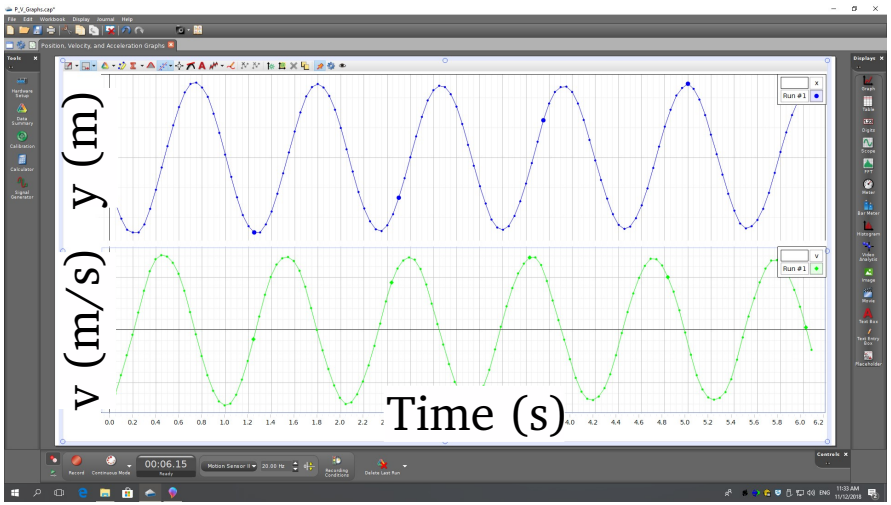
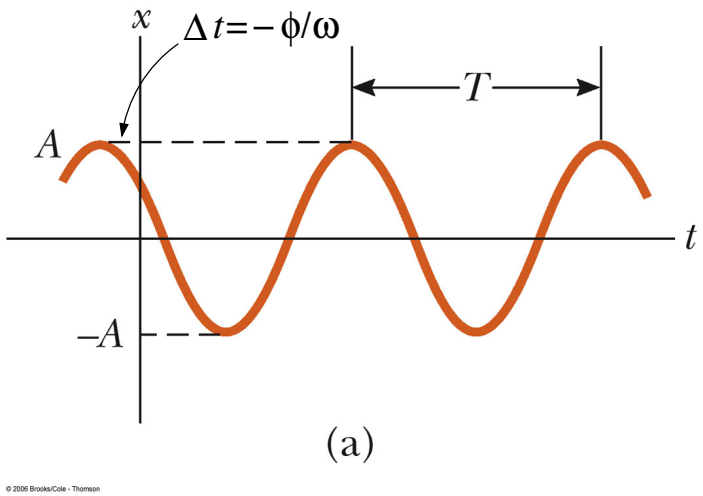
The Simple Harmonic Oscillator 1

1. The Force: $F_s = -kx$ where x is the displacement from equilibrium.

The Simple Harmonic Oscillator 2

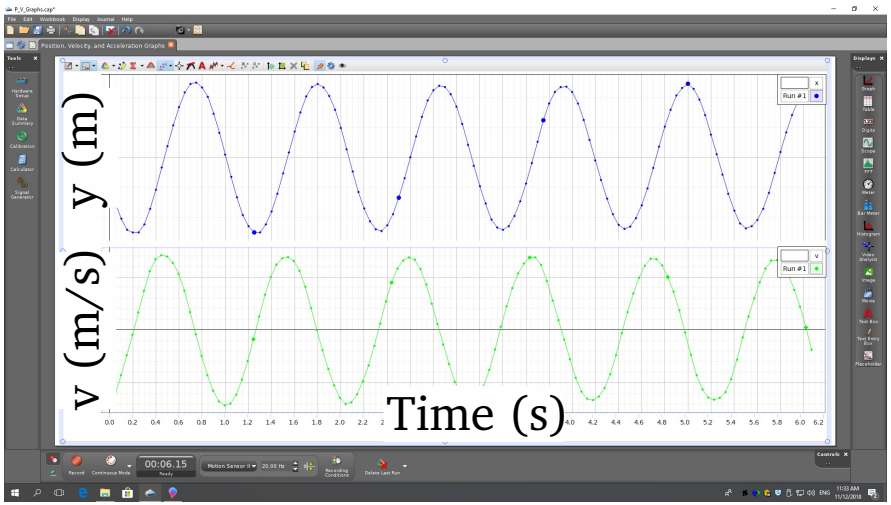
1. The Force: $F_s = -kx$ where x is the displacement from equilibrium.
2. Measurements:

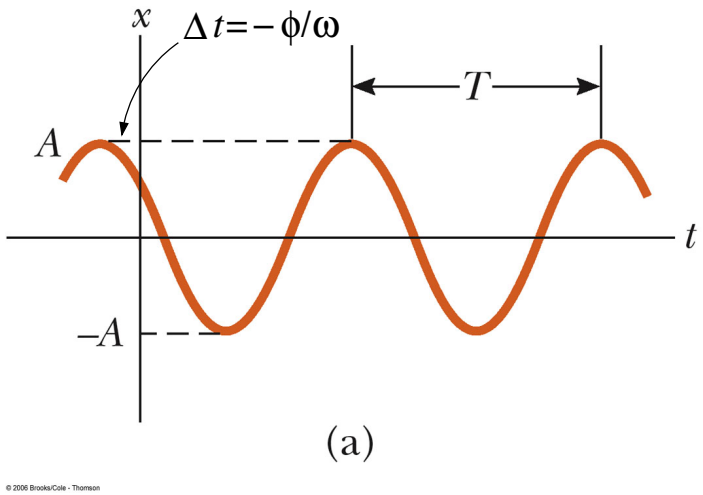




The Simple Harmonic Oscillator 3

1. The Force: $F_s = -kx$ where x is the displacement from equilibrium.
2. Measurements:





3. The Solution: $x(t) = A\cos(\omega t + \phi)$

The Simple Harmonic Oscillator 4

1. The Force: $F_s = -kx$ where x is the displacement from equilibrium.
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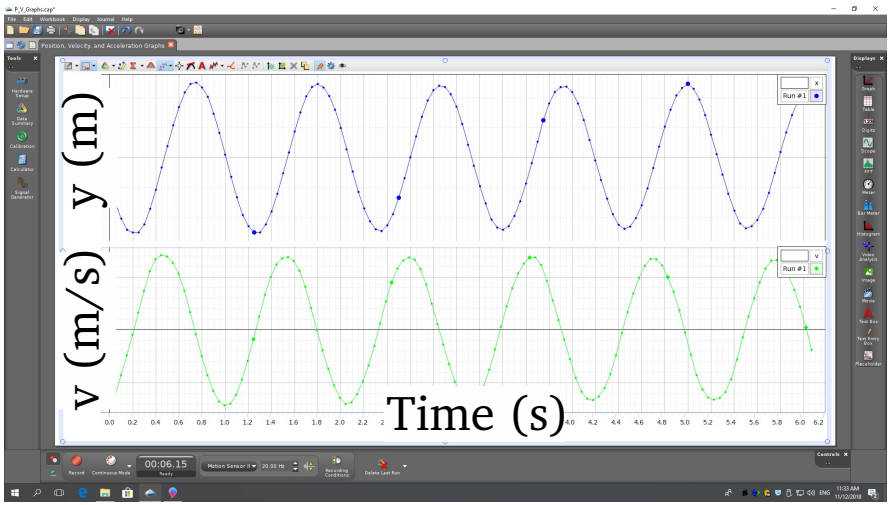

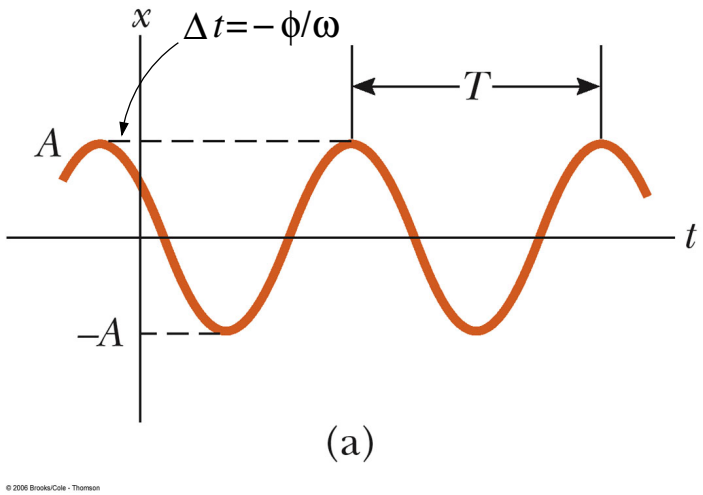

3. The Solution: $x(t) = A\cos(\omega t + \phi)$
4. Newton's Second Law yields

$$\frac{d^2x(t)}{dt^2} = -\frac{k}{m}x(t)$$

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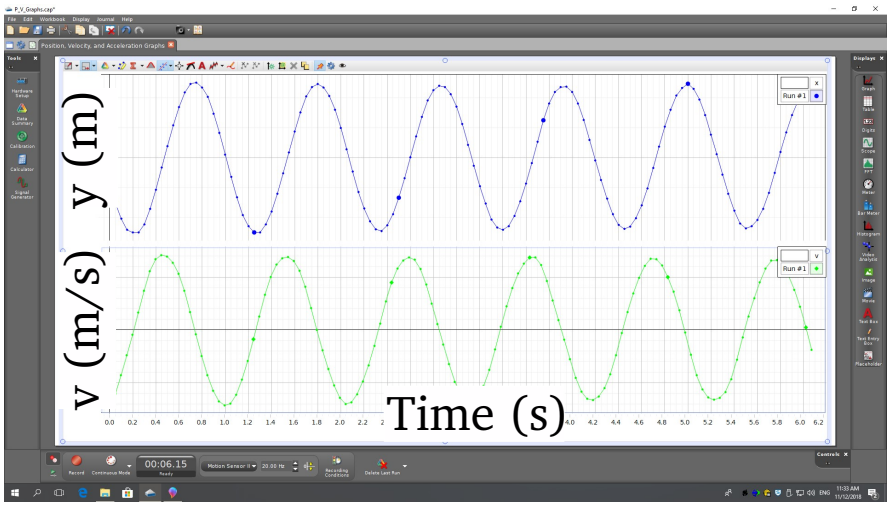

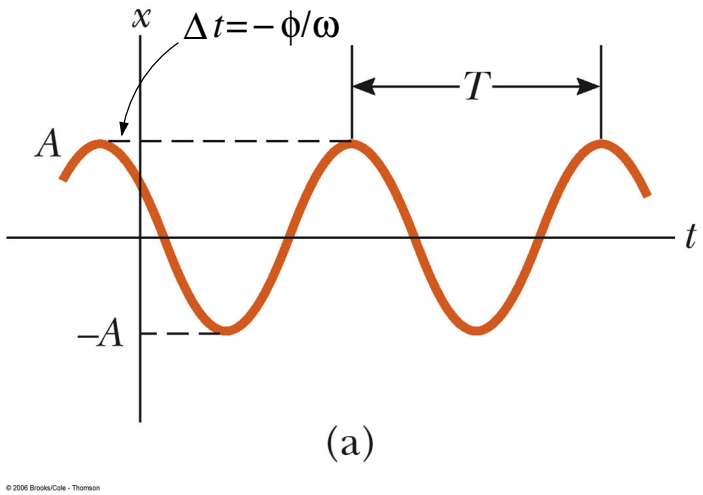

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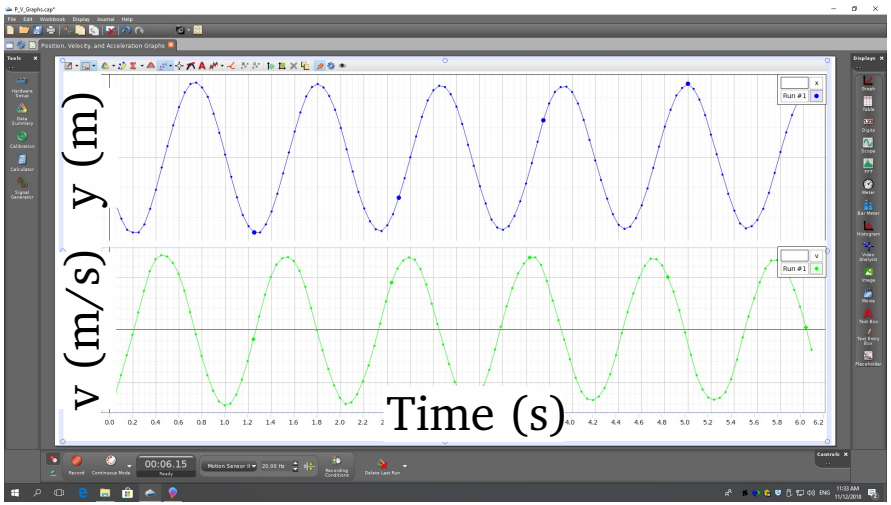
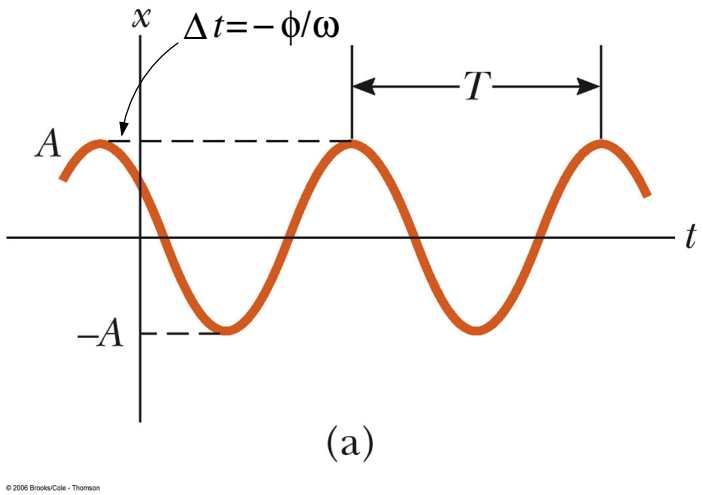




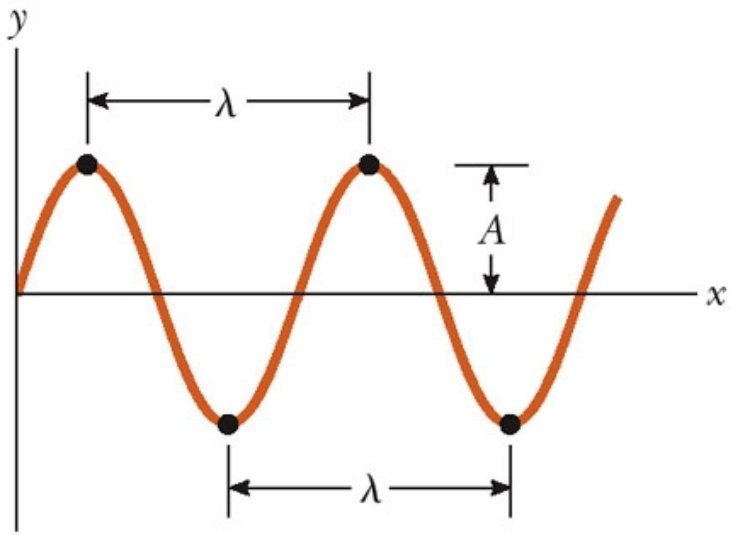
3. The Solution: $x(t) = A\cos(\omega t + \phi)$
4. Newton's Second Law yields

$$\frac{d^2x(t)}{dt^2} = -\frac{k}{m}x(t)$$

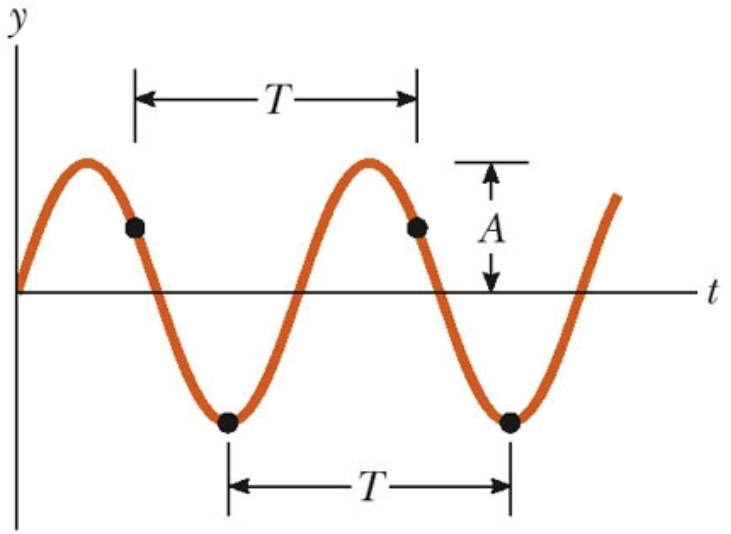
5. Parameters:

$$\omega = \sqrt{\frac{k}{m}} \quad T = \frac{2\pi}{\omega} \quad f = \frac{1}{T}$$

A and ϕ are initial conditions.



(a)



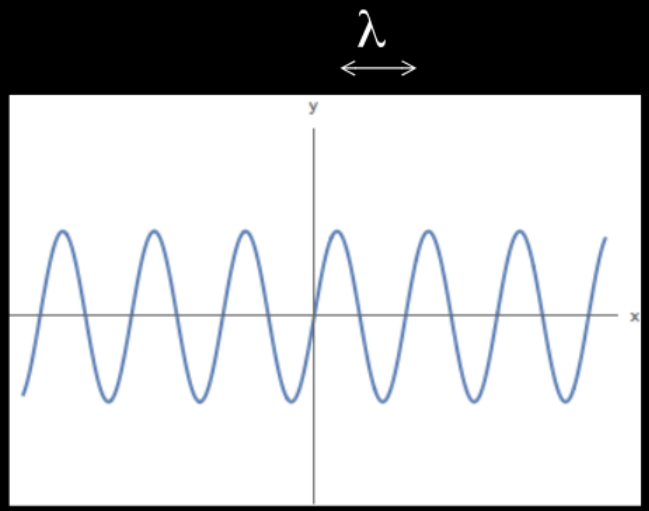
(b)

$$y = A\sin\left(kx - \omega t + \phi_0\right)$$

Demos are here and here.

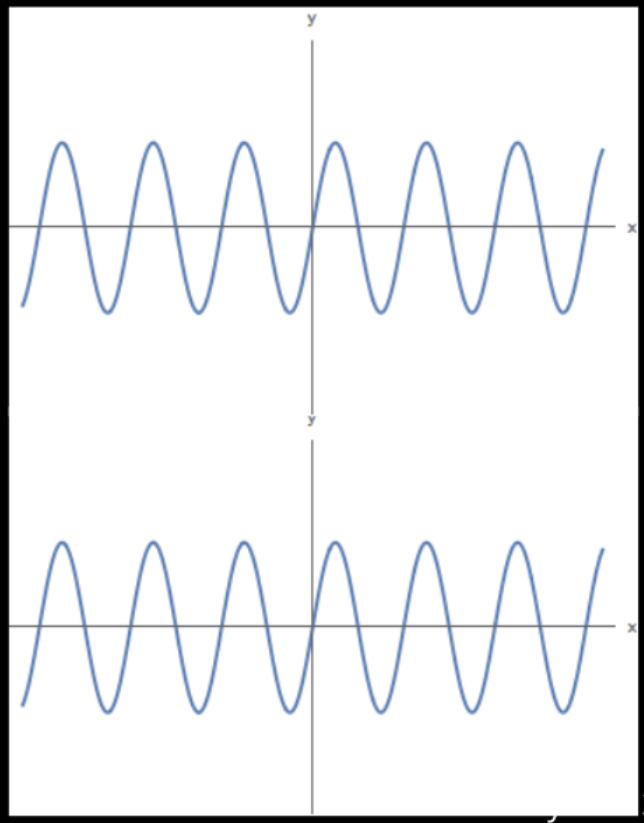
Frequency, wavelength, speed

- Wavelength (λ): Distance from one wave crest to the next.
  - » (Units?)
- Frequency (f): Number of wave cycles passing a given point per second.
  - » (Units?)
- How are these related to the wave propagation speed?



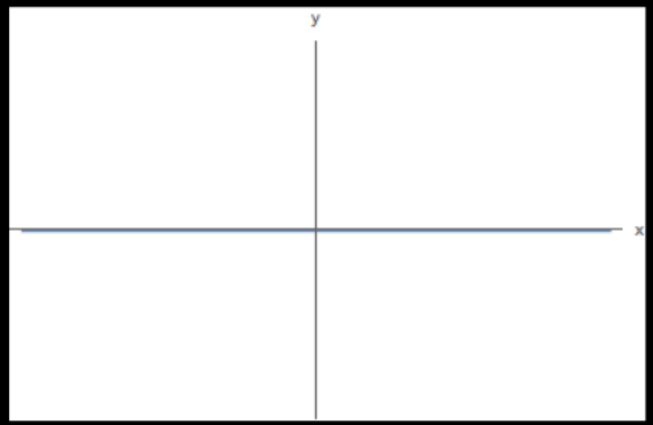
Physics 132: Spring 2025 1

Traveling and standing waves



Waves can travel left or right ...

But they can also oscillate in place



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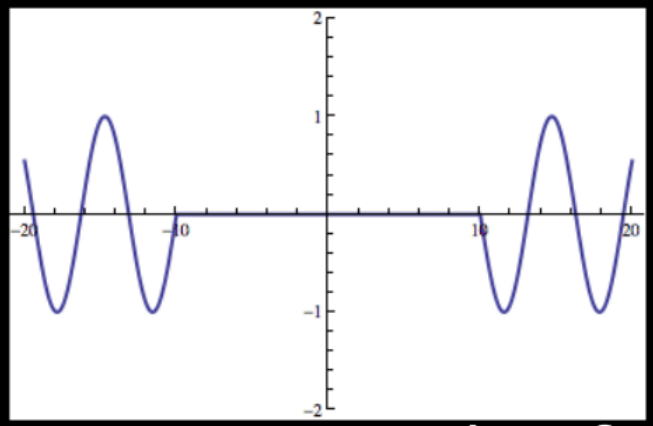
Superposition

General principle: When two waves overlap, their effects add together.



Imprtant example of this:

Two traveling waves Standing wave

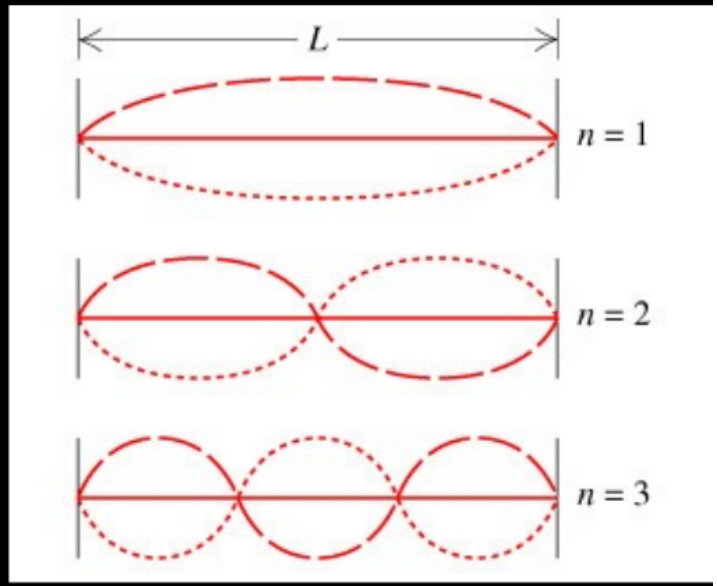
Physics 132: Spring 2025 3

Waves on a string

- T = tension in the string (newtons).
- μ = Linear mass density (kg/m).
- Your book gives a clever derivation of this rule, but I don't think it helps much with understanding why it's true.
- Check that the units are right, and convince yourself that it makes qualitative sense: v goes up when T goes up or when μ goes down.

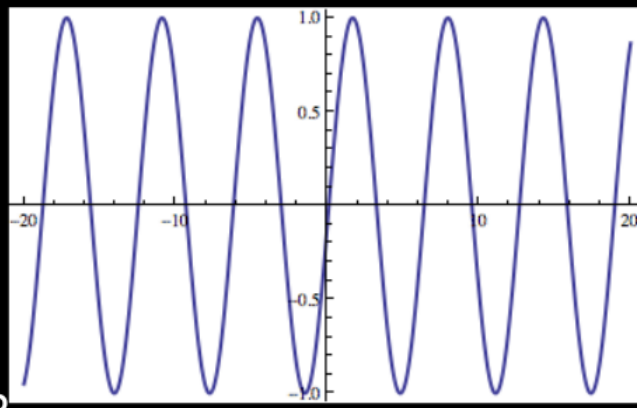
Standing waves on a string

- Both ends must be fixed **h** only certain wavelengths “fit” on the string.
- What’s the relationship between λ (wavelength) and n (number of segments of the wave)?



Sinusoidal waves

- Lots of waves form regular repeating patterns.
- We can describe these with a sine-wave model:



- How are k, ω related to frequency, wavelength, speed?
- What is the significance of the "phase constant" ϕ_0?