

Wave

Transfers Energy Without
Transferring Matter

Resonance



Clip from Mechanical Universe

Wave

- A wave can be described as a disturbance that travels through a medium from one location to another location.

There are three types of waves:

- Mechanical waves require a material medium to travel (air, water, ropes).
- Electromagnetic waves do not require a medium to travel (light, radio).
- Matter waves quantum mechanical waves - particles also exhibit wave properties

Mechanical Waves

- Transverse waves cause particles of medium to move perpendicular to the direction of the wave.
- Longitudinal waves cause particles of medium to move parallel to the direction of the wave.
- Surface waves - particles of medium oscillate in circular paths
- Torsional waves produce a twisting motion through the medium - such as the ones which caused the collapse of the Tacoma Narrows Bridge.

Tacoma Narrows Bridge Torsional Oscillation



Mechanical Universe Video

3 Types of Mechanical Waves

Longitudinal wave

Source moves left and right Coils move left and right

Energy Transport

Transverse Wave

Source moves up and down Coils move up and down

Energy Transport

The subsequent direction of motion of individual particles of a medium is the same as the direction of vibration of the source of the disturbance.

Surface Wave

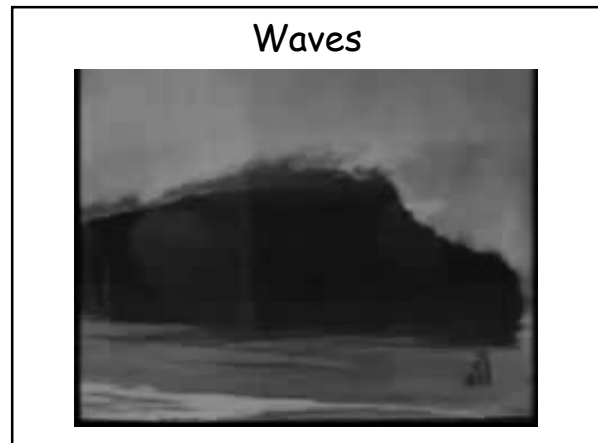
A surface wave is sometimes referred to as a circular wave since particles of the medium undergo a motion in a complete circle.

Wave Tutorial Links

- <http://library.thinkquest.org/10796/ch8/ch8.htm>
- <http://www.physicsclassroom.com/Class/waves/wavestoc.html>

Longitudinal Tuning Fork Wave

- Vibrating tines produce an alternating pattern of high pressure and low pressure regions.
- This pattern travels away from the fork.
- Compression - high pressure
- Rarefaction - low pressure



Period: T

- The **PERIOD** of a wave is the time for a particle of the medium to complete one oscillation.
- The SI unit for period is the second.

Frequency: f

- The **FREQUENCY** of a wave is the number of cycles per unit time.
- The unit is Hertz (Hz) which is a cycle per second.
- **FREQUENCY** is also the reciprocal of the period.

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

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

Amplitude: A

- The **AMPLITUDE** of a wave is the maximum distance of a particle from the equilibrium position.
- The SI unit for amplitude is meter

Wavelength: λ (lambda)

- The **WAVELENGTH** of a wave is the length of one complete cycle.
- It is the distance between two consecutive "in phase" points.
- In phase** points are those that are moving in step with each other.

- ### Wave Applets
- Wavelength, Amplitude, Phase
 - Frequency, Wavelength, Speed
 - Longitudinal Wave
 - Transverse Wave
 - Superposition Principle 1
 - Superposition Principle 2

Wave Equation

- The speed of a wave is equal to the product of the wave's frequency and wavelength.

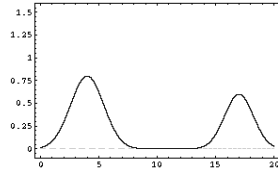
$$v = f \lambda$$

- v: wave speed
- f: frequency
- λ : wavelength

- ### Superposition Principle
- Wave **interference** occurs when two or more waves act simultaneously on a medium.
 - Whenever two or more waves pass through each other, the resulting disturbance at a given point in the medium may usually be found by adding the individual displacements that each wave would have caused. (**Principle of Superposition**)

Constructive Interference

- Constructive interference occurs when the waves are trying to displace the medium in the same direction.

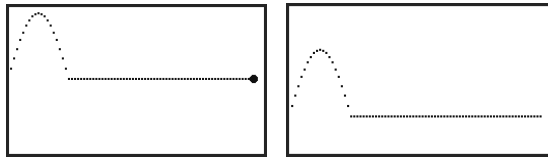


Destructive Interference



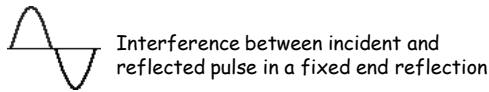
- When these two waves are completely overlapping, there will be complete destructive interference.
- Destructive interference occurs when the waves are trying to displace the medium in opposite directions.

Pulse/Wave Reflection



Fixed End Reflection

Free End Reflection

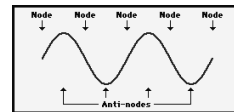
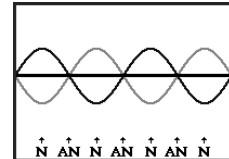


Interference between incident and reflected pulse in a fixed end reflection

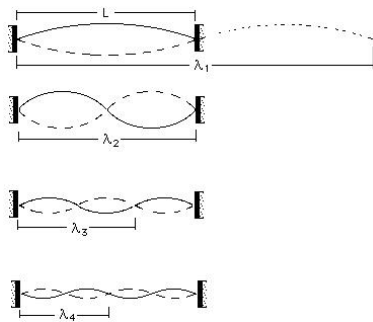
- Fixed/Free End Reflection of Sine Wave

Standing Waves

- For certain frequencies, the interference of the incident and reflected waves results in a standing wave pattern.

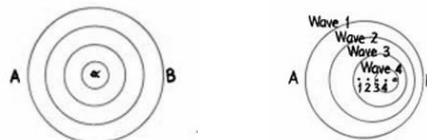


Fundamental Frequency and Harmonics

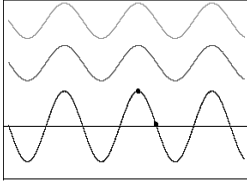


Doppler Effect

- Doppler Effect Lesson



Waves Moving in and Out of Phase



- When the 2 waves are in phase, the resulting disturbance has a maximum amplitude.
- When the 2 waves are out of phase, the resulting disturbance has a minimum amplitude.

Beats

- Waves of slightly different frequencies form a pattern of alternating maximum and minimum amplitude.
- The packets of maximum amplitude are called beats.

