Wave Motion

- Propagation of a disturbance
- Sinusoidal waves
- Speed of waves
- Reflection and Transmission

Propagation of a Disturbance

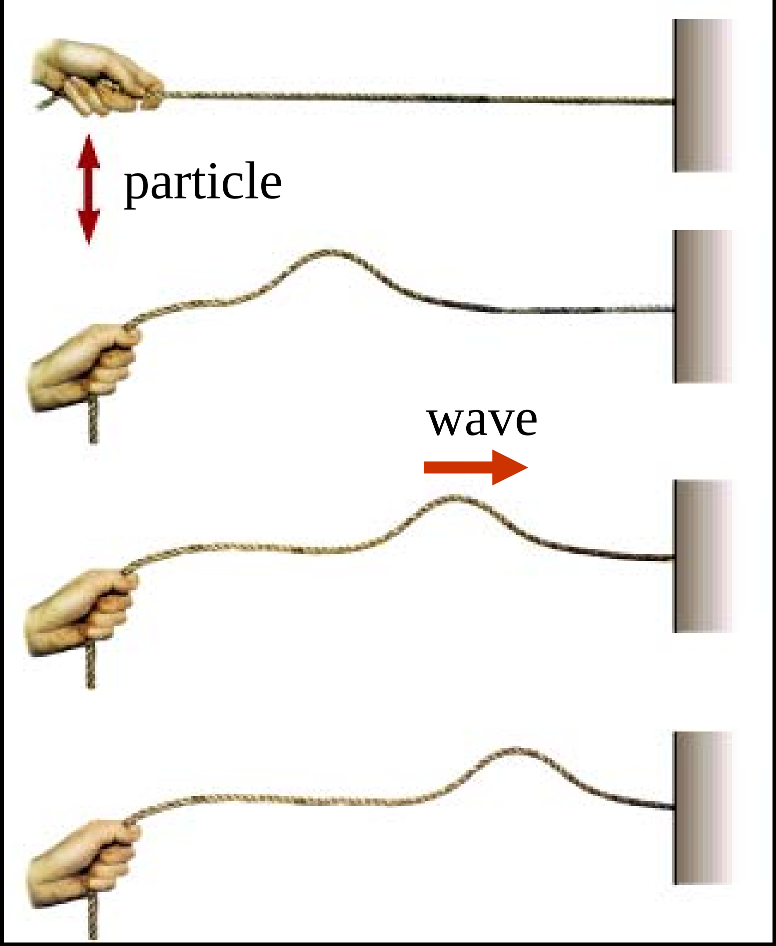
- Waves on a string
- Stadium waves
- Sound waves
- Waves on a spring
- Water waves

- All require
  - a disturbance
  - a medium to be disturbed
  - some mechanism of influence

Transverse Waves

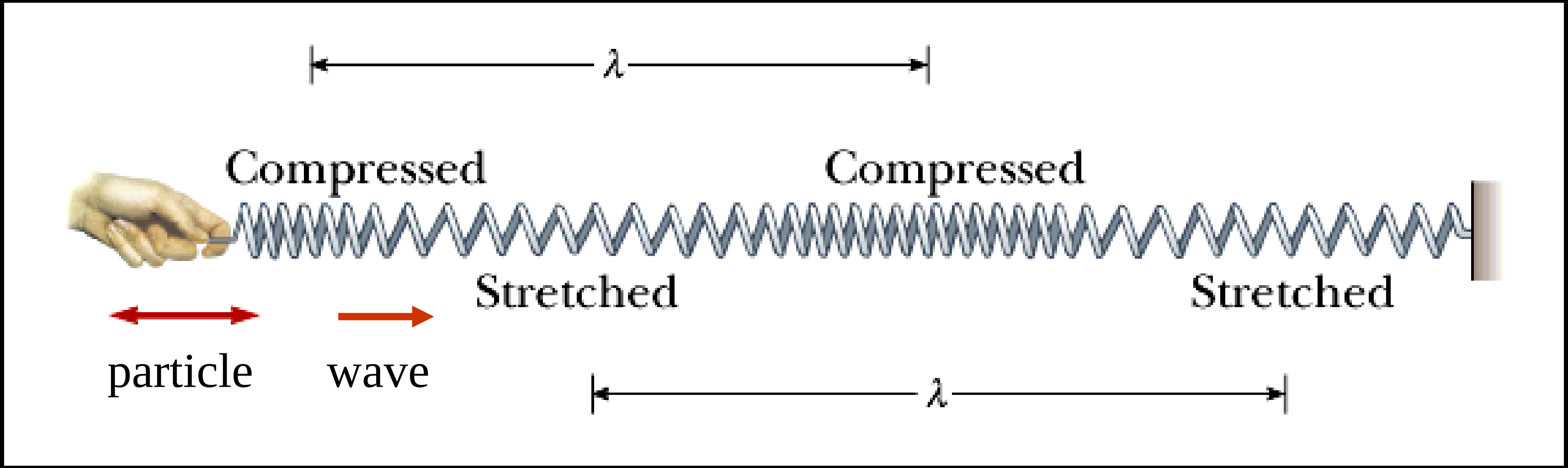
- Waves on a string
- Stadium waves

The disturbed particle and the wave move <u>perpendicular</u> to each other.



Longitudinal Waves

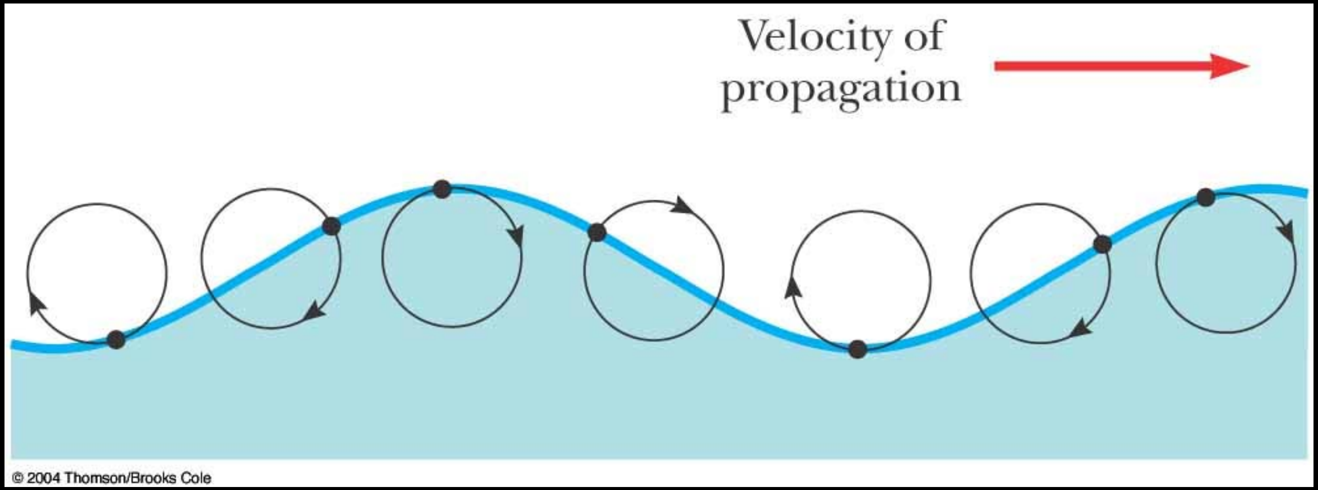
- Sound waves
- Waves on a spring



The disturbed particle and the wave move
<u>parallel</u> to each other.

Combined Wave Motion

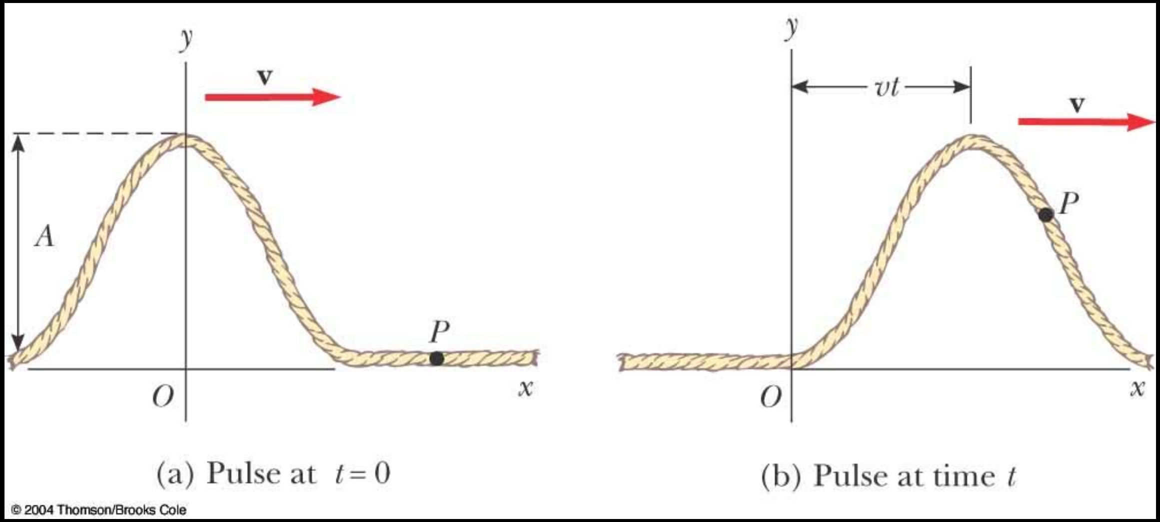
- Water waves



The disturbed particle moves both
parallel and perpendicular to the wave.

One Dimensional Wave

- The pulse is moving at a speed of ***v*** in the x-direction.
- It creates a displacement of ***y***.
- ***y*** is a function of ***x*** and ***t***.



Right moving pulse:

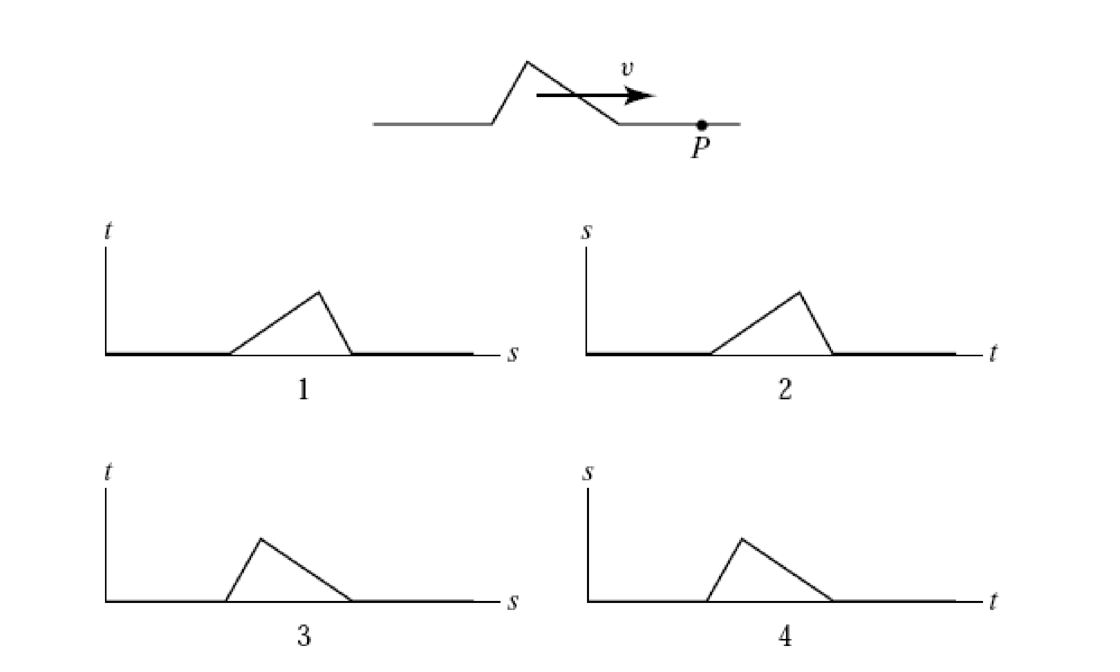
$$y = f(x - vt)$$

Left moving pulse:

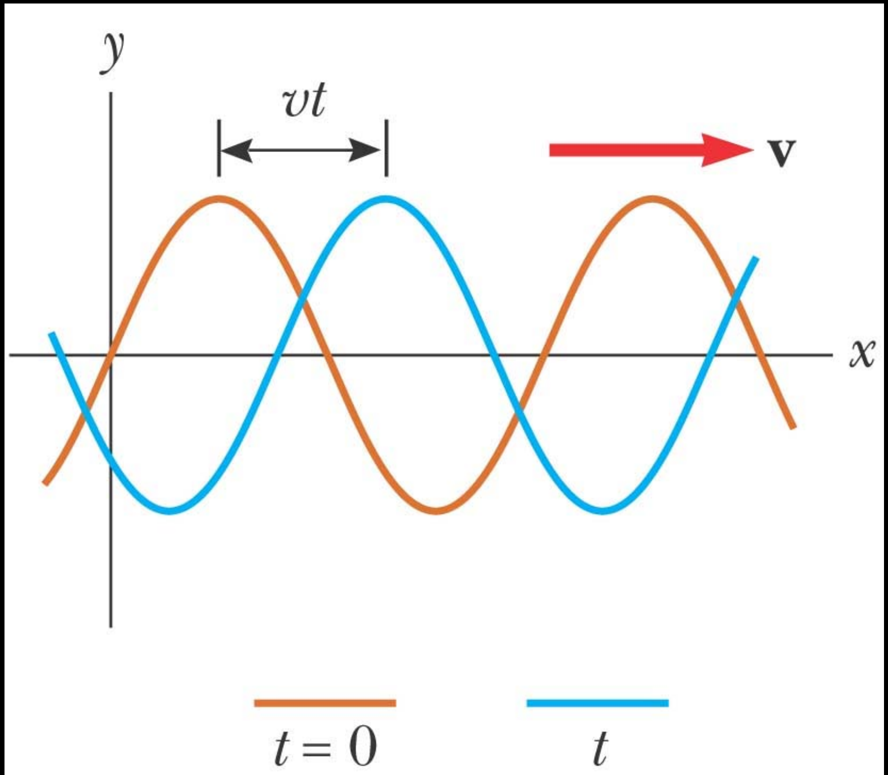
$$y = f(x + vt)$$

Example

A wave pulse is moving, as illustrated, with uniform speed *v* along a rope. Which of the graphs 1–4 below correctly shows the relation between the displacement *s* of point *P* and time *t*?



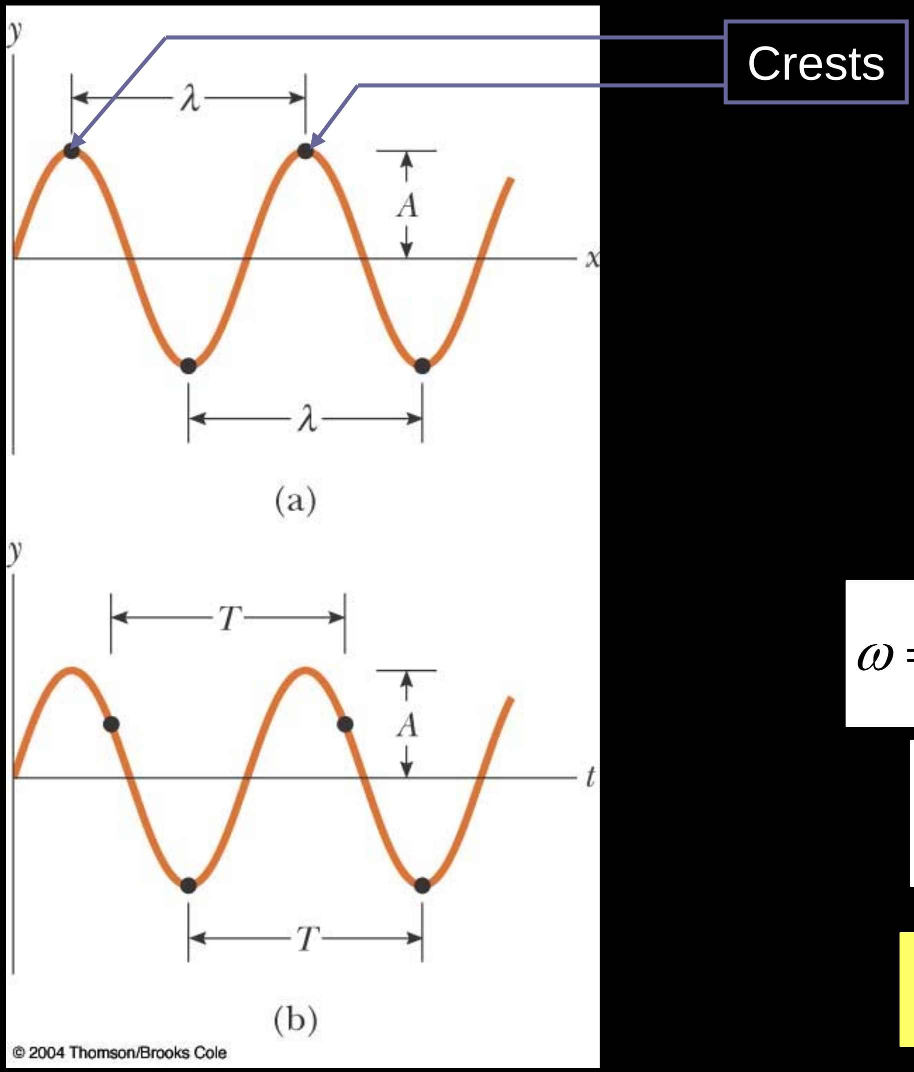
Sinusoidal Waves



$$y(x,t) = A\sin\left[\frac{2\pi}{\lambda}(x - vt)\right]$$

Variation in position (x) and time (t)

Sinusoidal Waves



- λ : Wavelength
- T : Period
- A : Amplitude

$$f = \frac{1}{T}$$ Frequency (Hz)

$$k = \frac{2\pi}{\lambda}$$ Wave number (m^{-1})

$$\omega = \frac{2\pi}{T} = 2\pi f$$ Angular frequency (rad/s)

$$v = \lambda f = \frac{\omega}{k}$$ Speed (m/s)

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

Example – P16.13

A sinusoidal wave is described by $y = (0.25m)\sin(0.30x - 40t)$

where x and y are in meters and t is in seconds. Determine;

a) the amplitude $A = 0.25m$

b) the angular frequency $\omega = 40\ rad/s$

c) the angular wave number $k = 0.30\ m^{-1}$

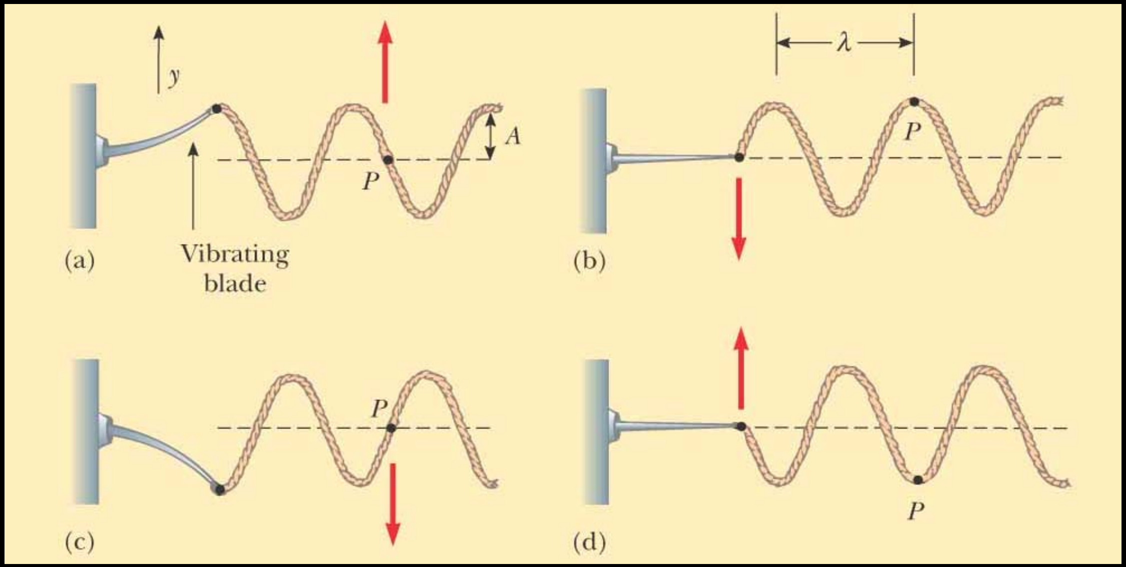
d) the wavelength $\lambda = 2\pi/k = 20.9\ m$

e) the wave speed $v = \omega/k = 133.3\ rad/s$

f) and the direction of motion. $+\ \mathrm{x}$ - direction

Waves on a String

Each element of the string oscillates vertically with simple harmonic motion.



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

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

$$a_y(x,t) = -\omega^2 A\sin(kx - \omega t)$$

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

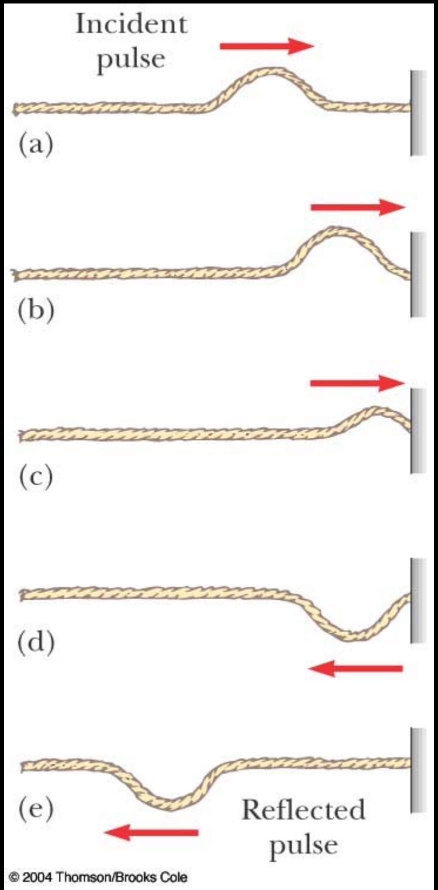
T = tension in the string

μ = mass per unit length of the string

Reflection of Waves

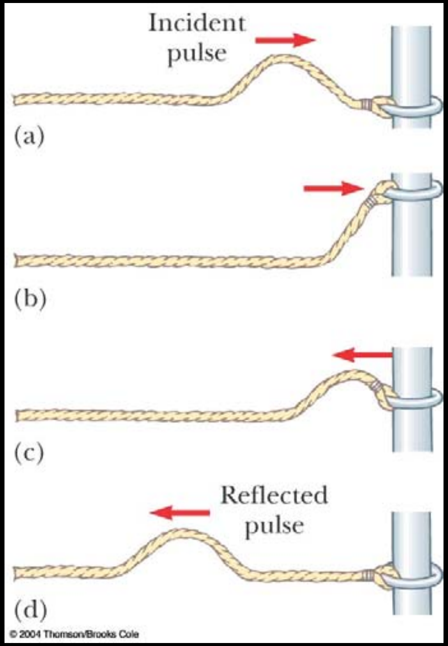
Rigid Support

The wave is <u>inverted</u> upon reflection.



Loose Support

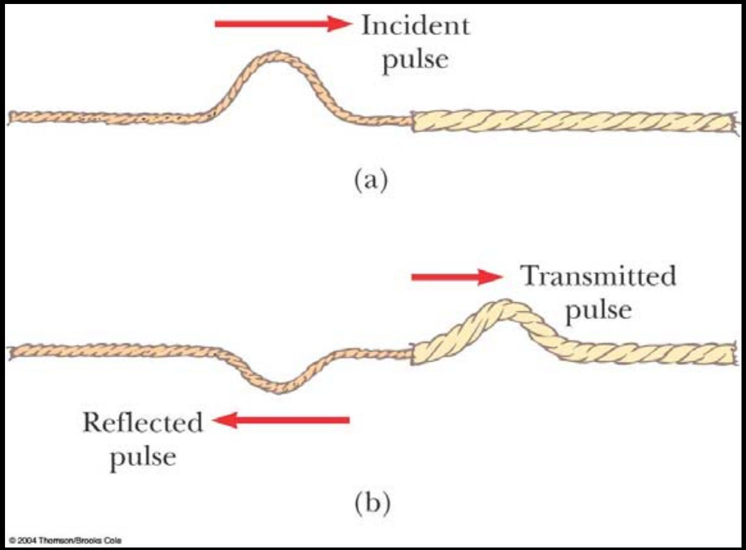
The wave is <u>not</u> <u>inverted</u> upon reflection.



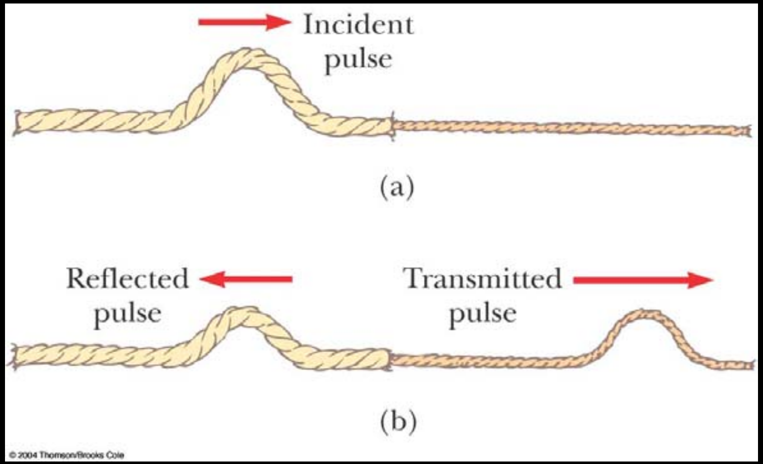
Transmission of Waves

When the boundary is neither totally rigid or loose, the wave is partially reflected and partially transmitted.

Light to heavy string:
Reflected wave is inverted
Transmitted wave is not inverted



Heavy to light string:
Reflected wave is not inverted
Transmitted wave is not inverted



In General …

- Transmitted waves are not inverted.
- If the wave is traveling from a medium of high speed to a medium of low speed (traveling from a lighter to a denser medium), the reflected wave is inverted.
- If the wave is traveling from a denser (low speed) to a lighter medium (high speed) then the reflected wave is not inverted.

Review

- Longitudinal and transverse waves.
- Traveling waves have amplitude and velocity.
- Sinusoidal traveling waves are periodic in time and space.
- Transmitted waves are not inverted.
- If a wave reflects off of a denser medium, it gets inverted, otherwise it does not.