Lecture 02: 01/18/2024

- Announcements
  Recitation – That assessment thing
  Clickers – Next Thursday
  Homeworks were extended (online Tues/Written Thurs)

- Waves
  - T, f, omega, lambda, k
  - Worked problems
  - Standing waves

Getting to know you

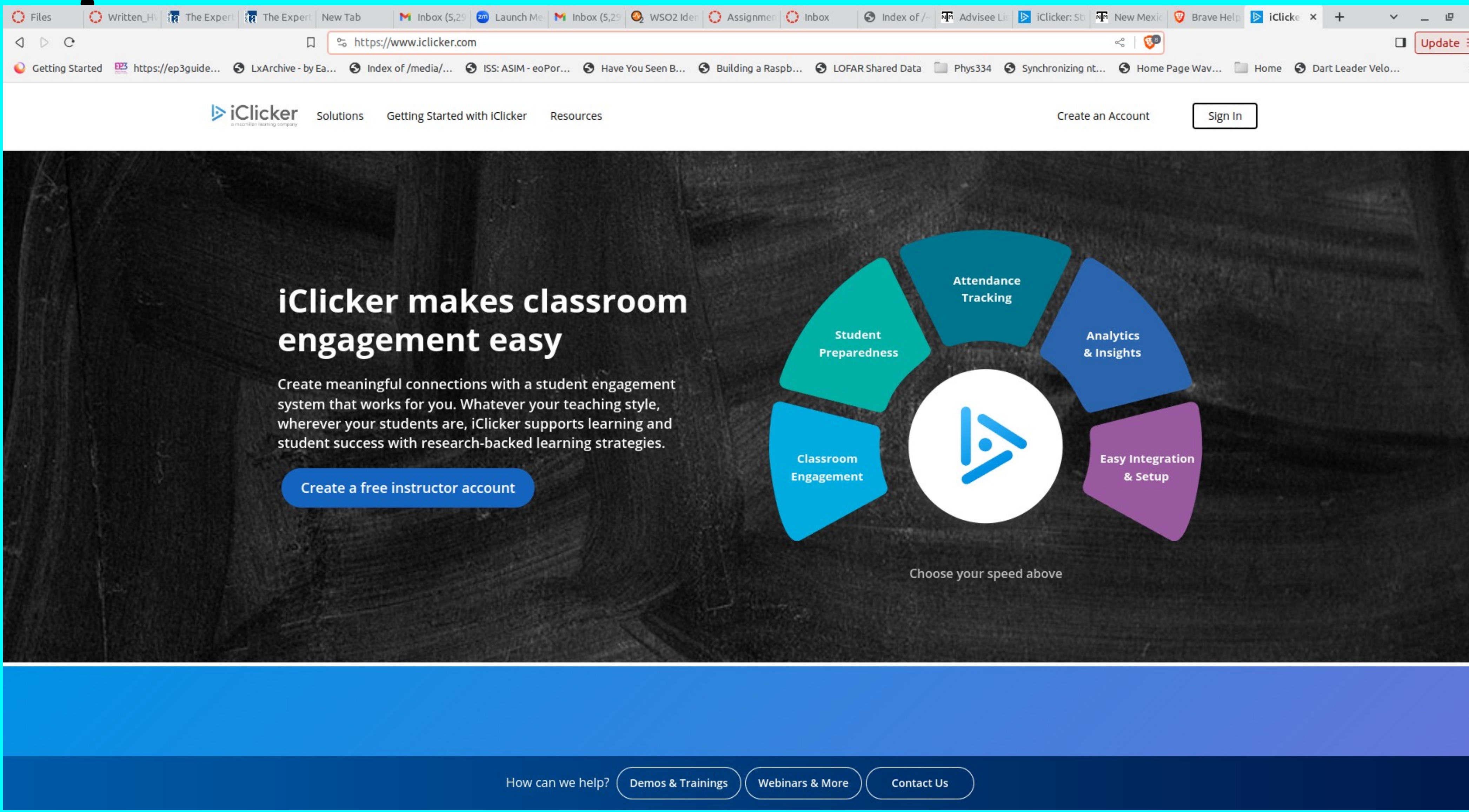
- Show us the formula and explain it
- Teach us about circuits and electricity
- Ask us about pets, favorite food and our backgrounds
- I'm a little nervous about the workload
- I enjoy solving difficult problems (eventually)
- I like to help people
- Don't forget to explain a variable
- I like group work / I don't like group work
- Give examples
- Give more examples
- Give lots of examples
- Ask about the largest animal we can take in a fight

Text

- The text is wordy, but backs up the lecture
- The text does derivations, and I will (mostly) not.

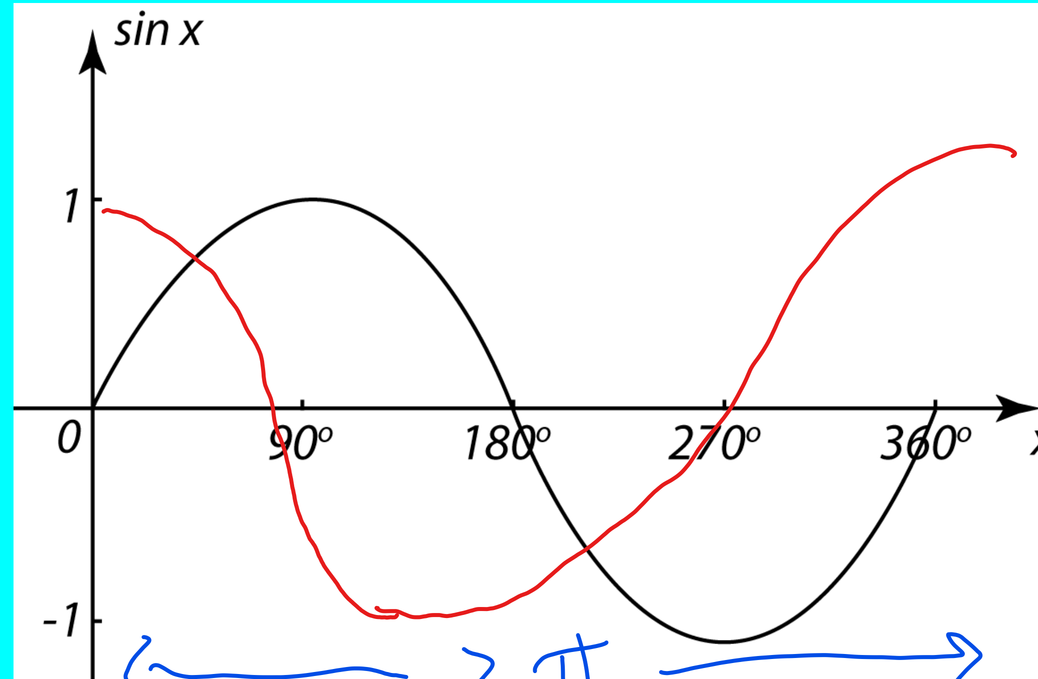
iClicker

- We will start using iClicker cloud next week.
- Go to www.iclicker.com and “Create an account”



Sine/cosine waves

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



$t = 0$

$A\sin kx = y$

$kx = 2\pi$

$\lambda x = \lambda$

$kx = 2\pi$

$x = \lambda$

$\longleftarrow 2\pi \longrightarrow$

$\longleftarrow \lambda \longrightarrow$

$y = A\sin(kx - \text{sarah}) = A\sin(.22x + 7t$

$k = \frac{2\pi}{\lambda}$

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

$\omega = \frac{2\pi}{T}$

Math of Waves

What is the period of

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

(A) $T = 2\pi$

(B) $T = \pi$

(C) $T = \frac{\omega}{2\pi}$

(D) $T = \frac{2\pi}{\omega}$

Math of Waves

What is the wavelength of

$$y = A \sin(k x - \omega t)$$

(A) $\lambda = \frac{v}{f}$

(B) $\lambda = \frac{\omega}{k}$

(C) $\lambda = \frac{2\pi}{k}$

(D) $\lambda = \frac{2\pi}{k v}$

Ch 16: 120 (like 40, 41)

A radio station broadcasts at 101.7 MHz. What is the wavelength of the waves?

3.00

$c = 3 \times 10^8$ m/s

Identify: The gave us f and asked λ

Did they give v? Yes … v = c

Develop: $v = f\lambda$ ⟶ $c = f\lambda$ $\lambda = \frac{c}{f}$

Execute: ⟶ $\lambda = \frac{3 \times 10^8 \text{ m/s}}{1.017 \times 10^8 \text{ Hz}}$ ~ $\lambda = 3$

Assess:

$\frac{3}{1.017} = 2.95$ m

$\frac{\text{m/s}}{1/\text{s}} = \text{m/s} \cdot \text{s} = \text{m}$

$c = 2.998\ldots$

Ch 16: 73b (like 47, 48)

A sinusoidal wave travels down a taut horizontal string

With linear mass density $\mu = 0.06\,\mathrm{kg/m}$

The maximum vertical speed is $v_{y_{max}} = 0.30\,\mathrm{cm/s}$

The wave equation is $y(x,t) = A\sin\left(\frac{6.00}{m}x - \frac{24}{s}t\right)$

What is v_x?

$v = f\lambda$

Identify: Can we calculate v_x?

$k = \frac{2\pi}{\lambda} \rightarrow \lambda = \frac{2\pi}{k}$

Develop: $v_x = \frac{\omega}{k}$ $y(x,t) = A\sin(kx - \omega t)$

Execute: $v = f\lambda$

$\omega = 2\pi f$

$= \frac{\omega}{2\pi}\frac{2\pi}{k}$

$f = \omega/2\pi$

Assess:

$v = \frac{\omega}{k} = \frac{24}{6} = 4\ m/s$

Ch 16: 73b (like 47, 48)

A sinusoidal wave travels down a taut horizontal string
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The wave equation is $y(x,t) = A\sin\left(\frac{6.00}{m}x - \frac{24}{s}t\right)$

What is v_x?

Develop:

Execute:

Assess:

Ch 16: 73a (like 72)

A sinusoidal wave travels down a taut horizontal string
With linear mass density $\mu = 0.06\,\mathrm{kg/m}$
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The wave equation is $y(x,t) = A\sin\left(\frac{6.00}{m}x - \frac{24}{s}t\right)$

What is A?

Is there a relation between v_y and A?

Develop: $v_y = \frac{dy}{dt}$ $\quad y(x,t) = A\sin(kx - \omega t)$

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

$v_y = \frac{dy}{dt} =$

Execute:

$v_y = \omega A \leftarrow v_y = \omega A\cos(kx - \omega t)$

$A = v_y / \omega$

Assess:

$v_y = 3\times10^{-3}\,\mathrm{m/s}$

$\omega = 24\,\mathrm{rad/s}$

$A = \frac{24}{3\times10^{-3}} = \frac{1}{8000}$ ← oops -- wrong!

$A = \frac{3\times10^{-3}}{24}$

$A = 1.25\times10^{-4}\,\mathrm{m}$

$$V_y =$$

$$A = \frac{V_y}{\omega} = \frac{m/s}{1/s} = m$$

Ch 16: 73a (like 72)

A sinusoidal wave travels down a taut horizontal string
With linear mass density $\mu = 0.06\,kg/m$
The maximum vertical speed is $v_{y_{max}} = 0.30\,cm/s$

The wave equation is $y(x,t) = A\sin(\frac{6.00}{m}x - \frac{24}{s}t)$

What is A?

Is there a relation between v_y and A?

Develop:

Execute:

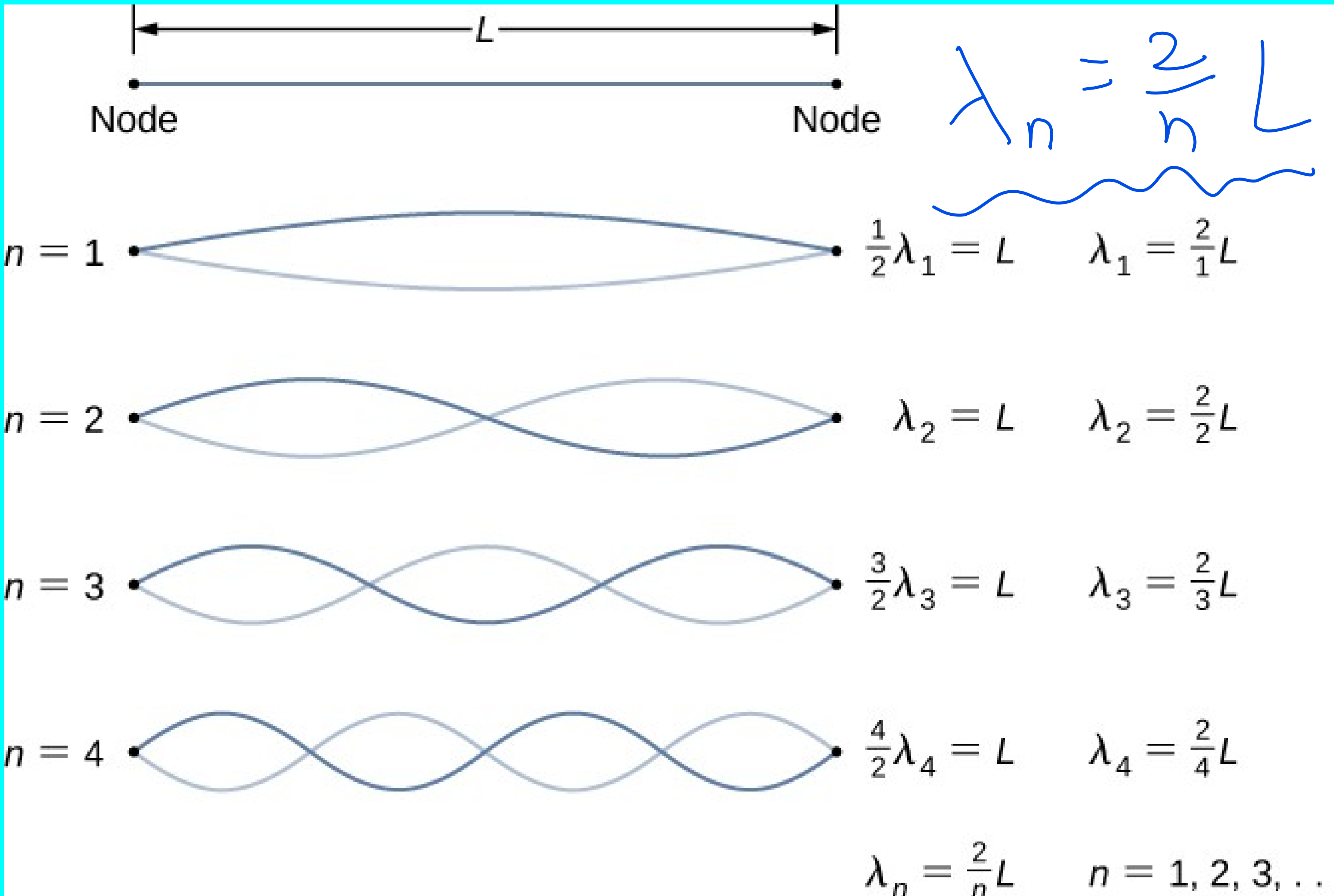
Assess:

Standing Waves

If you create a wave with fixed ends, it can only have certain wavelengths

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

$v = f\lambda$



Why are they "standing"

They don't appear to be moving left to right … they just oscillate up and down.

They can be made by adding a wave traveling left to a wave traveling right.

$$y_1 = A \sin(kx - \omega t)$$

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

$$2A \sin kx \cos \omega t$$

Ch 16: 104 (like 103)

$L=2\,m \quad \mu=6\,g/m \quad m=2\,kg$

What are λ and f for n=6?

$T = mg = (2\,kg)(9.8\,m/s^2)$

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

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

Identify: What the heck is n=6?

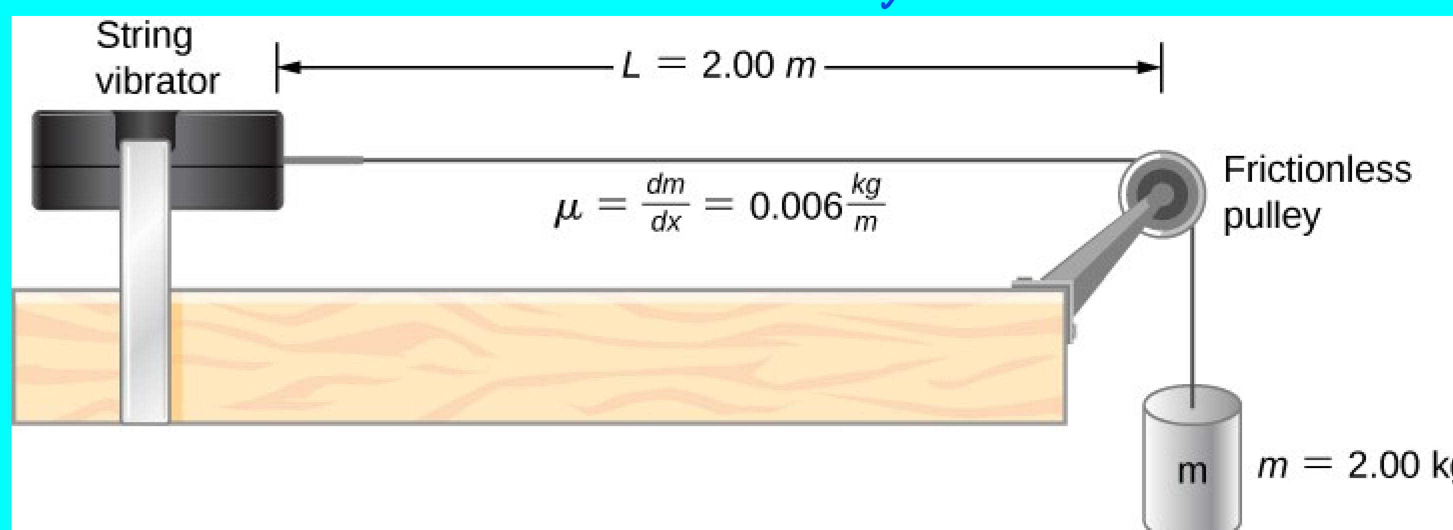
Develop:

$\lambda = \frac{2L}{6} = \frac{2}{6}L = \frac{2}{6}\cdot 2 = 2/3\,m$

Execute:

$v = f\lambda \Rightarrow f = \frac{v}{\lambda} = \sqrt{\frac{T}{\mu}}\,\frac{1}{\lambda}$

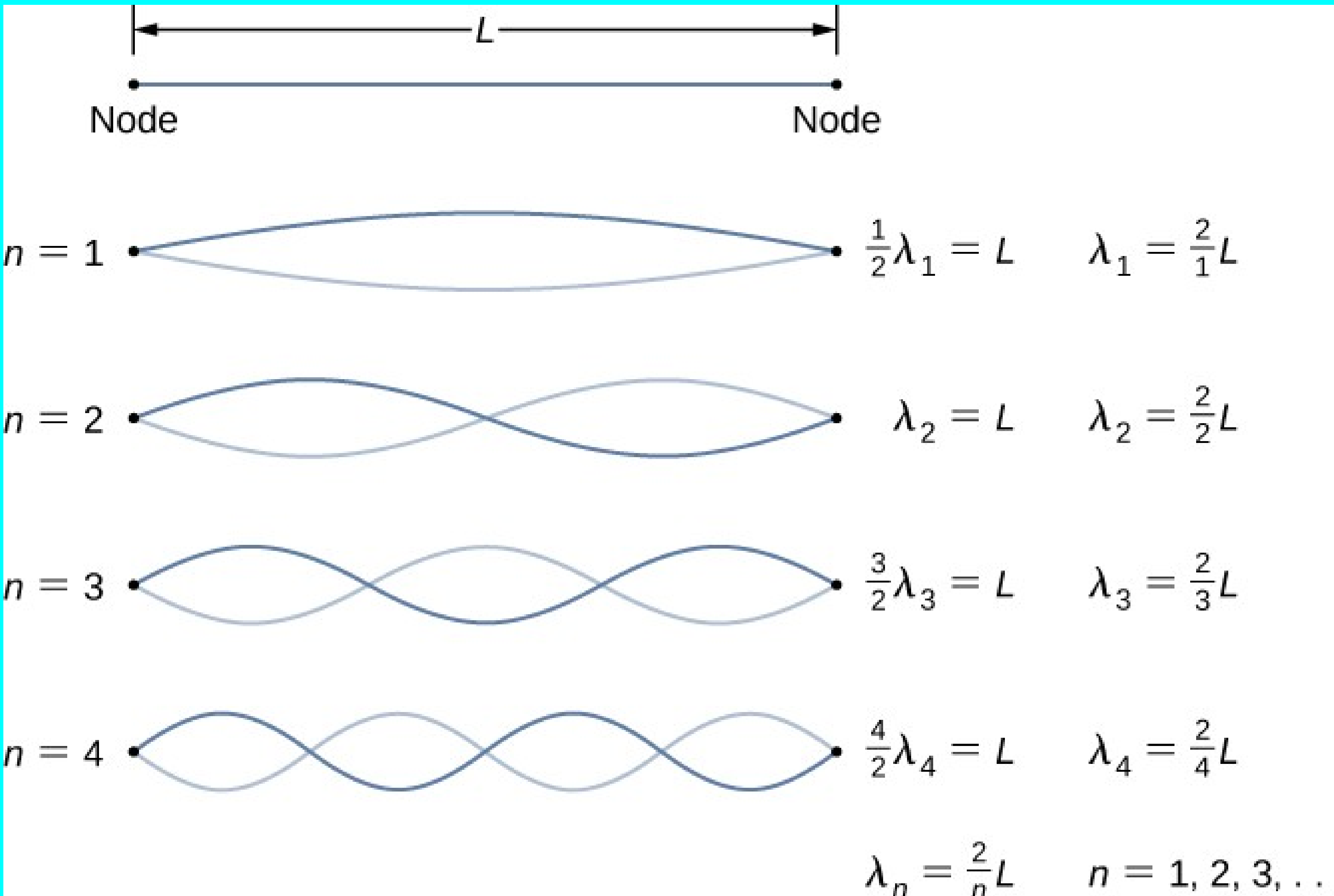
Assess:



Ch 16: 104 (like 103)

$L = 2\,m \quad \mu = 6\,g/m \quad m = 2\,kg$

What are λ and f for n=6?



Ch 16: 104 (like 103)

$L = 2\,m \quad \mu = 6\,g/m \quad m = 2\,kg$

What are λ and f for n=6?

Identify: What the heck is n=6?

Develop: $\lambda_6 = \frac{2}{6} L$

Execute:

Assess:

pHeT time?

Key Equations

Wave speed	$v = \frac{\lambda}{T} = \lambda f$
Linear mass density	$\mu = \frac{\text{mass of the string}}{\text{length of the string}}$
Speed of a wave or pulse on a string under tension	$\lvert v \rvert = \sqrt{\frac{F_T}{\mu}}$
Speed of a compression wave in a fluid	$v = \sqrt{\frac{B}{\rho}}$
Resultant wave from superposition of two sinusoidal waves that are identical except for a phase shift	$y_R(x,t) = \left[2A\cos\left(\frac{\phi}{2}\right)\right]\sin\left(kx - \omega t + \frac{\phi}{2}\right)$
Wave number	$k \equiv \frac{2\pi}{\lambda}$
Wave speed	$v = \frac{\omega}{k}$

A periodic wave	$y(x,t) = A\sin(kx \mp \omega t + \phi)$
Phase of a wave	$kx \mp \omega t + \phi$
The linear wave equation	[illegible]
Power averaged over a wavelength	$P_{\text{ave}} =$ [illegible] $\mu A^2 \omega^2 v$
Intensity	[illegible]
Intensity for a spherical wave	[illegible]
Equation of a standing wave	$y(x,t) = [2A\sin(kx)]\cos(\omega t)$
Wavelength for symmetric boundary conditions	$\lambda_n = \frac{2}{n}L, \quad n = 1, 2, 3, 4, 5\ldots$
Frequency for symmetric boundary conditions	$f_n = n\frac{v}{2L} = nf_1, \quad n = 1, 2, 3, 4, 5\ldots$

Summary

Next Class:

Introduction to charge and Coulomb's law