Chapter 14: Waves and Energy Transfer

Catch the Wave!


Amplitude
14.1
Wave Properties
Interference
Mechanical Waves
Trough and Crest
TRANSVERSE WAVES
LONGITUDINAL WAVES
Surface Waves

14.1 Objectives

Identify how waves transfer energy without transferring matter.

Contrast transverse and longitudinal waves.

Relate wave speed, wavelength, and frequency.

Waves: Friends or Foes?

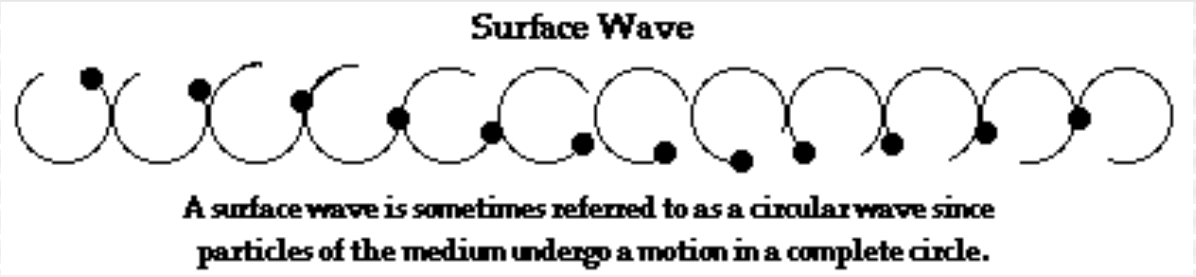
Have you ever watched surfing or done it yourself? Ocean waves can be loads of fun. But at the same time they are very dangerous. You do not want waves to be too big. The Tsunami in Indonesia reminds us of that.

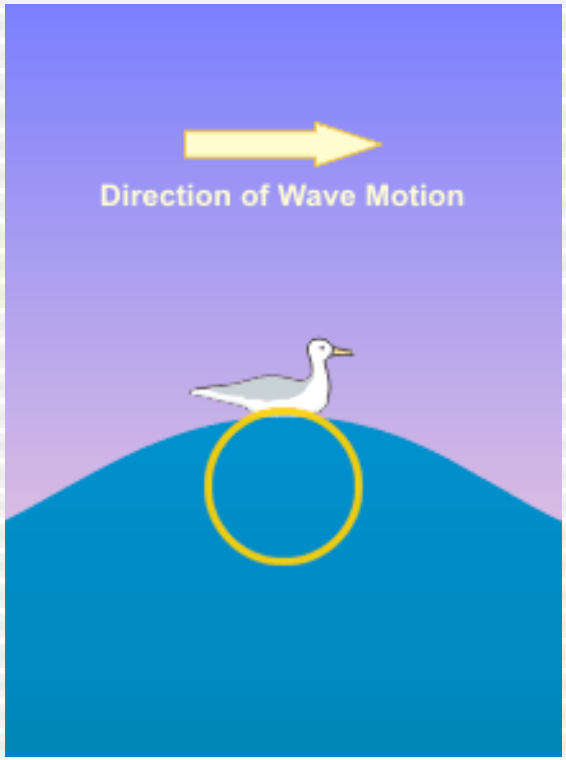
Ocean waves contain **energy**. But where does it come from? Normal weather creates the winds that make normal sized waves. Storms, monsoons, and hurricanes, create the stronger winds that make larger waves. Earthquakes can make wave disturbances that can catapult water several miles inland.

Anatomy of a Tsunami

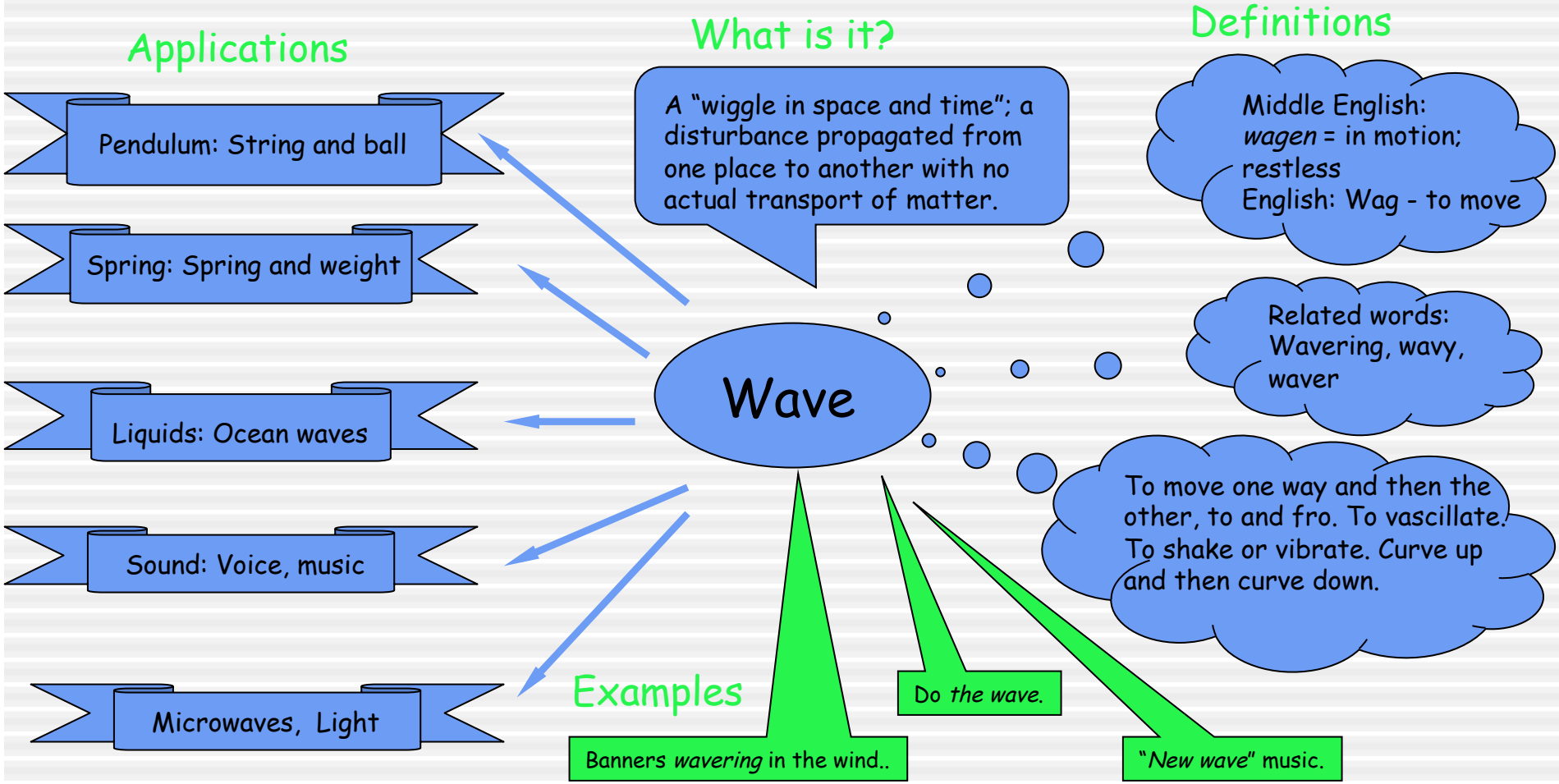
Indonesia Tsunami 12/26/04

Ocean Waves

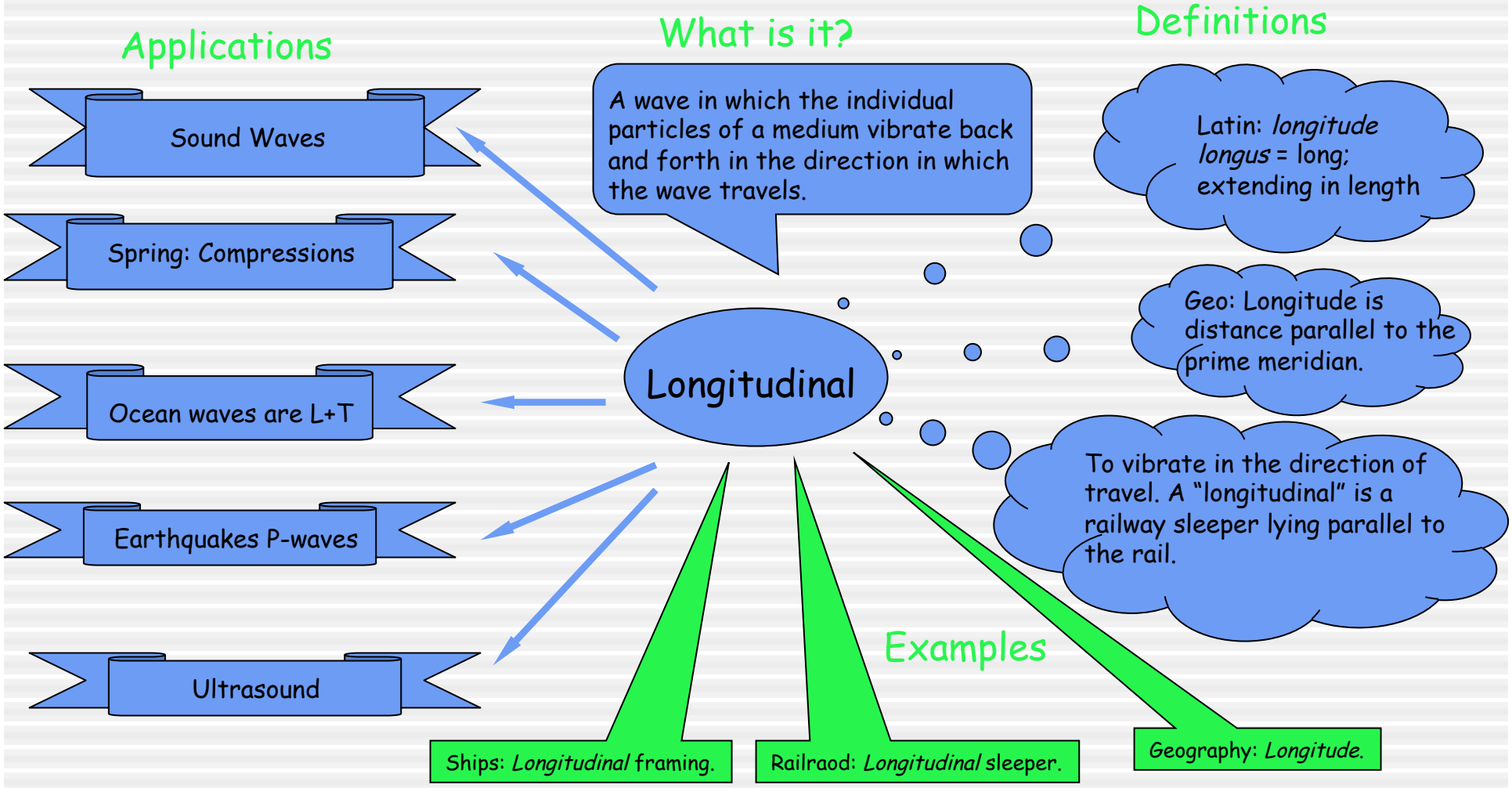

Surface Wave
A surface wave is sometimes referred to as a circular wave since particles of the medium undergo a motion in a complete circle.


Direction of Wave Motion

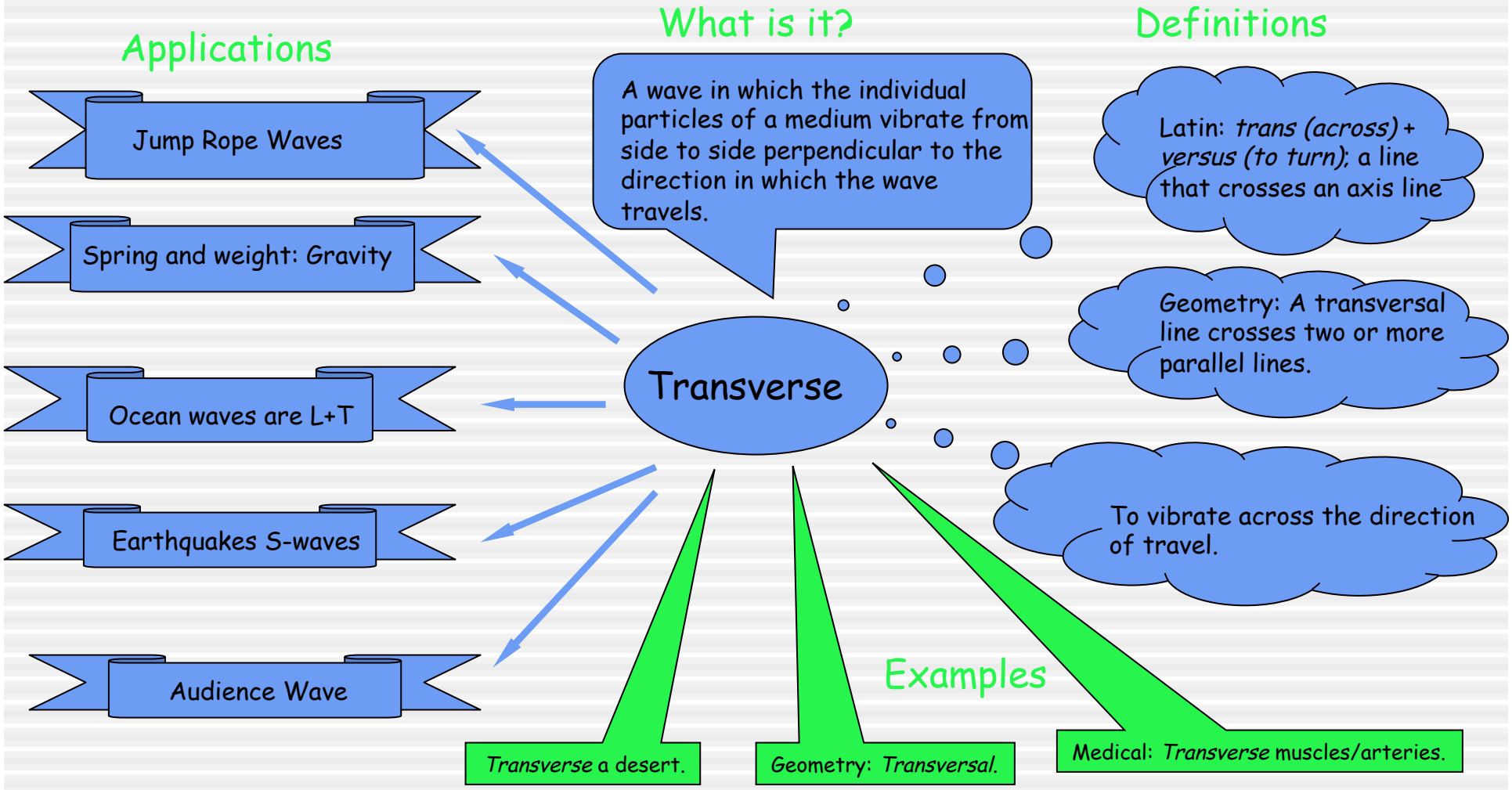
Concept Development Map



Concept Development Map



Concept Development Map



What is a Wave?

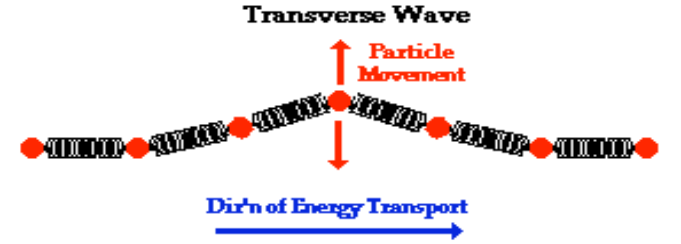
A **wave** is a rhythmic disturbance that carries energy through matter or space. **Waves transfer ENERGY** only, not matter.

Wave Pulse - A single disturbance traveling through a medium. A medium is the material through which the wave travels.

Continuous Wave - A continuous disturbance is generated from a source that travels through a medium.

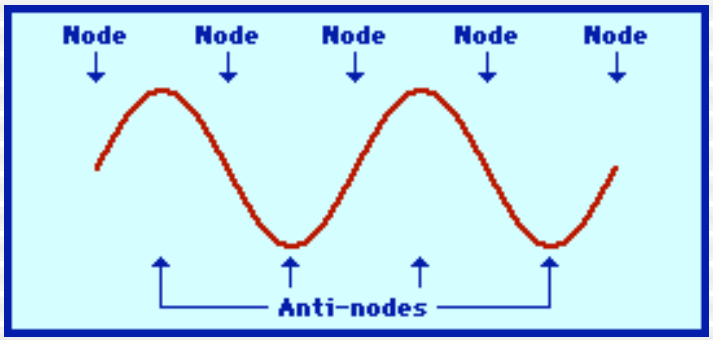
Mechanical Waves

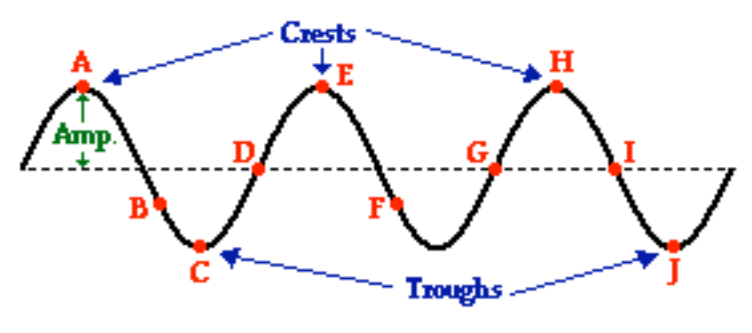
Transverse Wave - The disturbance vibrates perpendicular to the direction of wave travel (TRANS = Across). The simplest example is achieved by shaking a rope up and down.



Longitudinal Wave - The disturbance vibrates parallel to the direction of wave travel (LONGITUDINAL = Along direction of travel). The simplest example is achieved by the squeeze and relaease of a coiled spring.

Anatomy of a Wave





Anatomy of a wave

Amplitude and Wavelength

Frequency

Wave Parts

Longitudinal and Transverse Waves

Longitudinal/Transverse Demo

Slinky waves can be made by vibrating the first coil back and forth in either a horizontal or a vertical direction.

Wave Speed

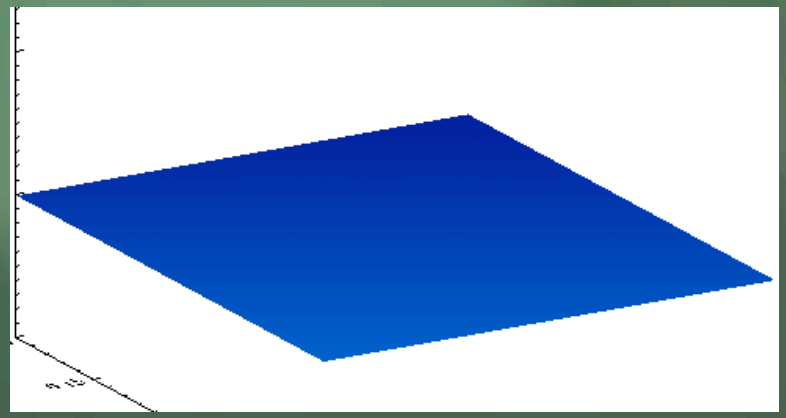
Wave Speed - The distance a wave travels in a given time. It is given as the frequency times the wavelength.

$$\upsilon = \frac{\Delta d}{\Delta t} = \frac{\lambda}{T} = \left(\frac{meter}{oscillation}\right)\left(\frac{oscillation}{\text{sec}ond}\right) = f\lambda$$

$$f = frequency = \frac{1}{T}; \quad T = period = \frac{1}{f}$$

$$\lambda = wavelength$$

14.2
Waves Behavior



14.2 Objectives

Relate a wave's speed to the medium in which the wave travels.

Describe how waves are reflected and refracted at boundaries between media, and **explain** how waves diffract.

Apply the principle of superposition to the phenomenon of interference.

Incidence and Reflection

Incident Wave - The wave that strikes the boundary, the incoming wave.

Reflected Wave - The wave that returns from the boundary, the returning wave.

Inverted Wave - Often the reflected wave is inverted (upside down) by the boundary if it is a wall.

Reflected Waves

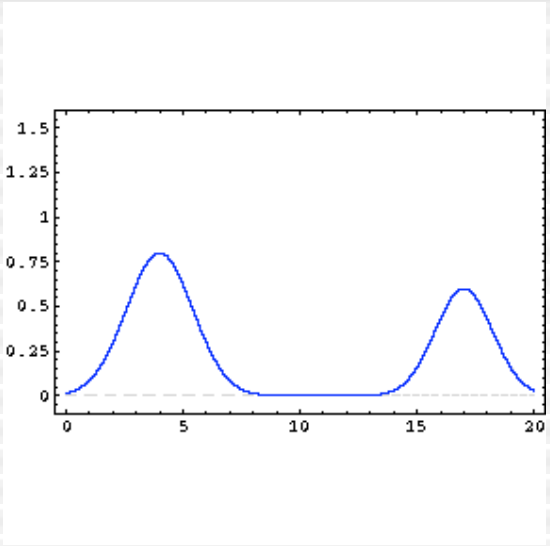
Superposition and Interference

Principle of Superposition - The algebraic sum of the displacements of the waves. If we superimpose several waves on top of each other, like when you stack transparencies, then add the values a each x-axis position, you get a combined wave.

Destructive Interference - The superposition of waves with displacements in the opposite direction.

Constructive Interference - The superposition of waves with displacement in the same direction.

Superposition



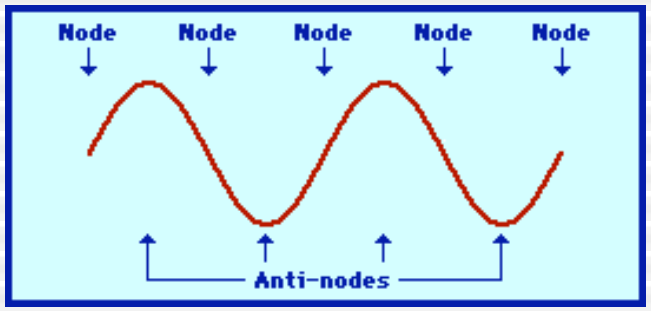
Simple Wave Superposition

Wave Superposition

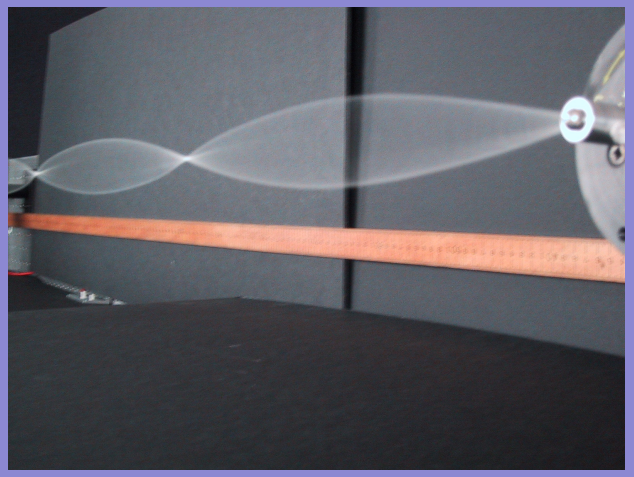
Wave Superposition Center

Standing Wave

Standing Waves - A wave with stationary nodes and antinodes.



Standing Waves Demo



Reflection, Refraction, Diffraction

Reflection - to bend or return back. The change in the direction of a wave at a surface. There is a returning wave that is either inverted or displaced in the same direction as the incident wave.

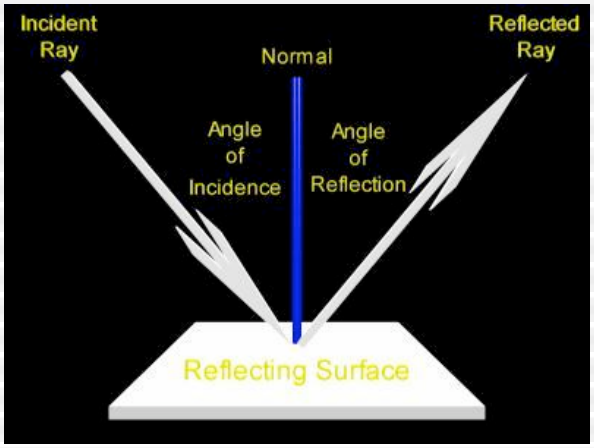
Refraction - to break or impair. The change in direction of a wave crossing a boundary between two different media. The different wave speed of the two media causes the bending. There is no returning wave.

Diffraction - to bend, break. The bending of waves around a barrier. The spreading of waves as they pass through a hole, slot, or slit. There is no returning wave.

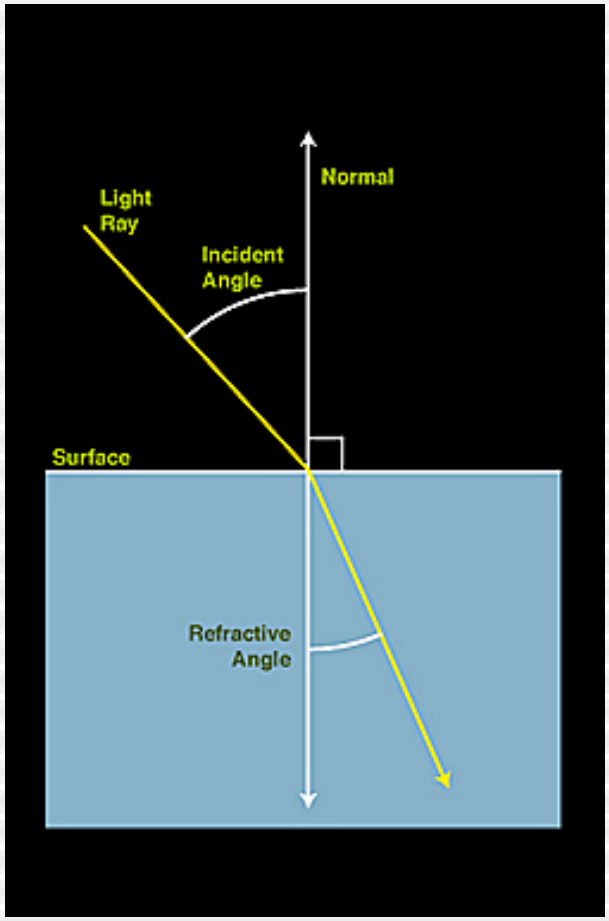
Reflection

Reflection - (Re= again) to bend or return back. The change in the direction of a wave at a surface. There is a returning wave that is either inverted or displaced in the same direction as the incident wave. It is like "seeing it again".

$$\angle incidence = \angle reflection$$



Refraction



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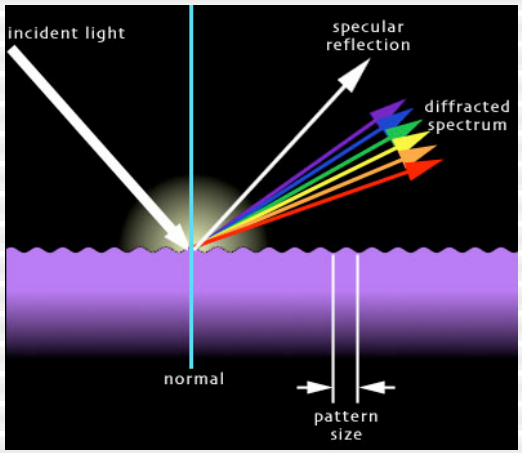

Refraction Demo

Diffraction

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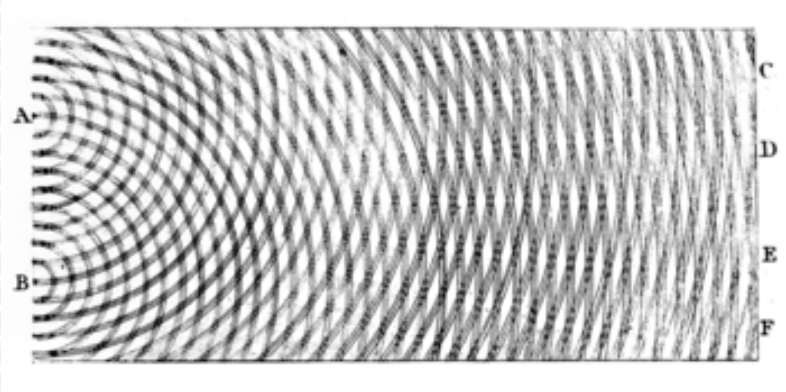

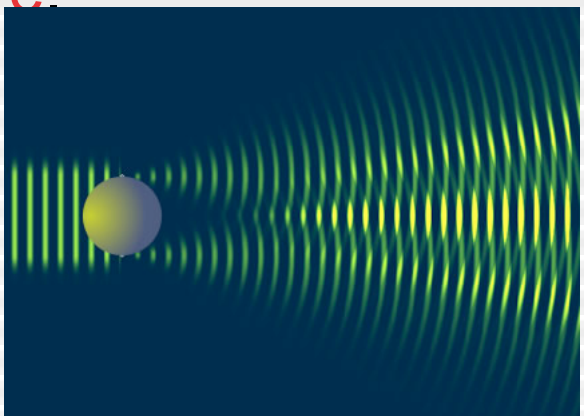

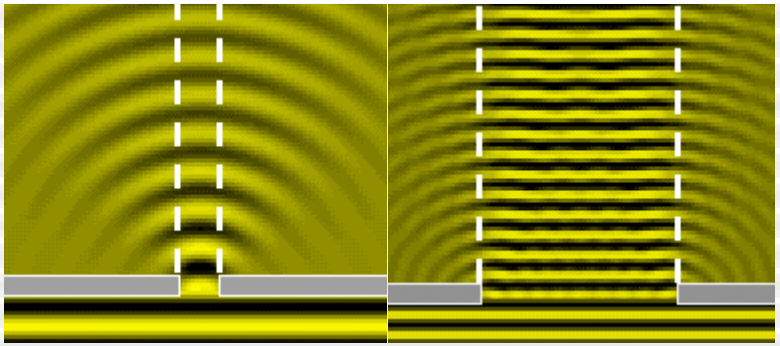

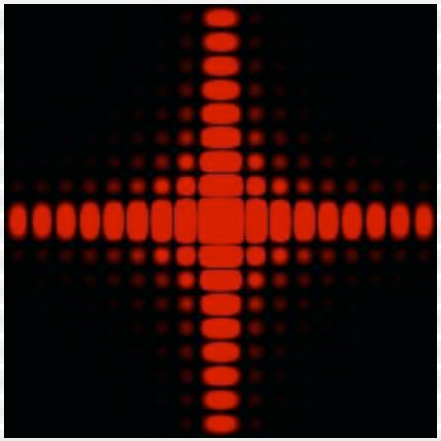

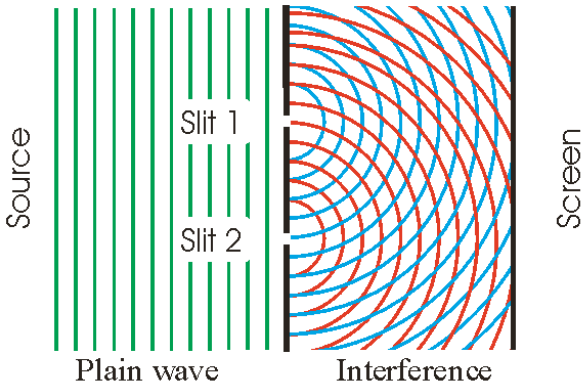

Tacoma Narrows Bridge

Wwwhhhaaattt Happened?

What do you think happened to the Tacoma Narrows Bridge?

This is an example of Bernoulli's Principle leading to oscillations (waves). The large vertical plates oscillated due to the wind passing by. By Bernoulli's Principle, the wind created pressure differences above and below the vertical plates. This was transformed to wave motion (oscillations).

Wave Examples

Spring Wave - An oscillating spring is a longitudinal wave. It moves in ONE dimension (1D).

Water Wave - An ocean wave has properties of both longitudinal and transverse waves. It moves in TWO dimensions (2D).

Sound Wave - A sound wave is a longitudinal wave. It moves in THREE dimensions (3D).