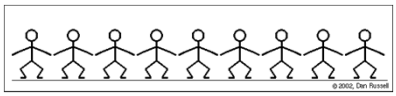
Waves

Wave - Susanne Nilsson (Attribution-ShareAlike 2.0 Generic)

A Wave is….

- a disturbance, a transfer of energy that travels from one place to another.



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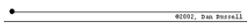
Wave Pulse

- A single disturbance that moves through the medium.



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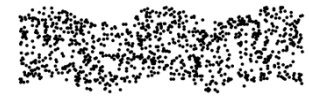
Periodic Wave

- A continuous disturbance traveling through the medium.



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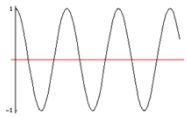
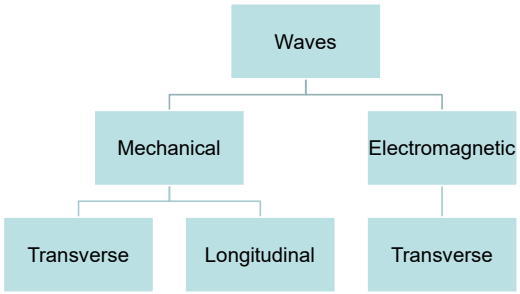


Lagaffe (pubic domain)

Types of Waves



Mechanical Waves

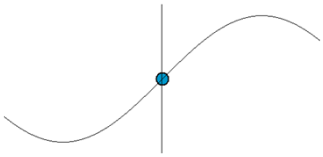
- Require a medium
  - Water, Sound

Electromagnetic Waves

- Can travel in a vacuum (no medium is required)
  - Light, Radio and TV signals

Transverse Waves

- The particles move perpendicular to the wave motion.



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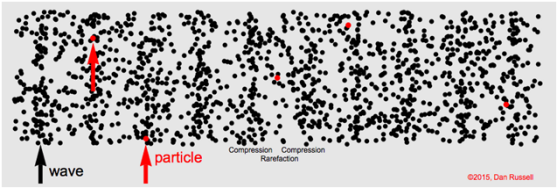
Evil saltine (public domain)

Longitudinal Waves

- The particles move parallel to the wave motion.



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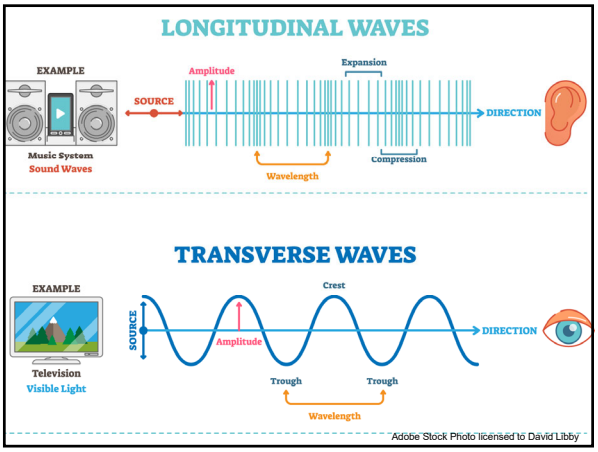
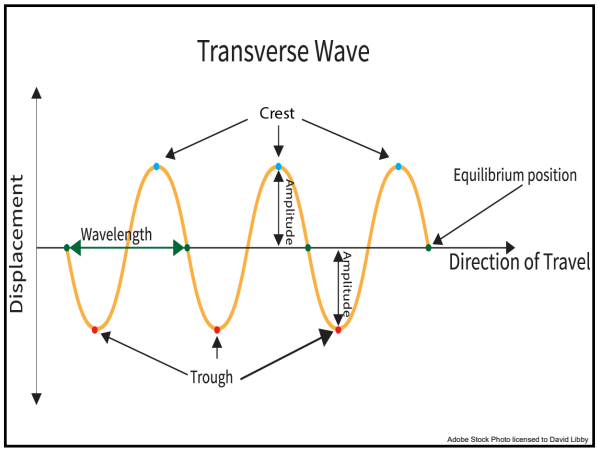
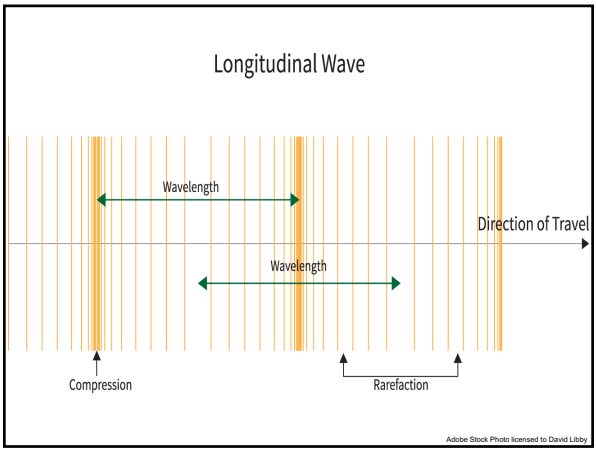


Wave Properties

- Crest
  - highest part of wave
- Trough
  - lowest part of wave
- Wavelength
  - distance between adjacent identical parts of the wave
    - crest to crest, trough to trough

- Amplitude
  - distance between the resting position and the maximum displacement of the wave
- Compression
  - a region in a longitudinal wave where the particles are closest together
- Rarefaction
  - a region in a longitudinal wave where the particles are furthest apart





Period and Frequency

- Period, T
  - The time needed to produce one full wave.
- Frequency, f
  - The number of waves passing a given point per second
  - Units: Hertz, Hz
- Period and frequency are mathematically related

$$\boxed{T = \frac{1}{f}}$$

Speed of a Wave

$$v = \frac{d}{t}$$

distance is wavelength, λ

time is period, T

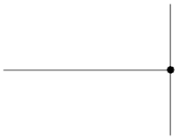
$$v = \frac{\lambda}{T} \qquad f = \frac{1}{T}$$

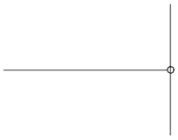
$$\boxed{v = f\lambda}$$

One Dimensional Waves

Reflection

- Fixed/Hard Boundary
- Free/Soft Boundary





- Pulse is inverted
- Pulse is not inverted

Animations courtesy of Dr. Dan Russell, Grad. Prog. Acoustics, Penn State

Refraction

- A wave traveling from one medium into another.
- Low to High Density

Animation courtesy of Dr. Dan Russell, Grad. Prog. Acoustics, Penn State

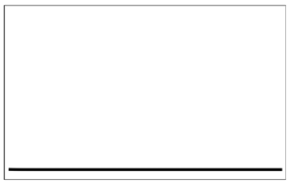
- High to Low Density

- Note
  - Velocity of the wave changes
  - Some of the wave is reflected
  - The frequency of the wave remains the same

Animation courtesy of Dr. Dan Russell, Grad. Prog. Acoustics, Penn State

Superposition

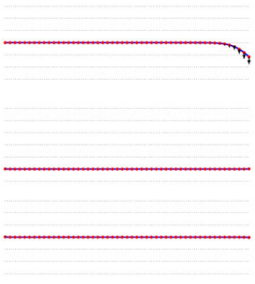
- When two waves meet, they pass through each other and continue their path as if nothing happened.



Animation courtesy of Dr. Dan Russell, Grad. Prog. Acoustics, Penn State

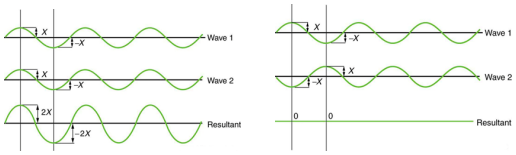
Principle of Superposition

- When two (or more) waves meet at some point in space the displacement at that point is the algebraic sum of the individual displacements



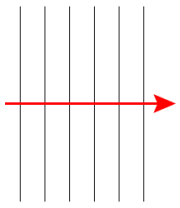
Interference

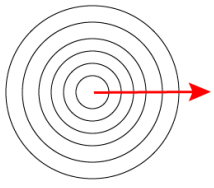
- Constructive
  - Resulting amplitude is greater
- Destructive
  - Resulting amplitude is smaller



Two Dimensional Waves

- Wavefronts
  - Lines representing the crests of the wave
- Wave Ray
  - Arrow representing the direction the wave is traveling
    - Perpendicular to the wavefront

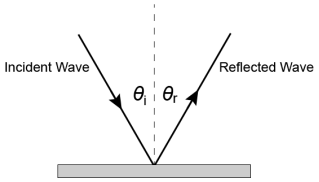




Reflection

- The angle of reflection equals the angle of incidence.

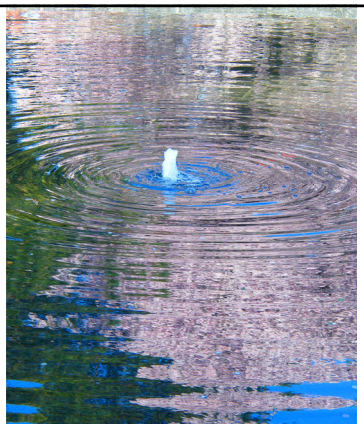
$$\theta_r = \theta_i$$



The angles are measured relative to the perpendicular to the surface at the point where the ray strikes the surface.

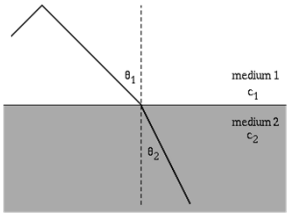
Reflection – troy mckaskle (Creative Commons Attribution-ShareAlike 2.0 Generic)

Reflection – Bobumil Kosera (Creative Commons Attribution-NonCommercial-NoDerivs 2.0 Generic)



Ripple Reflection – Stanley Zimmy (Creative Commons Attribution-NonCommercial 2.0 Generic)

Refraction

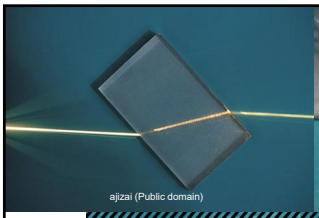


Animation courtesy of Dr. Dan Russell, Grad. Prog. Acoustics, Penn State

Dicklyon (Richard F. Lyon) (CC BY-SA 3.0)

Snell's Law: $$\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$$

(*n* is the index of refraction)



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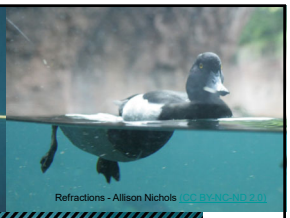
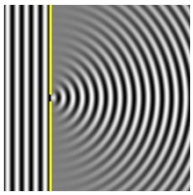


Refractions - Allison Nichols (CC BY-NC-ND 2.0)

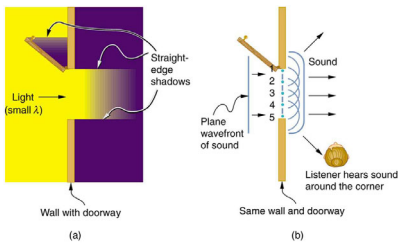
Refraction – ianzmackie (CC BY-NC-ND 2.0)

Diffraction

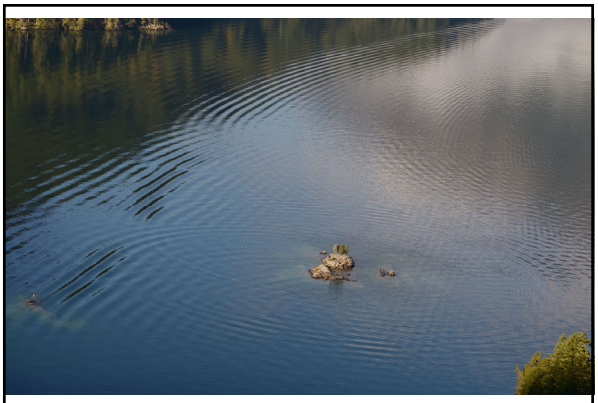
- When waves pass through a narrow gap or slit, or when their path is partially blocked by an object, the waves spread out into what one would expect to be a shadow region



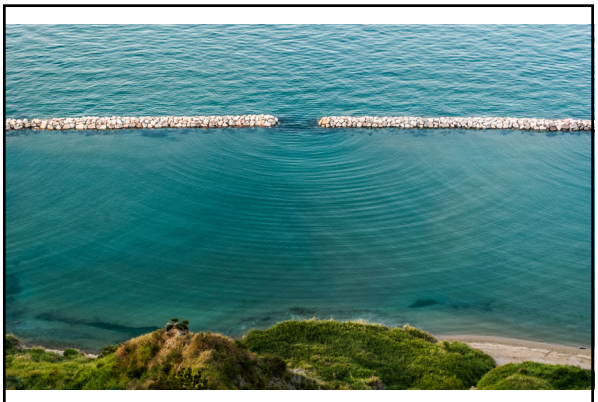
- Waves will only diffract if the wavelength is larger than the barrier or opening.



Fluted Cape Diffraction – ccdoh1 (Creative Commons Attribution-NonCommercial-NoDerivatives 2.0 Generic)



wave diffraction and interference – Richard Droker (Creative Commons Attribution-NonCommercial-NoDerivatives 2.0 Generic)



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