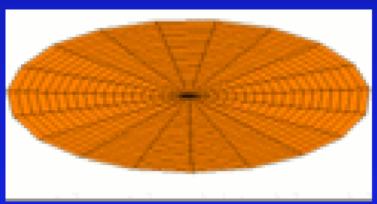
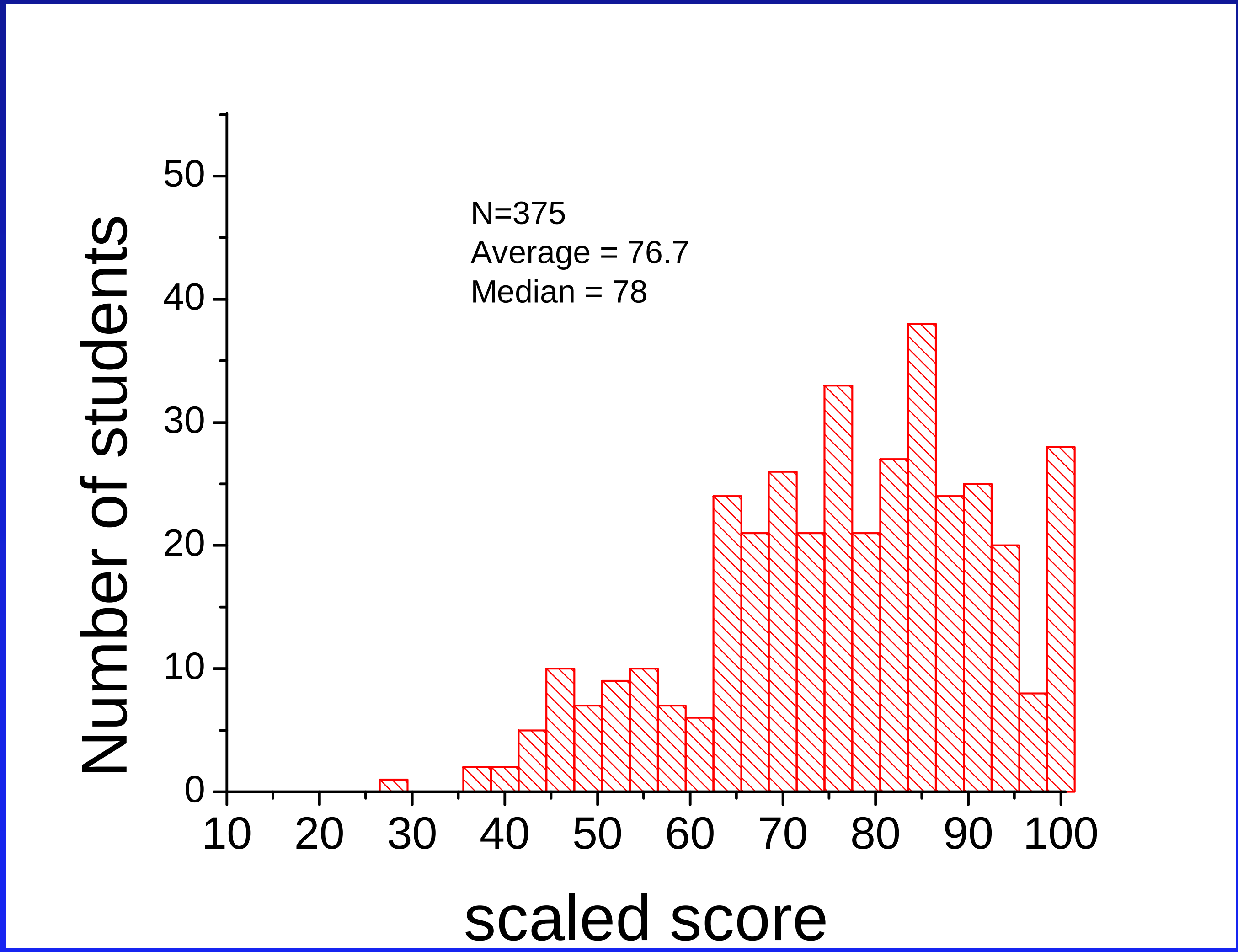
Exam III

Physics 101: Lecture 21
Waves

Today's lecture will cover Textbook Chapter 11



HE2 Results


N=375
Average = 76.7
Median = 78
Number of students
0
10
20
30
40
50
10
20
30
40
50
60
70
80
90
100
scaled score

Projection based on a previous semester

Avg (ex 1&2), max grade, median grade, min grade

53- 56	C-,	D-,	F	N: 10
57- 60	C,	D+,	F	N: 18
61- 64	C+,	D+,	F	N: 19
65- 68	B+,	C,	D	N: 37
69- 72	A-,	C,	D-	N: 52
73- 76	A-,	C+,	D-	N: 52
77- 80	A,	B,	D-	N: 55
81- 84	A+,	B+,	C-	N: 39
85- 88	A+,	A-,	D-	N: 47
89- 92	A+,	A,	C	N: 32
93- 96	A+,	A+,	A-	N: 22
97-100	A+,	A+,	A+	N: 03

Hour Exam 3

April 25.

Covers Lectures 17-24 (8 Lectures)

Finals will cover everything including the new materials in Lectures 25-28.

Preflight 5

Which concepts did you find the most difficult when preparing for this lecture?

there was a lot of info

Standing waves was difficult to understand. What does it mean and can you give another explanation as to how to calculate it? Also, reflection was not explained enough. What is the difference between a fixed and a free boundary?

Overtones!

harmonic waves.

Longitudinal waves.

Everything…

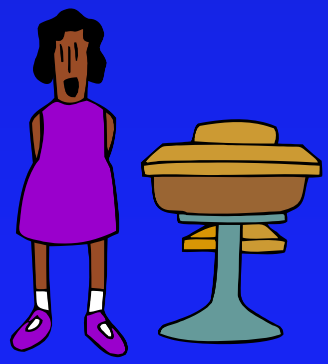
Nothing…

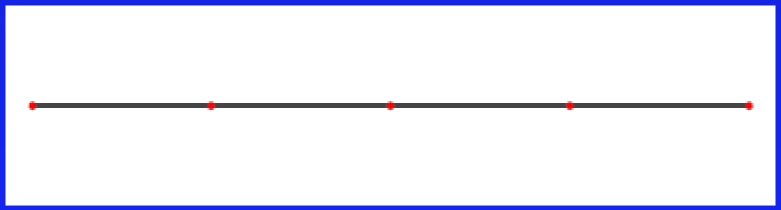
Not paying attention

Waves Overview

- Types
- Speed

- Harmonic
- Superposition
- Standing





Types of Waves

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

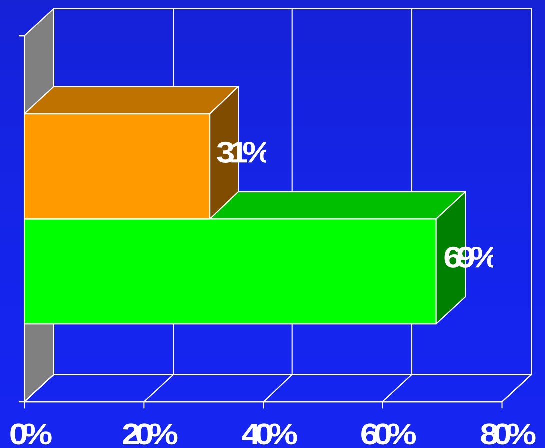
- **Longitudinal:** The medium oscillates in the same direction as the wave is moving
  - ➔Sound
  - ➔Slinky demo

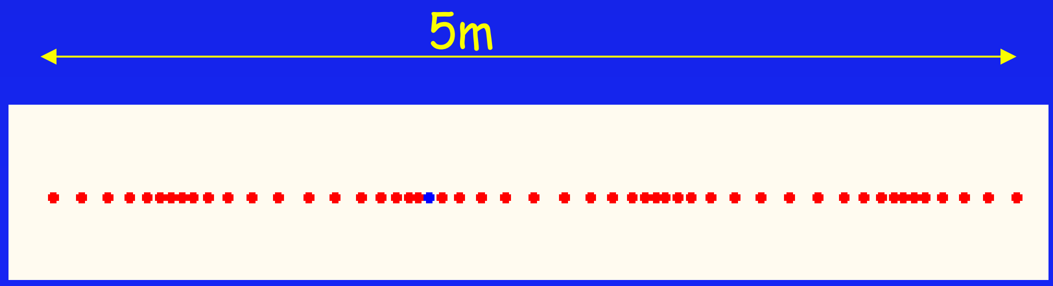
Slinky Preflight 3

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

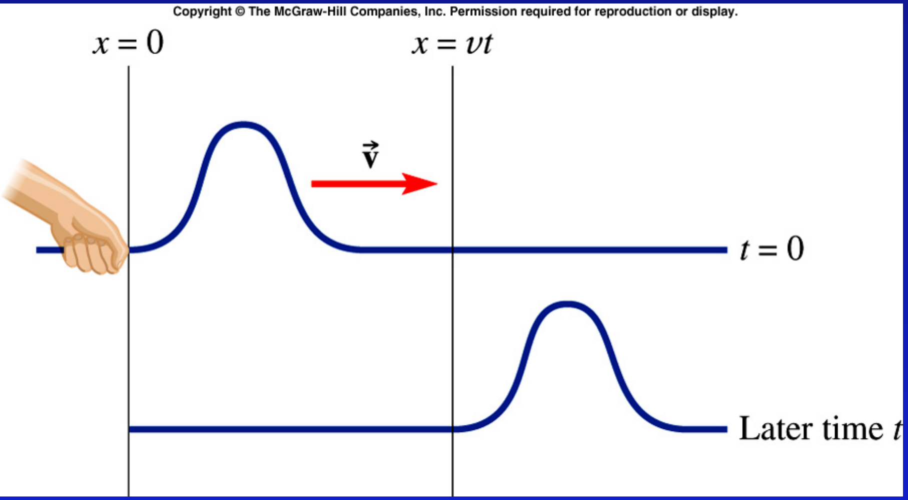
the coil won't move, 5m/s is the speed for wave propagation





Velocity of Waves Act

$$v = \sqrt{\frac{\text{Tension}}{m/L}} = \sqrt{\frac{\text{Tension}}{\mu}}$$



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.

Harmonic Waves

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

"the weird/new symbols get me confused i never know what they represent "

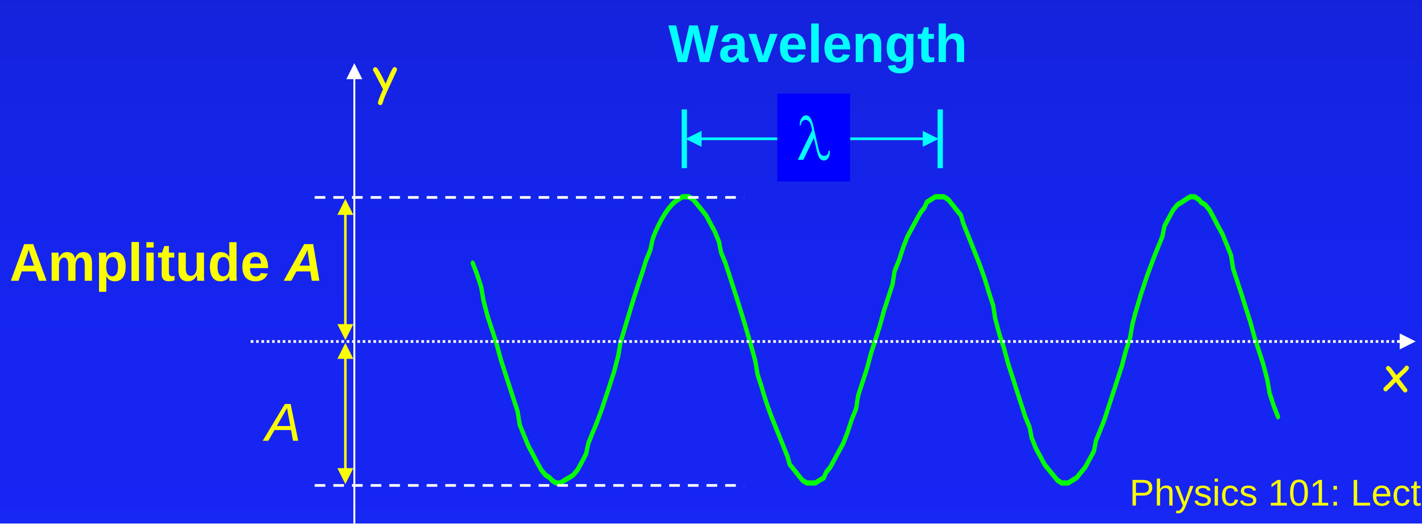
Wavelength: The distance λ between identical points on the wave.

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

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

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

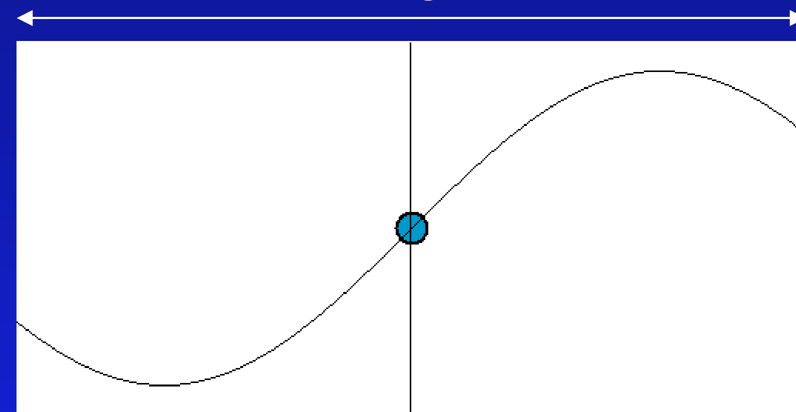
Recall: $f = v / \lambda$



Period and Velocity

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

wavelength λ



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

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

Harmonic Waves Exercise

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

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

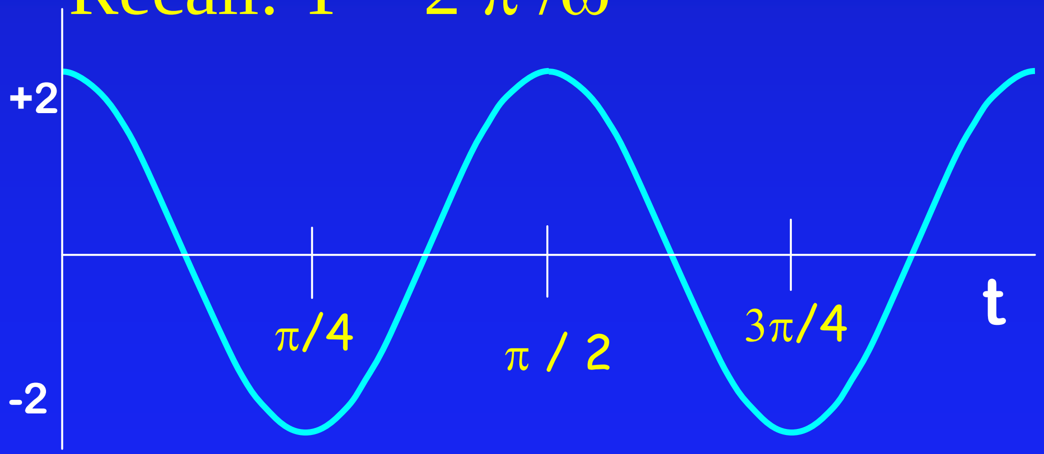
$y(x,t) = 2\cos(4t - 2x)$ at x=0.

$T = 2\pi / \omega$

$= 2\pi / 4$

$= 1.58$

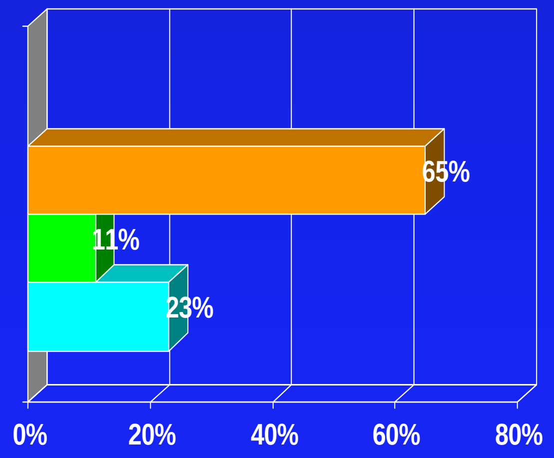
Recall: $T = 2\pi / \omega$



Preflight 1+2

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

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



$v = \lambda / T$

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*

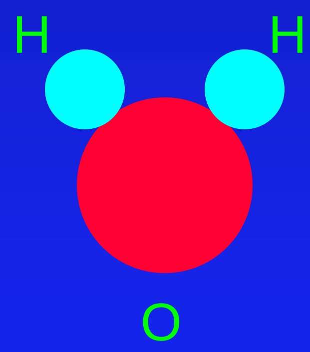
1 GHz = 10^9 cycles/sec

The speed of light is $c = 3 \times 10^8$ *m/s*

ACT Solution

- Recall that $v = \lambda f$.

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

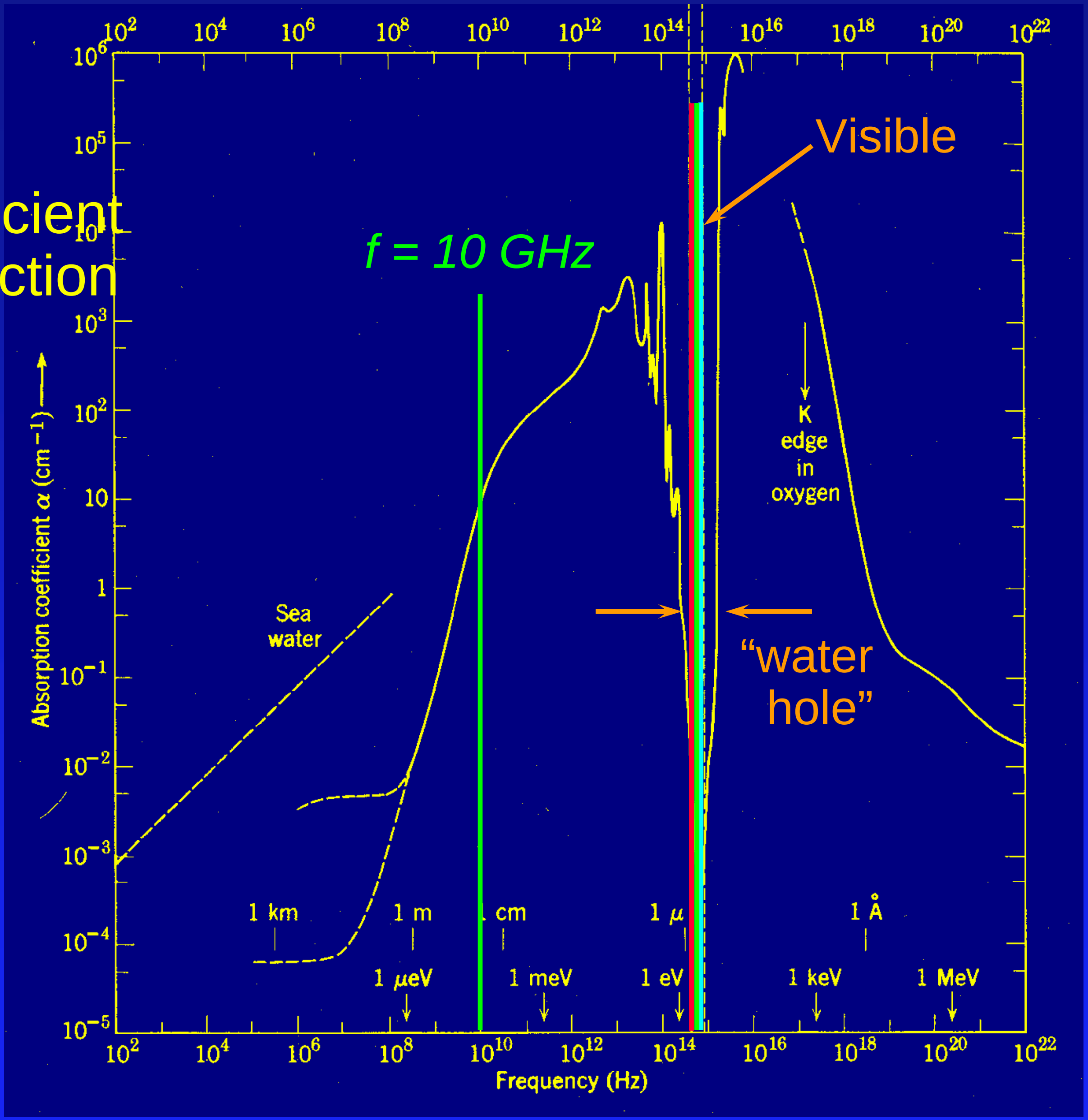


Makes water molecules wiggle

1 GHz = 10^9 cycles/sec

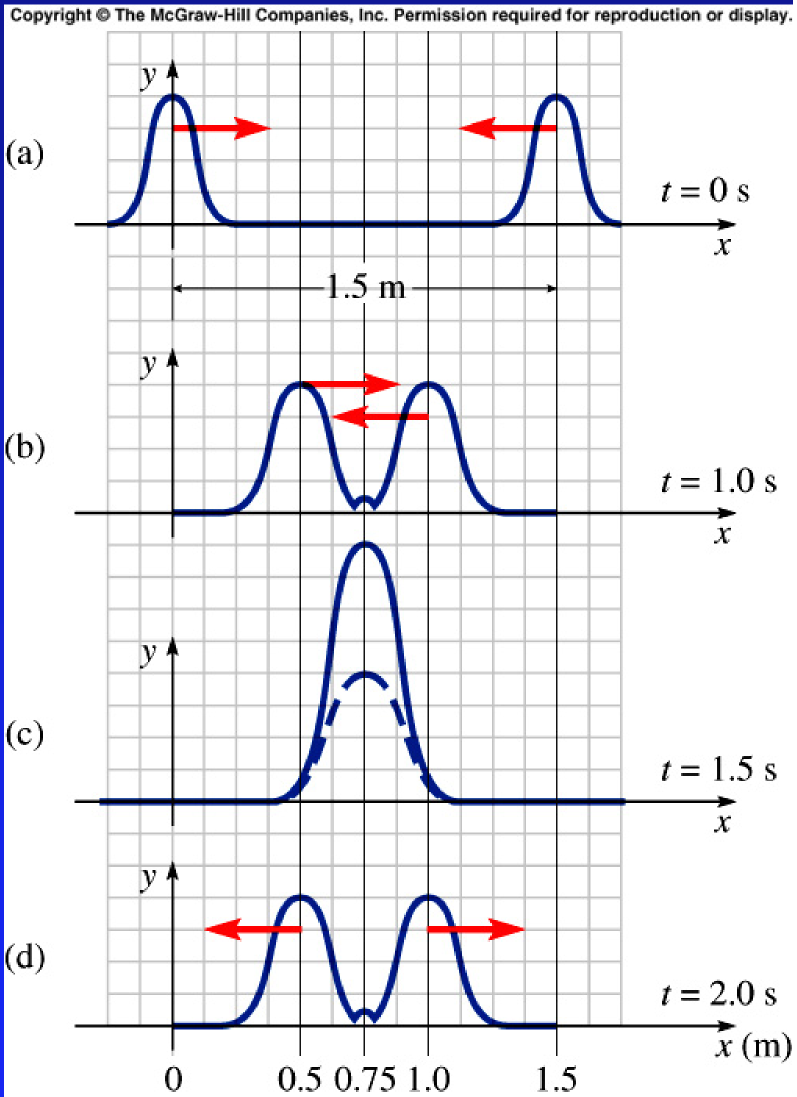
The speed of light is $c = 3x10^8\ m/s$

Absorption coefficient of water as a function of frequency.



Interference and Superposition

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



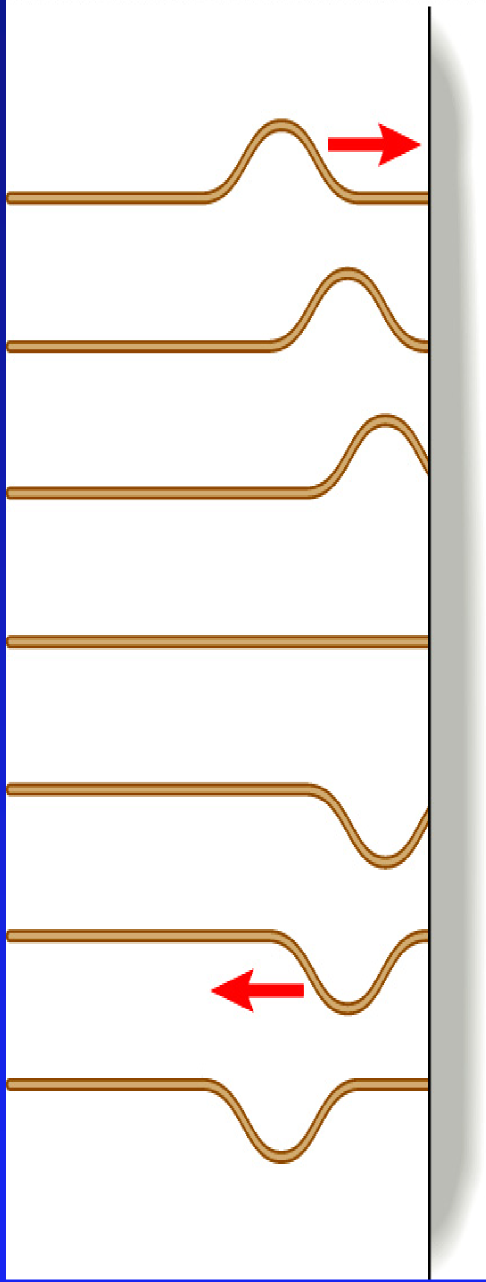
Reflection Act

- 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

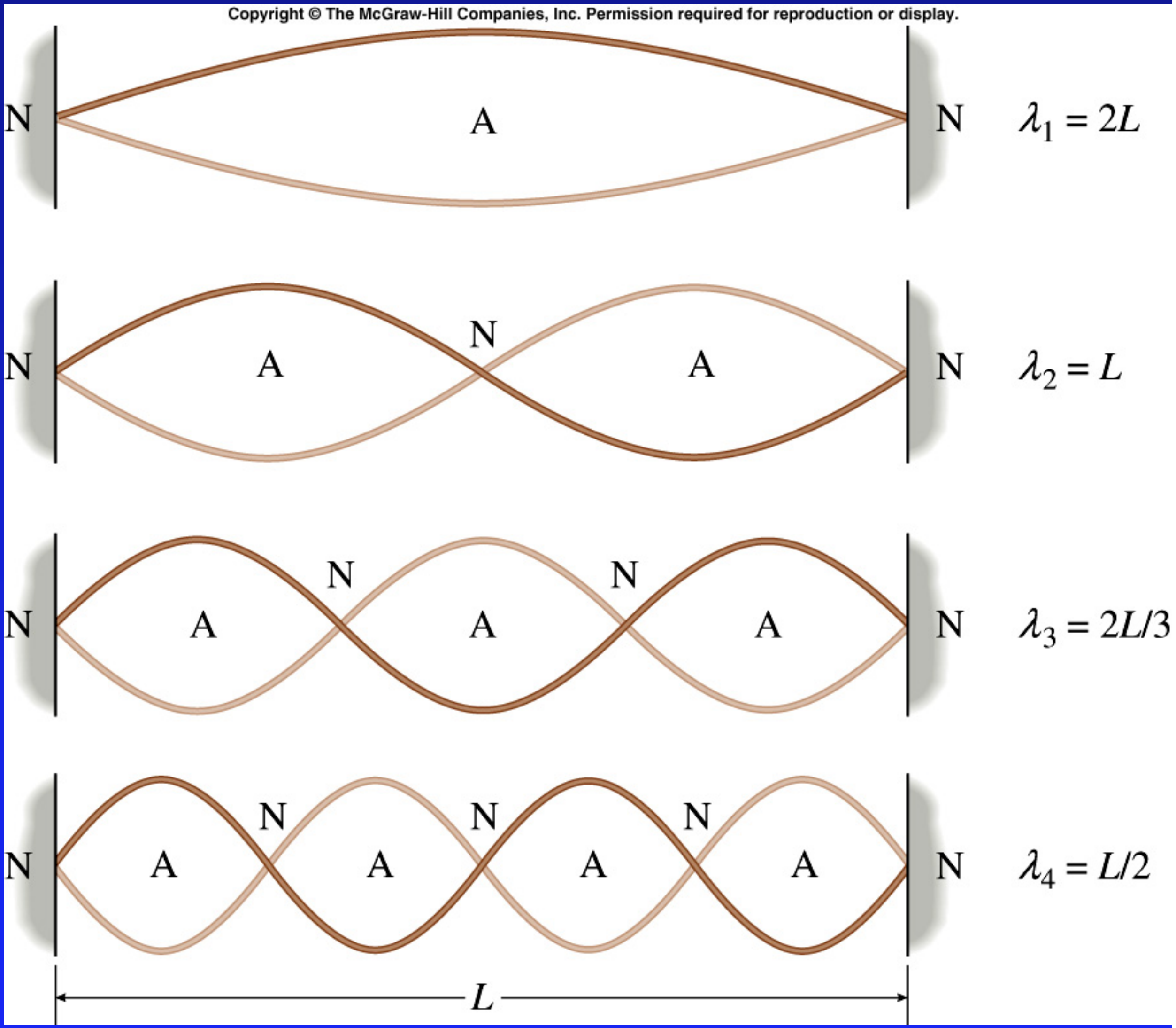
➔Fixed boundary reflected wave inverted

➔Free boundary reflected wave upright

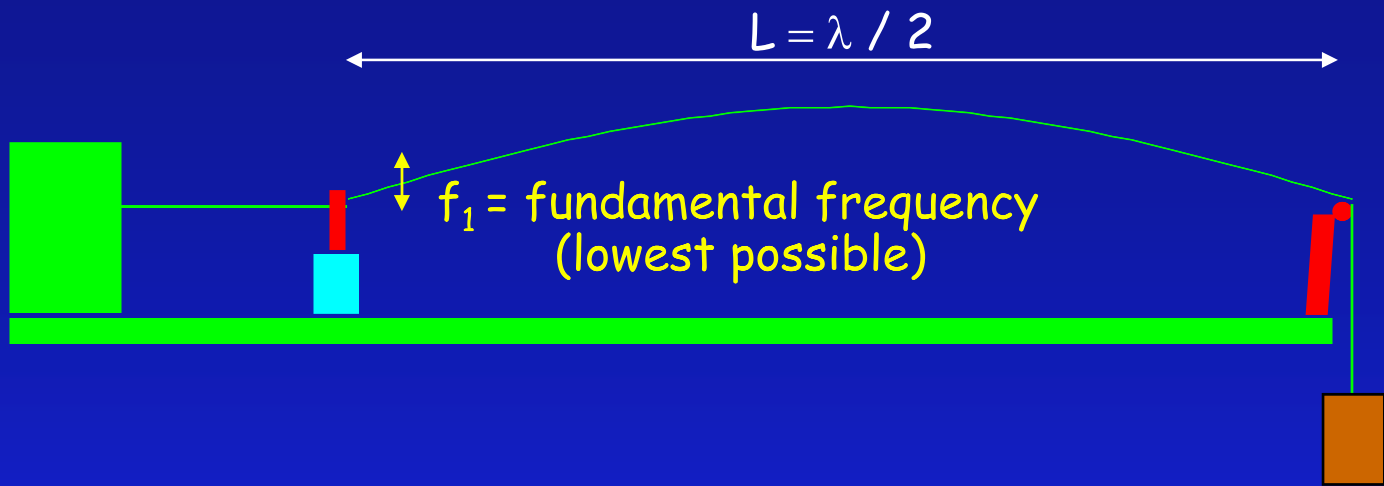


Standing Waves Fixed Endpoints

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



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?

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

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

$v = \lambda f$

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

$= 428.5\ m/s$

$v^2 = T / \mu$

$\mu = T / v^2$

$m = T\ L / v^2$

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

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

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)
  - ➔ $\lambda_n = 2L/n$
  - ➔ $f_n = n\, v / 2L$