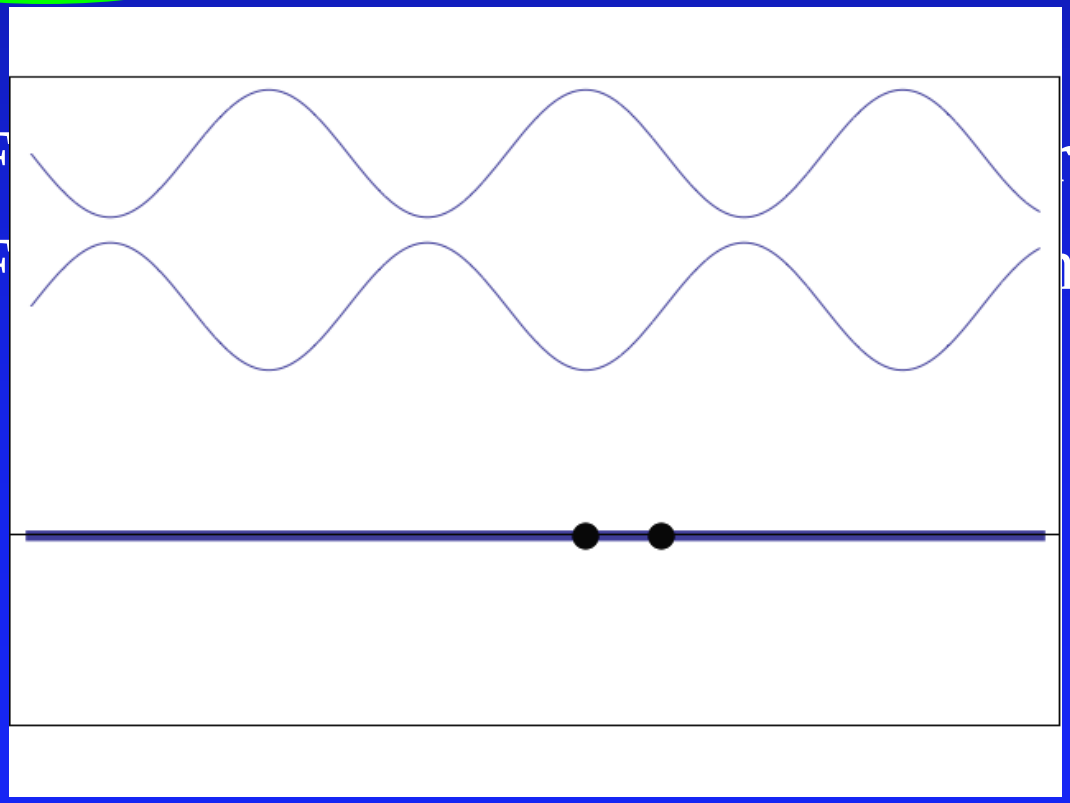
- When two waves overlap, the amplitudes add.
  - ➔Constructive: increases amplitude
  - ➔Destructive: decreases amplitude

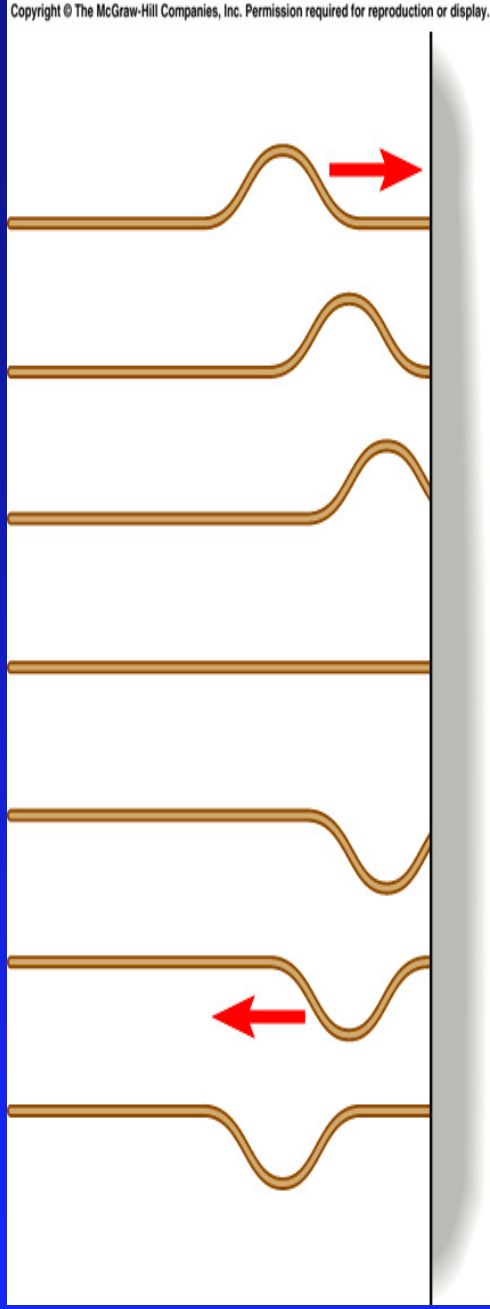


Reflection Act

- A slinky is connected to a wall at one end. A pulse travels to the right, hits the wall and is reflected back to the left. The reflected wave is

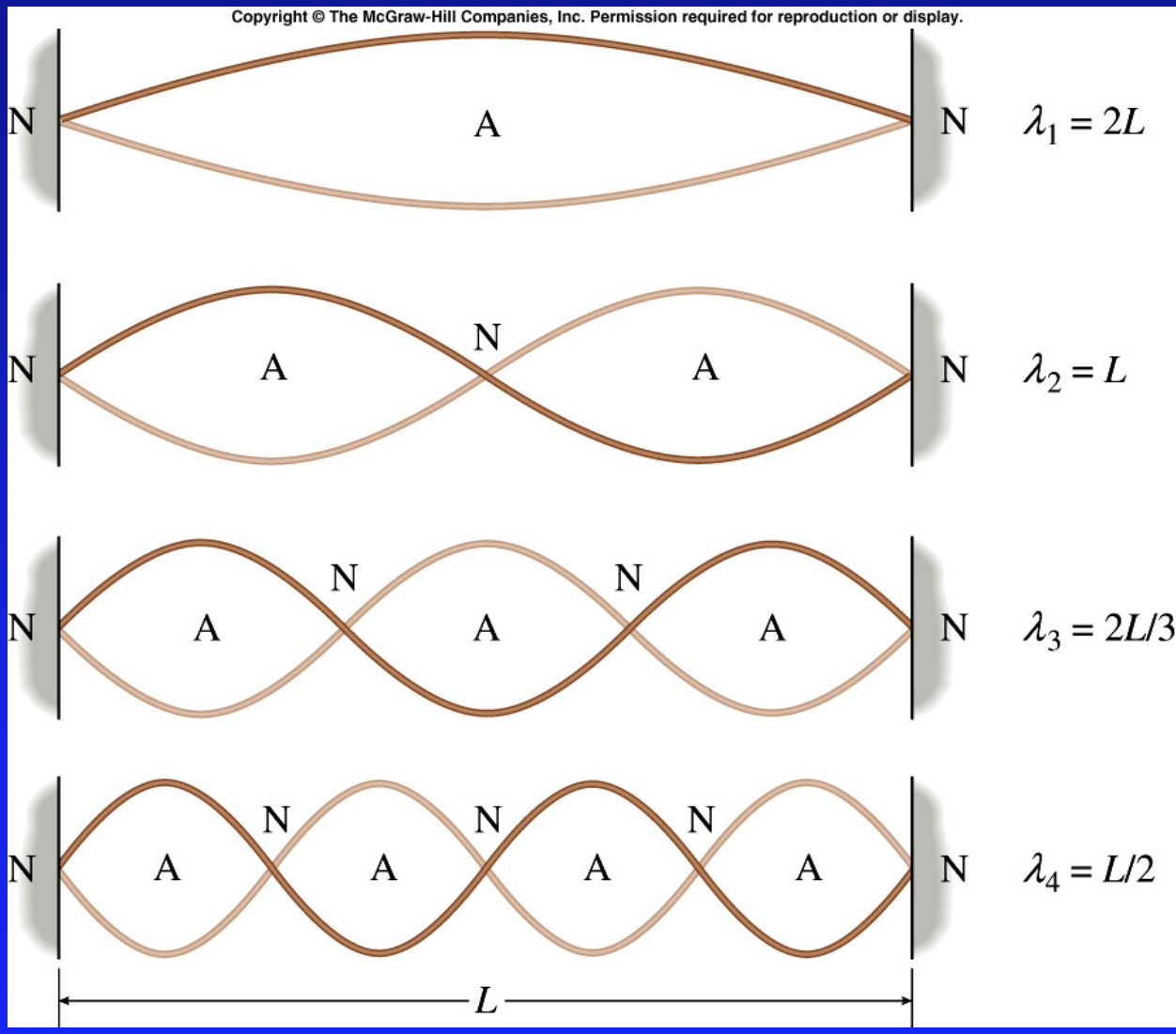
A) Inverted B) Upright





Standing Waves Fixed Endpoints

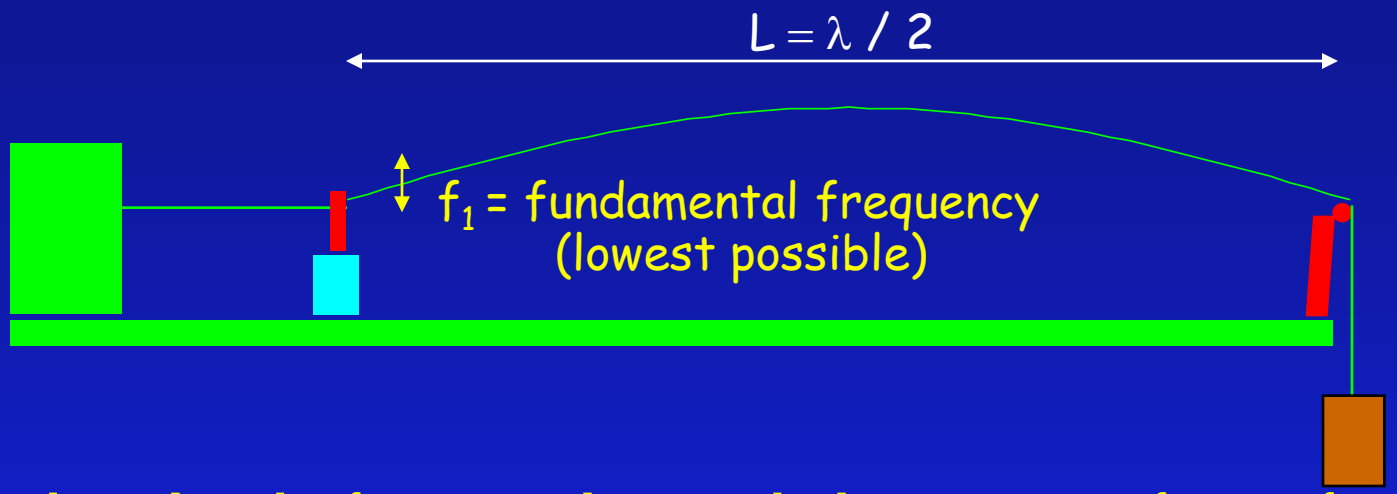
- Fundamental n=1 (2 nodes)
- $\lambda_n = 2L/n$
- $f_n = n\ v / (2L)$



https://www.youtube.com/watch?v=j2pPJywRGTk

https://www.youtube.com/watch?v=xhrBDcQq2DM

Standing Waves:



A guitar's E-string has a length of 65 cm and is stretched to a tension of 82N. If it vibrates with a fundamental frequency of 329.63 Hz, what is the mass of the string?

$$v = \sqrt{\frac{T}{\mu}}$$

f = v / λ tells us v if we know f (frequency) and λ (wavelength)

$v = \lambda f$

$= 2\ (0.65\ m)\ (329.63\ s^{-1})$

$= 428.5\ m/s$

$v^2 = T / \mu$

$\mu = m/L = T / v^2$

$m = T L / v^2$

$= 82\ (0.65) / (428.5)^2$

$= 2.9 \times 10^{-4}\ kg$

Summary

- Wave Types
  - ➔Transverse (eg pulse on string, water)
  - ➔ Longitudinal (sound, slinky)
- Harmonic
  - ➔$y(x,t) = A\cos(\omega t - kx)$ or $A\sin(\omega t - kx)$
- Superposition
  - ➔Just add amplitudes
- Reflection (fixed point inverts wave)
- Standing Waves (fixed ends)
  - ➔$\lambda_n = 2L/n$
  - ➔$f_n = n\,v / 2L$