Wave Transferring Energy

Grade 11 Physics

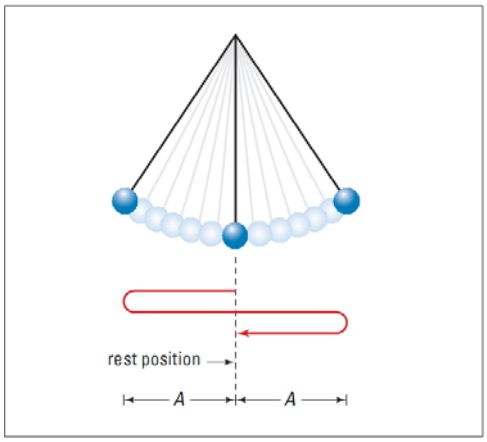
Vibration

Key Words

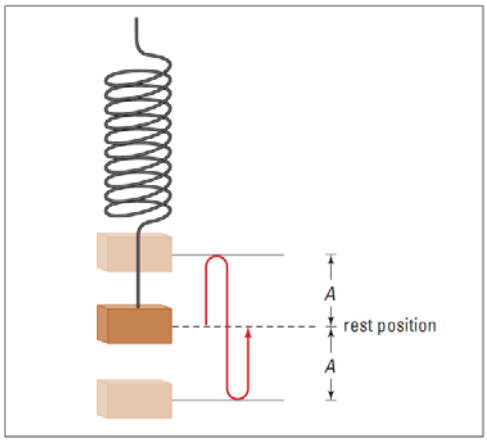
- Periodic Motion.
  - Object moves in a repeated pattern over regular time intervals.
- Cycle
  - One complete repeat of the pattern/vibration
- Period
  - The time required to complete on cycle. (T)
- Amplitude
  - The distance from the rest position to the maximum displacement when in motion. (A)

Keywords (Cont.)

- Amplitude in Two Different Scenario:



Simple Pendulum



Simple Spring

Period and Frequency

- Period and Frequency
  - Reciprocal of each other

$$T = \frac{\Delta t}{N} \qquad f = \frac{N}{\Delta t} \qquad f = \frac{1}{T}$$

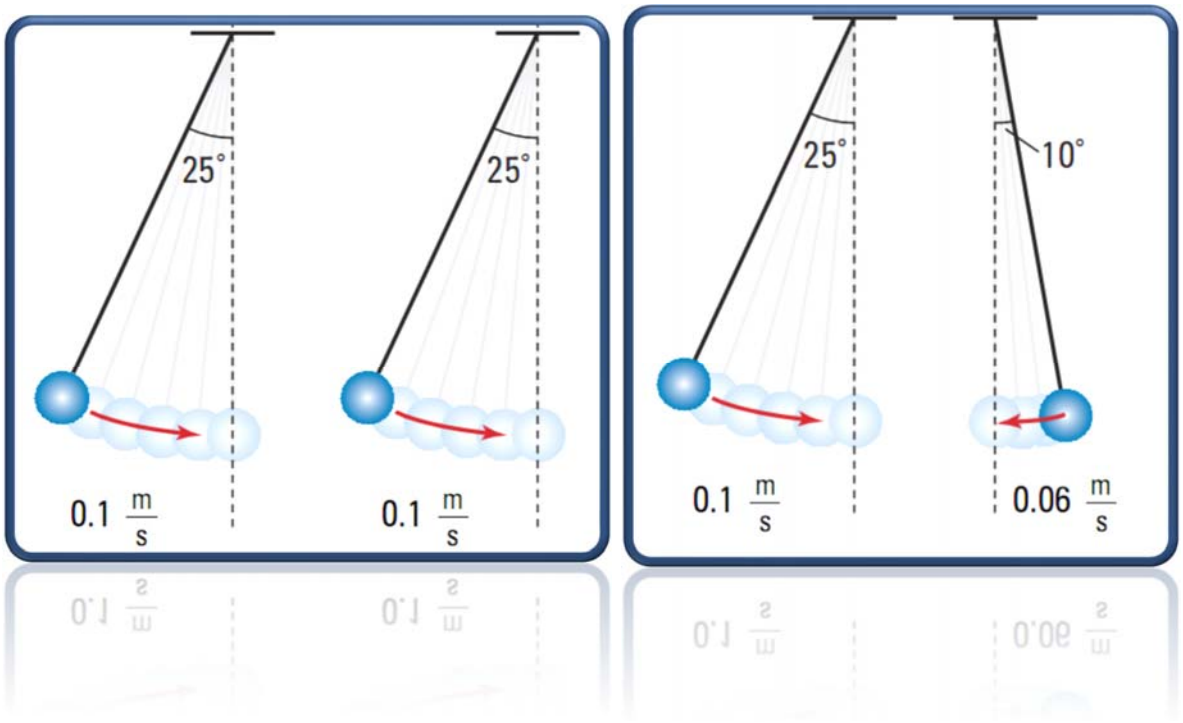
Quantity	Symbol	SI unit
period	T	s (seconds)
frequency	f	Hz (hertz)
time interval	Δt	s (seconds)
number of cycles	N	none (pure number)

Note: $1\ \text{Hz} = \frac{1}{\text{s}} = 1\ \text{s}^{-1}$

Phase

- Phase (Vibrating Object)
  - Phase Difference
    - Same amplitude and frequency, may not be at the same point in their cycles at the same time.
  - In Phase
    - Always moving in the same direction at the same time.
  - Out of Phase
    - Any part of their cycle, moving in opposite direction.

Phase



Example Problem

- Q1:
  - A mass suspended from the end of a spring vibrates up and down 24times in 36s. What are the frequency and period of the vibration?

Natural Frequencies and Resonance

- Natural Frequency
  - When an object is allowed to vibrate freely (on a simple spring or pendulum), it vibrates in Natural Frequency.
- Resonance
  - In phase
  - Same frequency to the natural frequency
  - Amplitude of the vibration becomes very large.

Tacoma Narrows Bridge

- 1940, November 7th
  - Video showed in the very first class
- Why did it collapse?
  - Of course Engineering Error
  - Natural Frequency and Resonance
  - Collapse around relatively moderate winds of 60 to 70km/h.

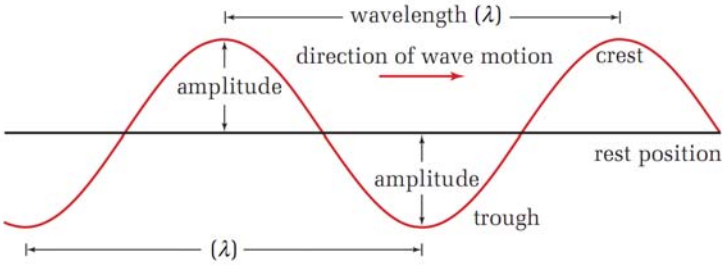
Wave Behavior

Wave

- Wave
  - How is a wave transferred?
  - A disturbance that transfers energy through a medium.
  - The medium vibrates and have a displacement of zero.
  - Each particles vibrates instead of moving horizontally, and the vibration get transferred to the next particle.

Describing Waves

- Crest
  - Highest point
- Trough
  - Lowest point
- Wavelength
  - Shortest distance between two points in the medium that are in phase.

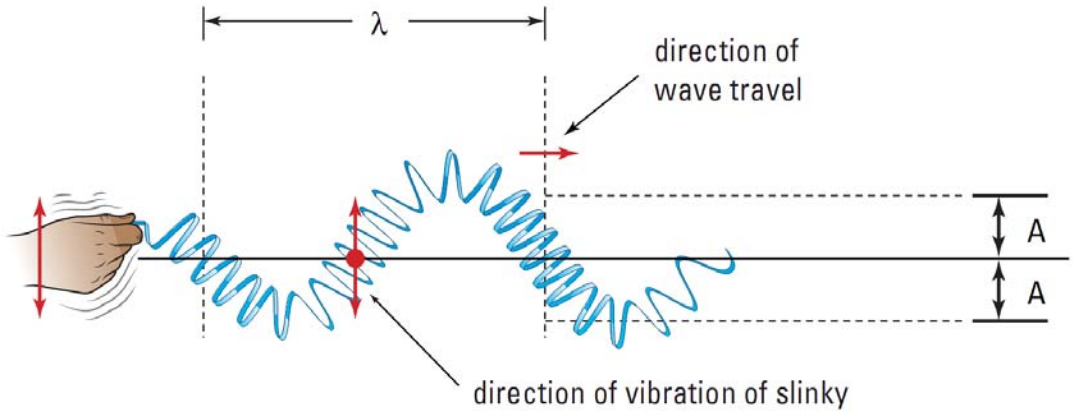


Frequency and Speed of A Wave

- Frequency of A Wave
  - The number of complete wavelengths that pass a point in a given amount of time. (hertz)
  - Does not depend on the medium
  - Depends on the source that is producing the wave.
- Speed of A Wave
  - Solely depends on the medium.

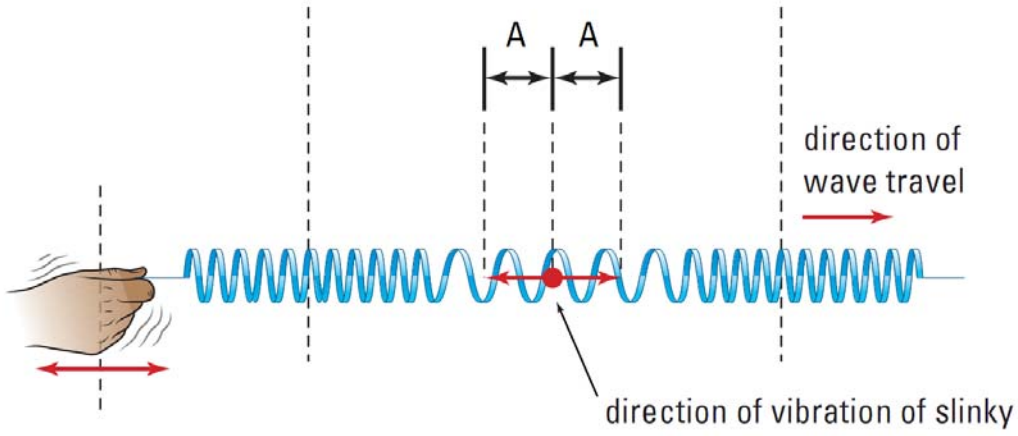
Transverse Wave

- Transverse Wave
  - The particles of a medium vibrate at right angles to the direction of the motion.
  - IE. Water waves and wave on a rope.



Longitudinal Wave

- Longitudinal Wave
  - The particles of a medium vibrate parallel to the direction of the motion of the wave
  - IE. A spring used in the common way.



Example Problem

- Q2:
  - A wave has an amplitude, A, frequency, *f*, and wavelength, λ. How can you find the speed of the wave using these variables?

Example Problem

- Q3:
  - A physics student vibrates the end of a spring at 2.8Hz. This produces a wave with a wavelength of 0.36m. Calculate the speed of the wave.

Example Problem

- Q4:
  - Water waves with wavelength 2.8m, produced in a wave tank, travel with a speed of 3.80m/s. What is the frequency of the straight vibrator that produced them?

The Wave Equaiton

- The speed of a wave is the product of the wavelength and the frequency.

$$v = f\lambda$$

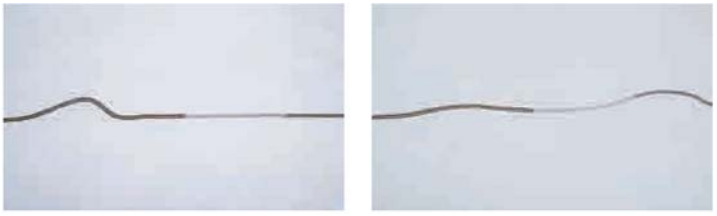
Quantity	Symbol	SI unit
speed	v	m/s (metres per second)
frequency	f	Hz (or s^{-1})(hertz)
wavelength	λ	m (metres)

Unit Analysis

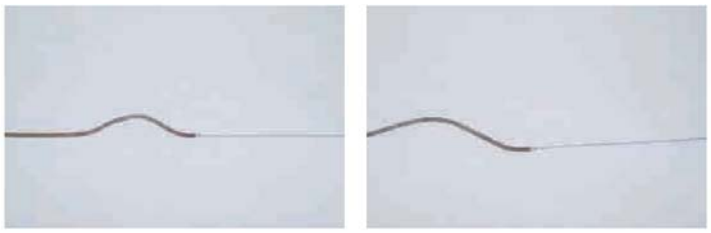
(frequency)(wavelength) = Hz m = s^{-1} m = m/s

Waves at Boundaries: Reflection and Transmission

- Free End and Slow to Fast Medium
  - Reflected wave is on the same side of the rest position as the incoming wave.



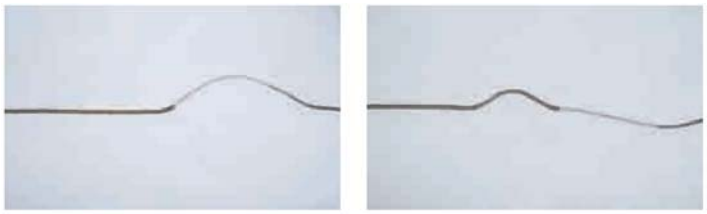
Slow to Fast Medium



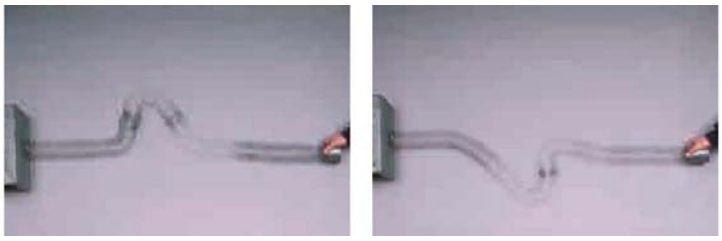
Free End

Waves at Boundaries: Reflection and Transmission (Cont.)

- Fixed End and Fast to Slow Medium
  - Reflected wave is inverted to the opposite side of the incoming wave.



Fast to Slow Medium



Fixed End

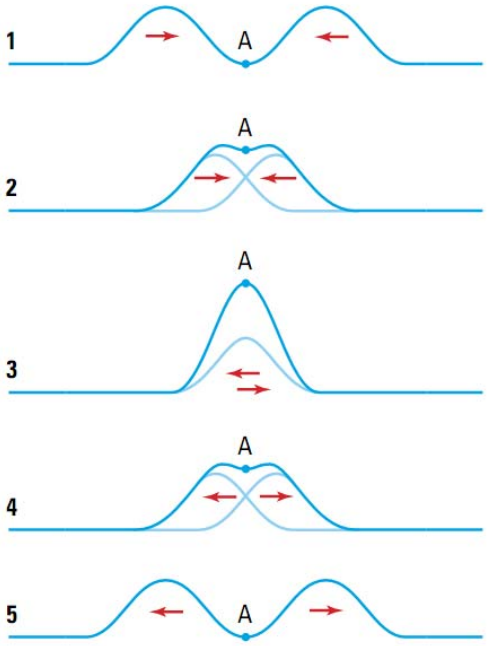
Interference of Waves

Superposition of Waves

- Superposition of Waves
  - Waves passes through each other
  - Constructive Interference
    - In phase **wave fronts** sum together
  - Destructive Interference
    - Out of phase **wave fronts** shows the difference of the wave fronts

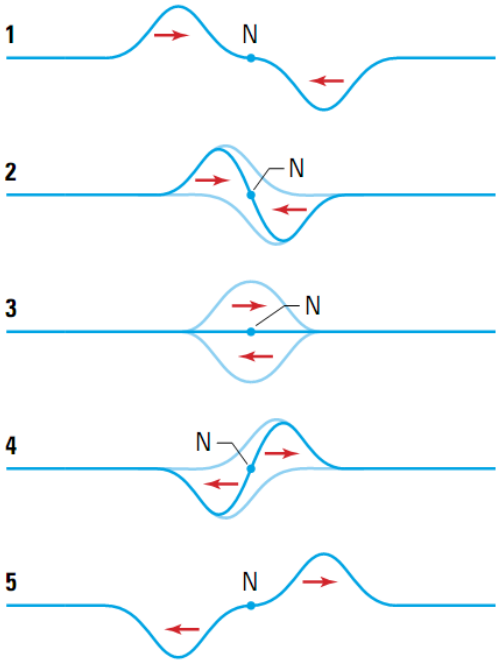
Superposition of Waves (Cont.)

- Constructive Interference
  - In phase **wave fronts** sum together



Superposition of Waves (Cont.)

- Destructive Interference
  - Out of phase **wave fronts** shows the difference of the wave fronts

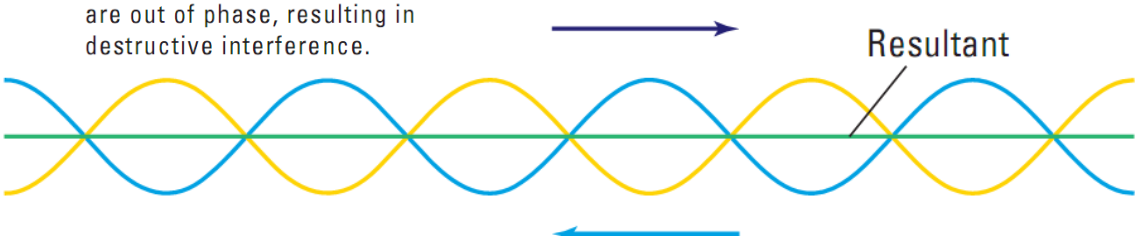


Standing Waves

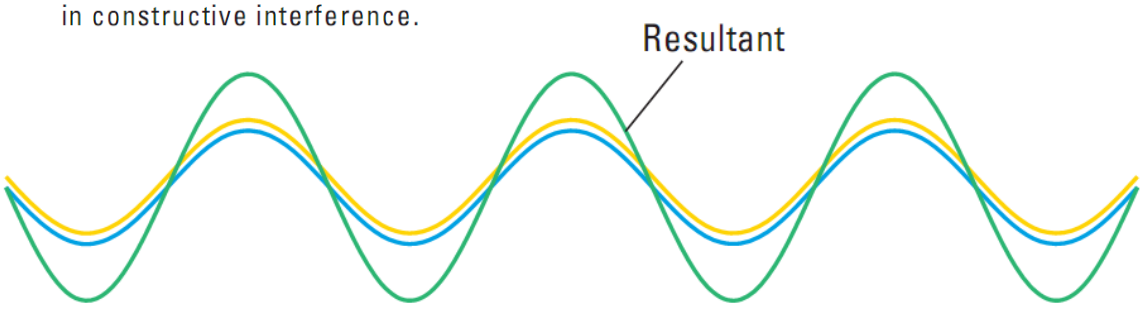
- Node
  - A point that never moves
- Antinode
  - A point which moves/vibrates maximally

Standing Waves (Cont.)

A Two waves are travelling in the same medium. Here, the waves are out of phase, resulting in destructive interference.



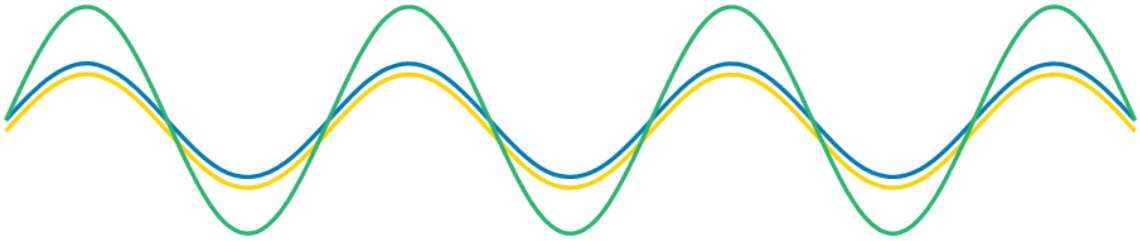
B One quarter of a period after (A), the waves are in phase, resulting in constructive interference.



Standing Waves (Cont.)

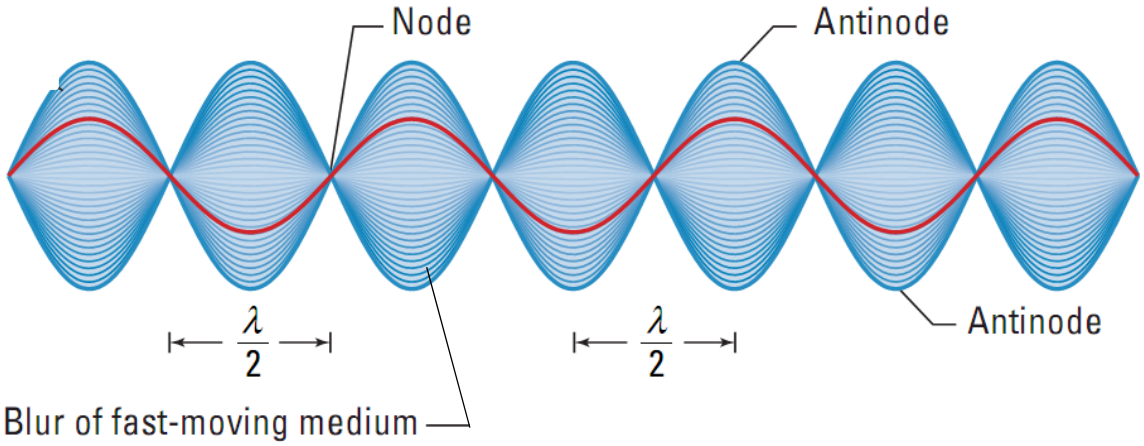
C One half of a period after (A), the waves are again out of phase.

D Three quarters of a period after (A).



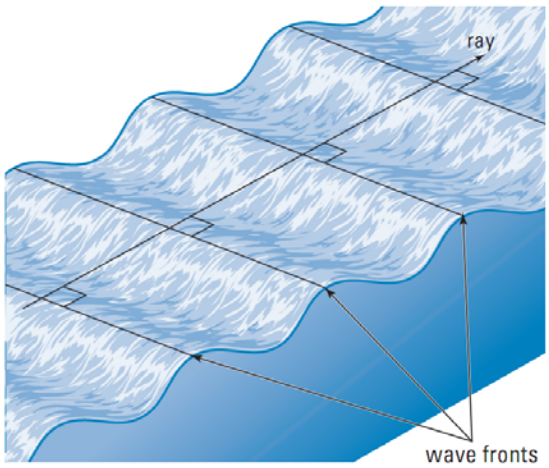
Standing Waves (Cont.)

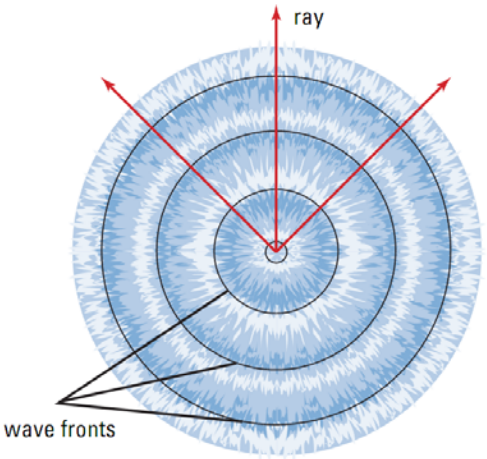
E This is the standing wave pattern that results from combining (A) and (D) above.



Waves in Two Dimensions

Water Wave

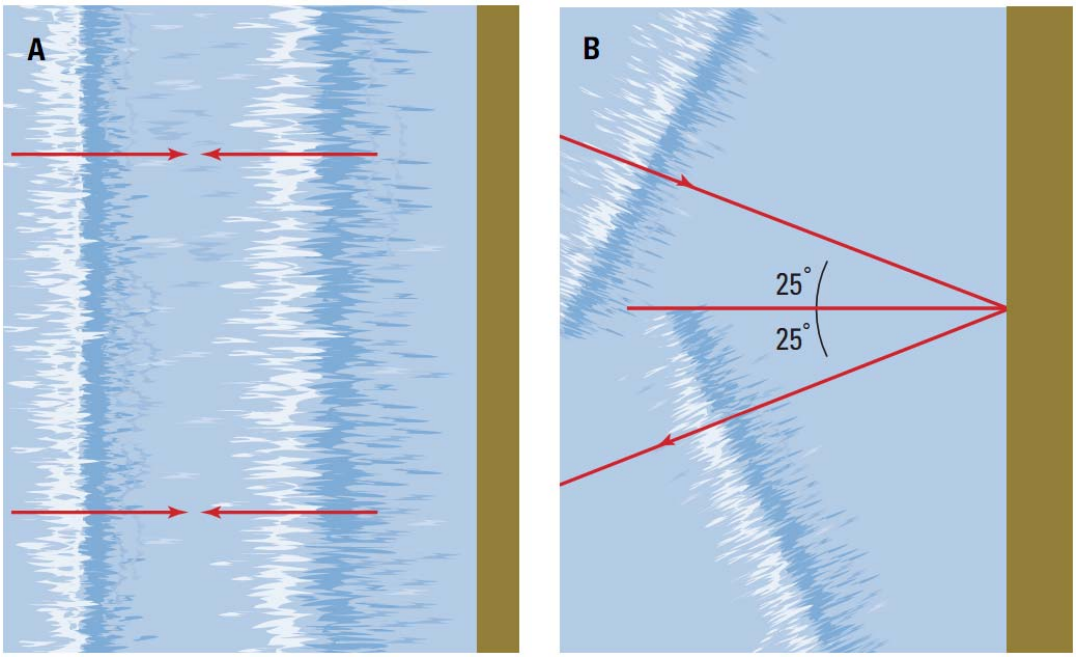




Wave Reflection

- Angle of incidence
  - The angle between the normal line and the direction of the wave relatively to the barrier
- Angle of reflection
  - The angle between the normal and the ray representing the reflected wave.
- Angle of refraction
  - The speed of the wave differs when entering to a different object.
  - The angle between the normal and the direction of the refraction wave. Will go in more depth in light section

Wave Reflection



Diffraction of Wave