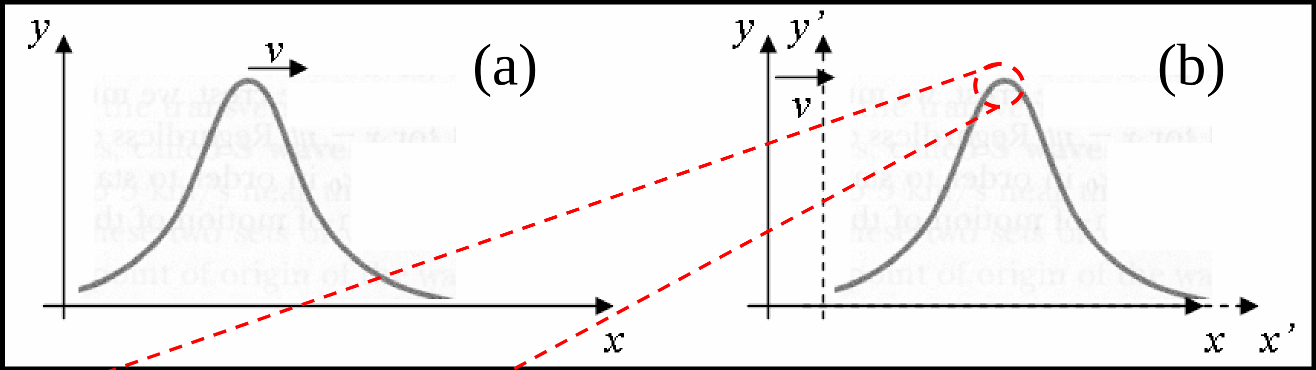
16.3. Speed of a wave on a stretched string

Find the speed of a traveling wave by

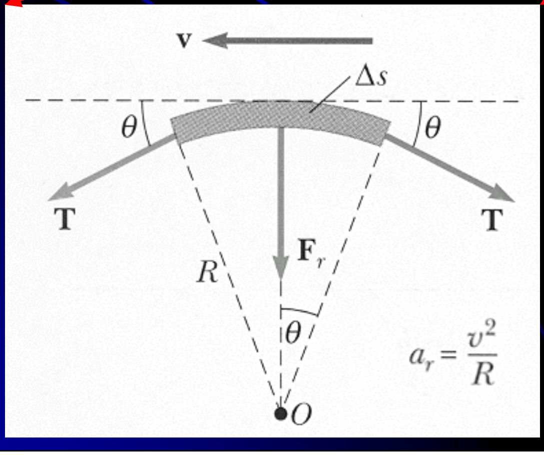
(*i*) using conceptual and dimensional analysis : → $v = C\sqrt{\dfrac{T}{\mu}}$

(*ii*) using mechanical analysis : considering a single symmetrical pulse.

(a) In a stationary frame of reference : (b) In a frame moving with the pulse :



- Consider a small segment of Δs, forming an arc of a circle of radius R

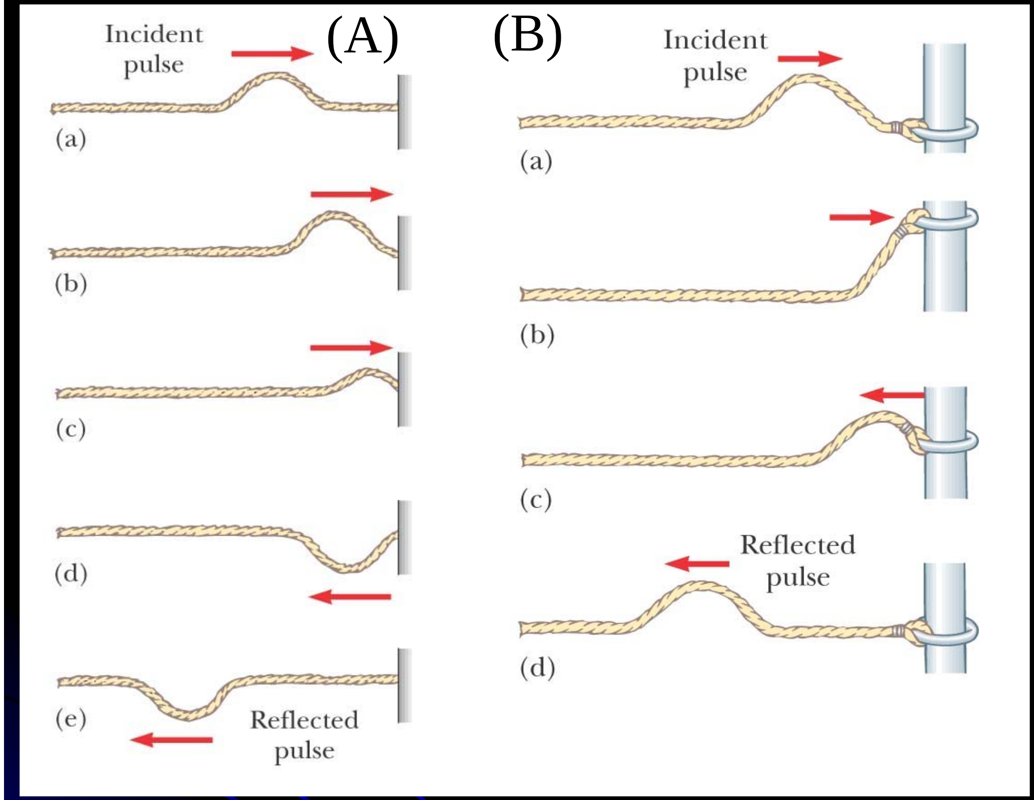


$$\boxed{v = \sqrt{\frac{T}{\mu}}}$$

$$\text{Wave speed} = \sqrt{\frac{\text{Force factor}}{\text{Mass factor}}}$$

16.4. Reflection and Transmission (*descriptive*)

(A) Fixed end (B) Free end

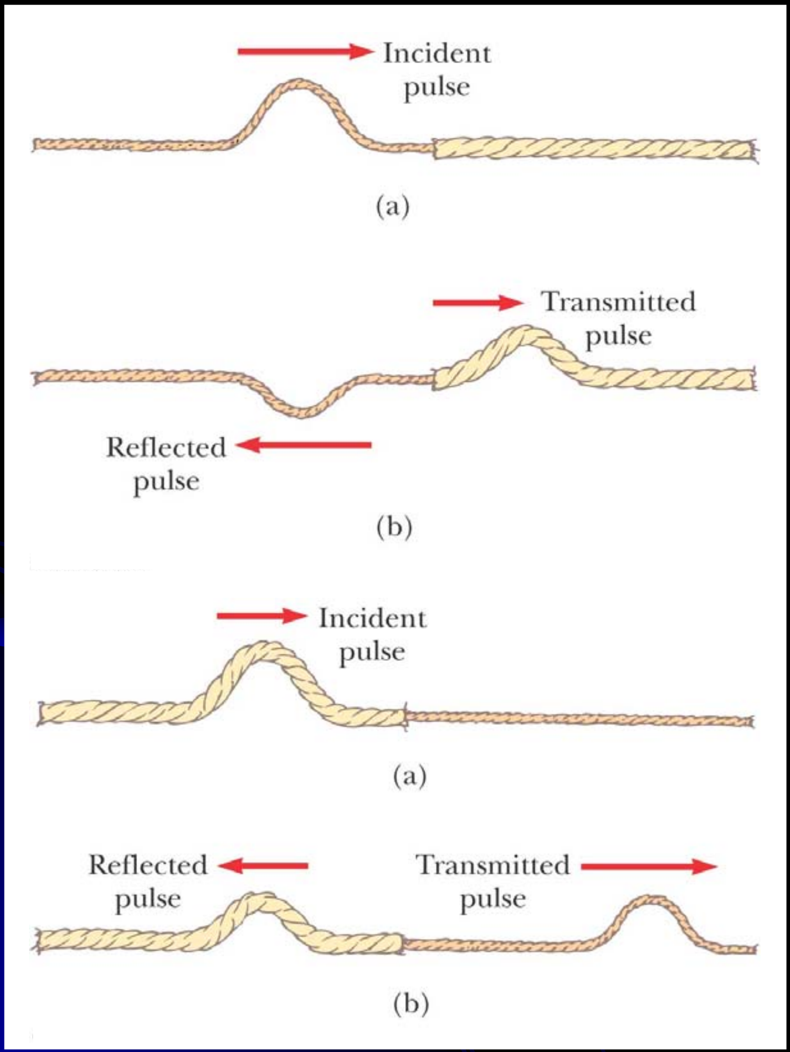


(A) Reflection of a wave pulse on a rope when the end of the rope is *fixed*. The reflected pulse is inverted, since the pulse exerts a force (upward) on the support. Due to the *Newton's third law*, the support exerts an equal but opposite force downward on the rope. This downward force on the rope generates the inverted reflected pulse.

(B) Reflection of a wave pulse on a rope when the end of the rope is *free*. The rope overshoot, when it reaches the free end. The overshooting end exerts an upward pull on the rope, and this generates the reflected pulse, which is not inverted.

16.4. Reflection and Transmission (*descriptive*)

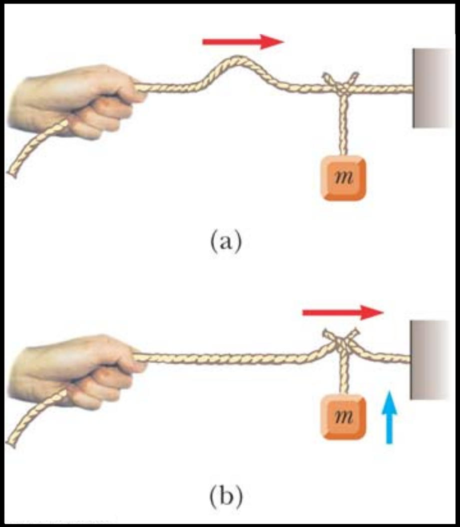
- A rope is connected to another rope of different mass density.



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

$$\textit{Wave speed} = \sqrt{\frac{\textit{Force factor}}{\textit{Mass factor}}}$$

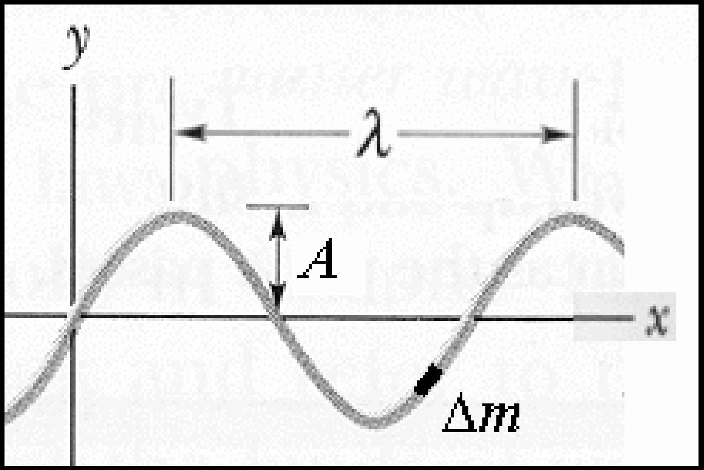
16.5. Rate of energy transfer by sinusoidal waves on strings



→ In waves energy is transmitted without the transport of mass.

(a) A pulse traveling to the right on a stretched string that has an object suspended from it.
(b) Energy is transmitted to the suspended object when the pulse arrives.

$$\boxed{\begin{aligned} E_\lambda &= K + U \\ &= \tfrac{1}{2}\,\mu\,\omega^2 A^2 \lambda \end{aligned}}$$



Power : $P = \frac{1}{2}\,\mu\,v\,\omega^2 A^2$

(Rate of energy transport)

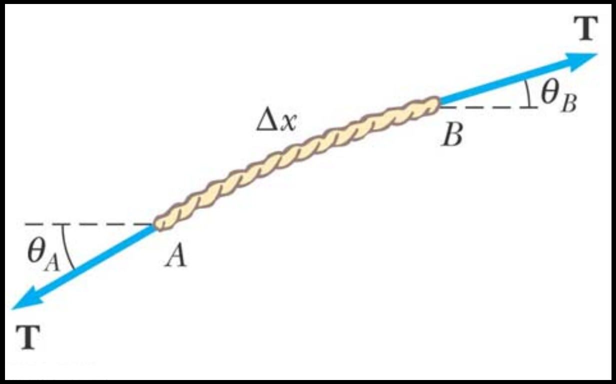
depends on the material and tension.

depends on the process that generates the wave.

16.6. The Linear Wave Equation

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$ (Wave equation)

The wave equation is the equation of motion of the wave, just as Newton's 2nd law is the equation of motion of a particle.



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

→ Any function of the form of $f(x \pm vt)$ will satisfy this diff. equ.