Physics 101: Lecture 22
Waves

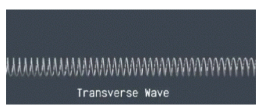
Waves Overview

- Types of waves
- Speed or a wave
- Harmonic waves
- Superposition and Interference
- Standing waves

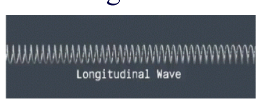
Bottom line for today: Lots of definitions to remember, and some algebra/trig to do, but material is not difficult

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



Harmonic Waves

y(x,t) = A cos(ωt – kx) or A cos(kx – ωt)

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

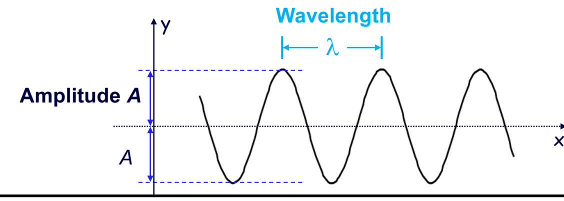
Amplitude: The maximum displacement *A* of a point on the wave.

Angular Frequency ω: ω = 2 π f = 2 π / T

f is simply called the Frequency

Wave Number k: k = 2 π / λ

Remember: f = v / λ or f λ = v



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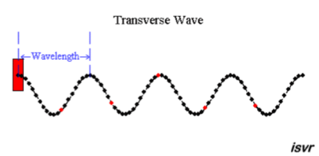
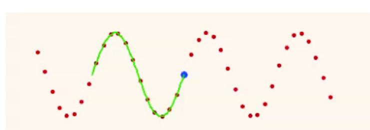
Period and Velocity

- 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* = λ / *T*.

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



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Harmonic Waves Exercise

Plot wave at a fixed position as time passes

y(x,t) = A cos(ωt – kx)

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

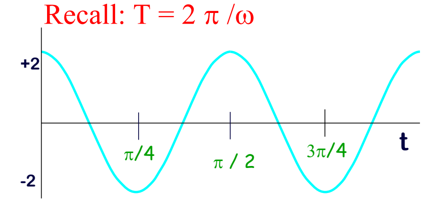
y(x,t) = 2 cos(4t –2x) at x=0.

T = 2 π / ω

= 2 π/ 4

= π/ 2

Recall: T = 2 π /ω



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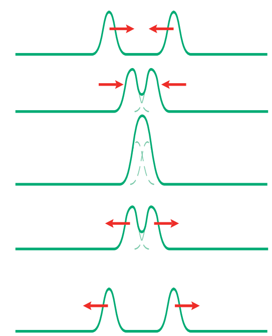
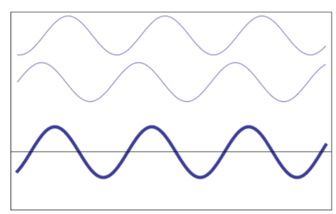
Interference and Superposition

- When two waves overlap, the amplitudes add (sign important).
  - Constructive interference: increases amplitude
  - Destructive interference: decreases amplitude





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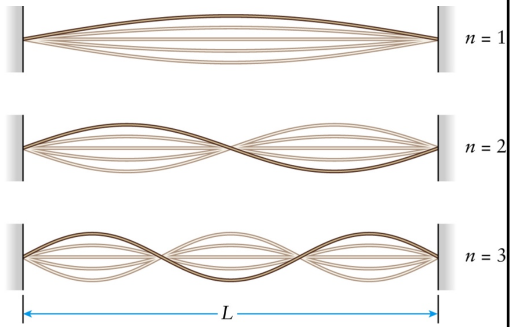
Standing Waves Fixed Endpoints

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



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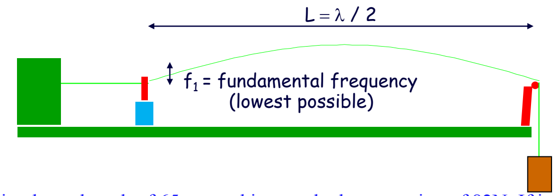
Standing Waves Example



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)

$v = \lambda f$
$= 2\,(0.65\text{ m})\,(329.63\text{ s}^{-1})$
$= 428.5\text{ m/s}$

$v^2 = T / \mu$
$\mu = T / v^2$
$m = T L / v^2$
$= 82\,(0.65) / (428.5)^2$
$= 2.9 \times 10^{-4}\text{ kg}$

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

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