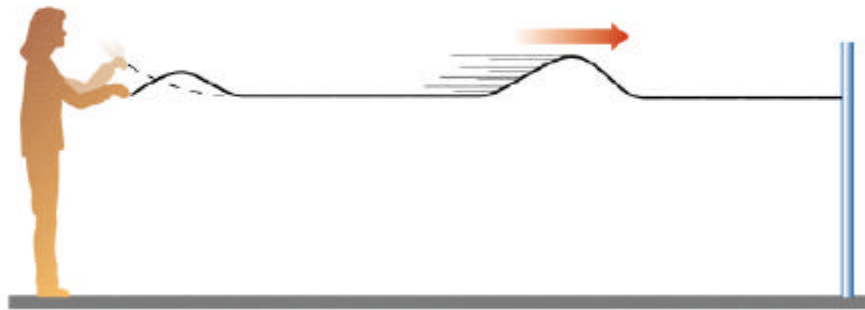


Waves - Transverse and Longitudinal Waves

- A wave may be defined as a *periodic disturbance in a medium that carries energy from one point to another*.
- All waves require a *source* and a *medium* of propagation.
- Waves may lose energy as they propagate through a dense medium (attenuation).
- Waves that radiate *isotropically* (uniformly in all directions) from a source also lose intensity due to the fact that the energy they carry is spread out over an increasingly large area. This is known as the inverse square law.

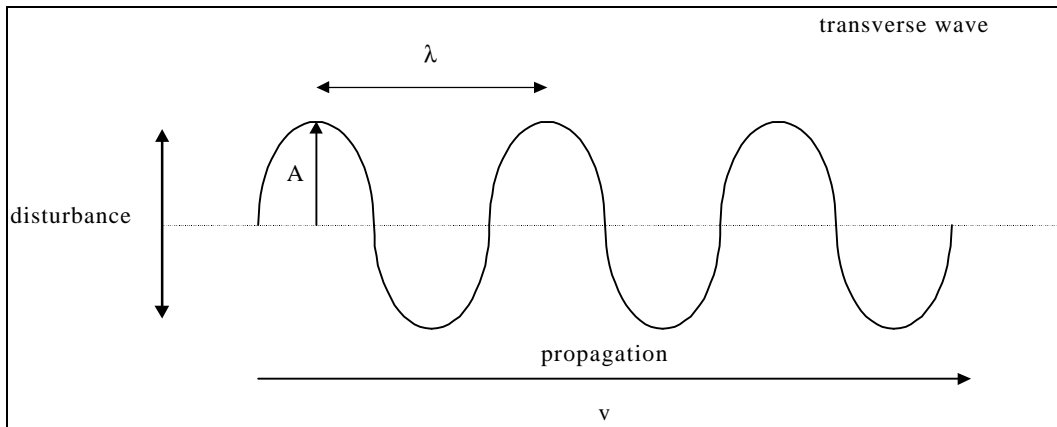


- There are two distinct types of waves: *Longitudinal* and *Transverse*. Sound waves are an example of longitudinal waves while electromagnetic waves, such as light, are examples of transverse waves.
- Transverse waves transfer energy in a direction perpendicular to the direction of the disturbance in the medium. A vibrating string is an example of a transverse wave. Although all points on the string itself are constrained to move only up and down, wave pulses move perpendicularly along the length of the string. The *wave speed* is the speed with which a pulse moves along the string.
- A transverse wave may consist of more than one pulse. Transverse waves consisting of many pulses result when the wave source oscillates about some equilibrium position for long periods of time. Under such conditions an initial pulse is followed immediately by another pulse of opposite displacement. A series of such alternating pulses is known as a *wave train*.

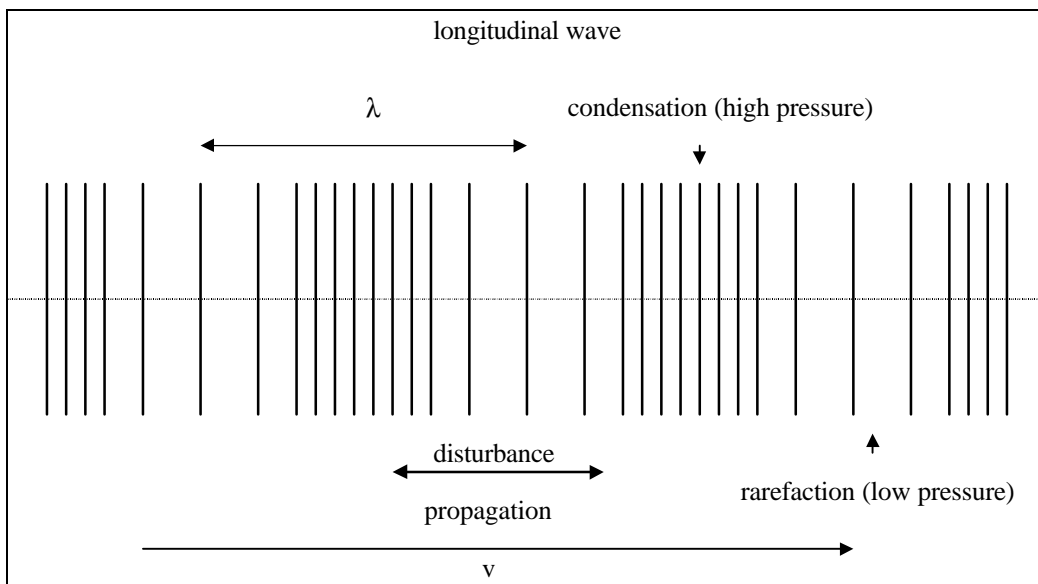


- If the oscillations are steady the resulting waveform is periodic. If the oscillations are *harmonic* in the series of pulses is known as a *harmonic wave train*. All of the electromagnetic spectrum, including light, consists of transverse waves that result from harmonic oscillations in molecular, atomic or nuclear structures.
- Longitudinal waves are waves that transfer energy in the same direction as the disturbance in the medium of propagation. Like transverse waves, longitudinal waves may consist of single or multiple pulses. All longitudinal waves consist of regions of high and low density known as condensations and rarefactions that oscillate around local positions of equilibrium parallel to the path of energy transfer. Sound waves are longitudinal waves. Sound waves propagating through air consist of a series of pressure fluctuations above and below atmospheric pressure.

Wave Properties



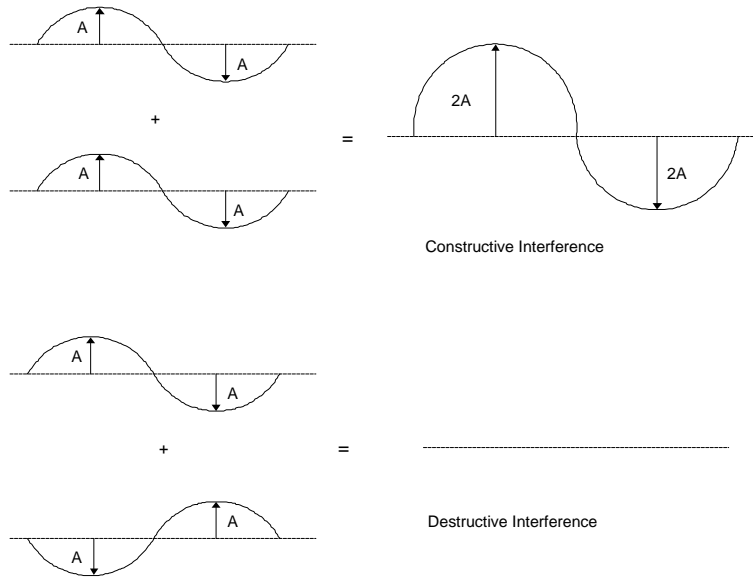
A transverse waveform.



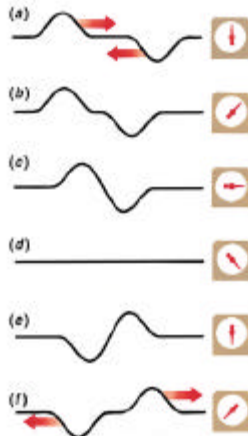
A longitudinal waveform. Areas of high pressure (pressure nodes) correspond to condensed regions of low molecular displacement (displacement antinodes).

- Wavelength – the distance between the same points on successive waves (meters).
- Period – the amount of time it takes a wave to complete one oscillation or cycle, i.e., wavelength expressed in units of time (seconds).
- Frequency – number of oscillations per second (s^{-1} or Hertz).
- Amplitude - the maximum displacement of a wave media from its undisturbed position. In transverse waves, the amplitude is the maximum distance the disturbance moves from the axis of propagation (undisturbed position). In longitudinal waves the amplitude is usually related to the rise and fall of pressure within the wave medium.

- Interference/Superposition - combining waves together in such a manner as to cause either constructive (strengthen) or destructive (lessen) effects.

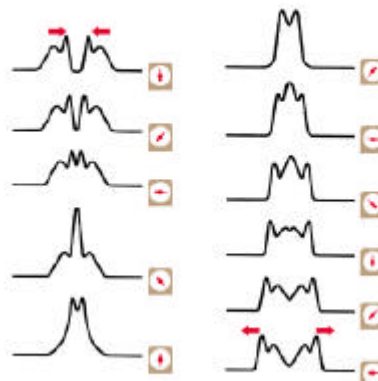


Kirkpatrick, Physics: A World View, Fourth Edition
Figure 14.12



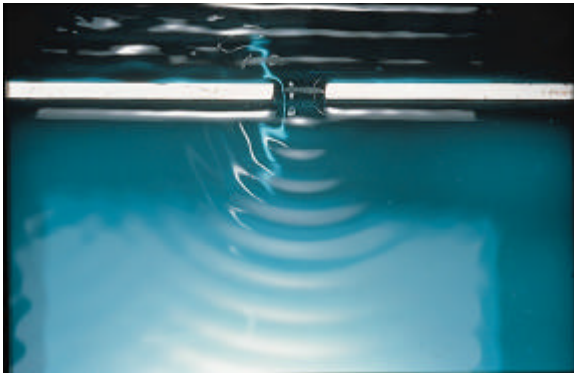
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Kirkpatrick, Physics: A World View, Fourth Edition
Figure 14.13

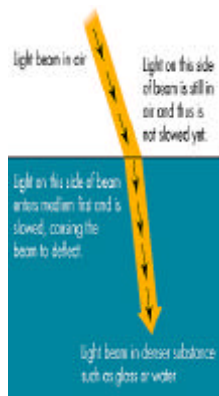


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- Diffraction – bending of waves as they pass through narrow openings or around sharp corners

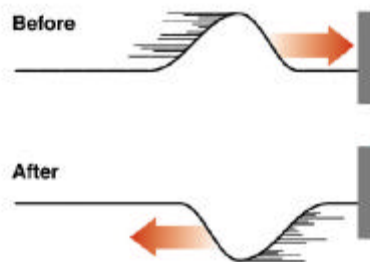


- Refraction – the change of speed and direction that occurs when a wave goes from one medium to another.



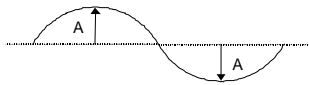
- Scattering – what happens, in general, when waves interact with matter. Reflection that does not obey the *Law of Reflection*, i.e., waves reflect at all angles.
- Reflection - a form of scattering that may be described with a simple geometric relationship, i.e. angle of incidence equals angle of reflection. Most waves experience a phase shift upon reflection.

Knight, Physics: A World View, Fourth Edition
Figure 14.92



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- Polarization – orientation of oscillations in space with respect to the disturbed medium. Polarization is a property unique to transverse waves. A polarized wave vibrates in a single plane in space. Since longitudinal waves vibrate along their axis of propagation, it is not possible to polarize a longitudinal wave. Polarization is an important factor in reflection, refraction, and scattering of electromagnetic waves.
- It is interesting to note that while the behavior of both acoustic and light waves under reflection, for instance, is the same the physical cause is quite different in each case.
- Frequency, wavespeed and wavelength are related mathematically by the expression: $v = \lambda f$. The velocity a wave in a given media is fixed and is related to the physical characteristics (temperature, density, etc.) of the media. Frequency and wavelength, therefore, are inversely proportional to each other, i.e.; higher frequencies correspond to shorter wavelengths.
- Phase – the orientation of wave pulses in space with respect to the origin of the wave.



InPhase



Out ofPhase

