Ch. 16 Wave Motion

Mechanical:

Sound
Water
Strings

} **Disturbance in a medium**

Electromagnetic

Light Microwaves
Radio x-rays
Radar γ-rays

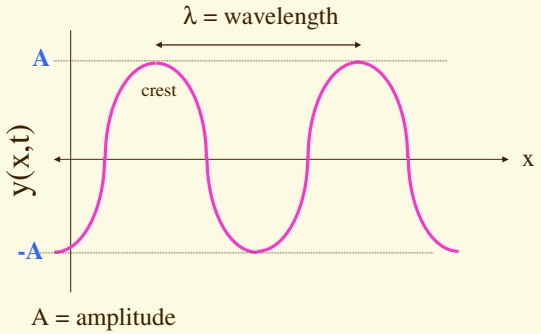
} **no medium**

Waves Waves Waves Waves Waves Waves

Propagation of a disturbance
(usually through a medium)

- ✓Speed depends on medium
- ✓Waves transmit energy
- ✓Waves can be longitudinal or transverse
- ✓Transverse waves can be polarized
- ✓Show Interference

Wave Basics- space

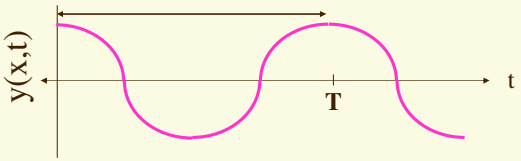


A = amplitude

This is a snapshot at a particular time t.

Wave Basics- time

Motion of a point fixed at a particular x.



T = period = time to repeat once
f = 1/T = frequency = repeats (cycles) per time

Wave Speed

During one period, a point at x will move through one cycle (crest to crest). At the same time, the wave will move a distance of one wavelength.

Wave Speed: $v = \lambda/T = f\lambda$

Speed of Waves on a String

- ✓ Speed increases with tension, T
- ✓ Speed decreases with increased mass density

μ = mass/length

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

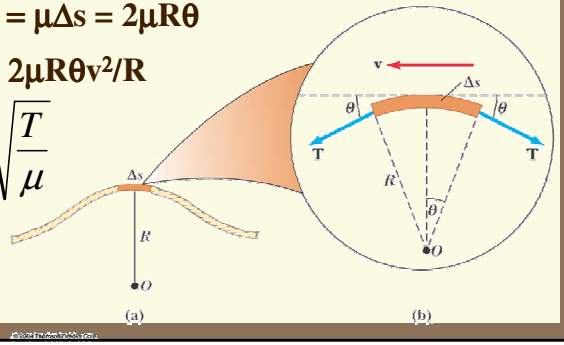
Derivation

$\Sigma F_r = 2T\sin\theta \cong 2T\theta = mv^2/R$

$m = \mu\Delta s = 2\mu R\theta$

$2T\theta = 2\mu R\theta v^2/R$

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



Harmonic Waves

Sinusoidal waves:

Simple to treat

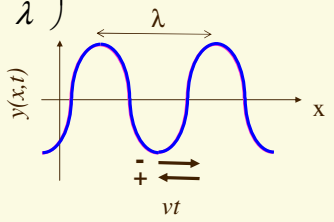
Can be added together to form arbitrary waveforms

$$y(x,t) = A\sin\left(2\pi ft \pm \frac{2\pi x}{\lambda}\right)$$

A = amplitude

λ = wavelength

f = frequency

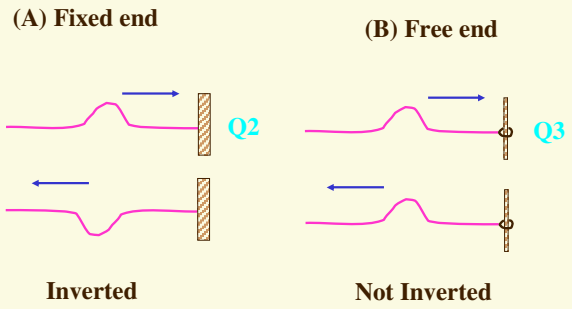


Reflection and Transmission

What happens when the medium through which a wave is travelling suddenly

1. Ends?
2. Changes properties?

(1) Medium ends:



(2) Medium Change:

When a traveling wave reaches a boundary with a new medium, the wave has **reflected** and **transmitted** components.

Examples:

String-rope
Coaxial cable to twisted pair
Deep to shallow water
Light traveling from air to glass

Reflection and transmission

The transmitted wave is always non-inverted.

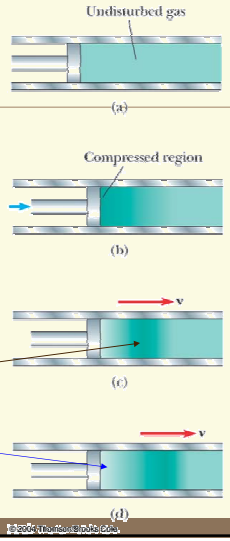
The reflected wave may or may not be inverted:

$v_i > v_t$ inverted

$v_i < v_t$ non-inverted

$v_i = v_t$ no reflection

Sound Waves



- Longitudinal (in fluids)
- Disturbance is:
  - Density, Pressure
  - Particle Displacement from Equilibrium
- Medium is vibrating particles

Condensation:
High pressure
High density

Rarefaction:
Low pressure
Low density

Frequency Ranges:

Audible: 20 Hz to 20 kHz
Infrasonic: < 20 Hz
Ultrasonic: > 20 kH

Frequency of sound waves are interpreted by our brains as *PITCH*.