Traveling Waves

4.1.1 Describe a wave pulse and a continuous traveling wave.

If we attach a rope or spring to a fixed object and we displace the free end of the rope or spring up and down only once we will generate a wave pulse. If we continue to shake the free end rope or spring we will generate a continuous traveling wave. A continuously traveling wave can be thought of as a series of wave pulses. Or vice versa a wave pulse could be thought of as a segment (one wavelength) of a continuously traveling wave.

An oscillation causes waves, but the oscillation is not the wave. If I shake a rope, I am not the wave I am the cause of the wave. For electromagnetic waves (most often) an electrically charged particle is oscillating and thus generating the wave.

4.1.2 State that waves transfer energy.

If we take the example of a wave pulse in a rope it is clear to see that the rope particles are not traveling down the rope, they are oscillating up and down but they do not travel with the wave. This is true for all waves. Water waves do not cause objects to move horizontally only up and down. This can be seen by filling up a bath tub, making waves and observing the motion of a floating object. One could argue that the medium (the stuff that's waving) is in fact moving, but after one full cycle or period there is no net displacement of the medium. All the particles will return to their starting place waiting for the next wave pulse…

So if the medium isn't traveling with the wave what is? Energy… When you shake a rope, the rope moves up and down, i.e. the rope particles have velocity and thus kinetic energy. This energy is transmitted when a particle accelerates, it pulls (applies a force) on the particle(s) next to it, thus accelerating the particle, changing its velocity and thus changing its kinetic energy. The tendency is for a particle to speed up the particles in front of it (increasing their KE) and slow down the particles behind it (decreasing their KE), this causes the energy to be transmitted down the rope…

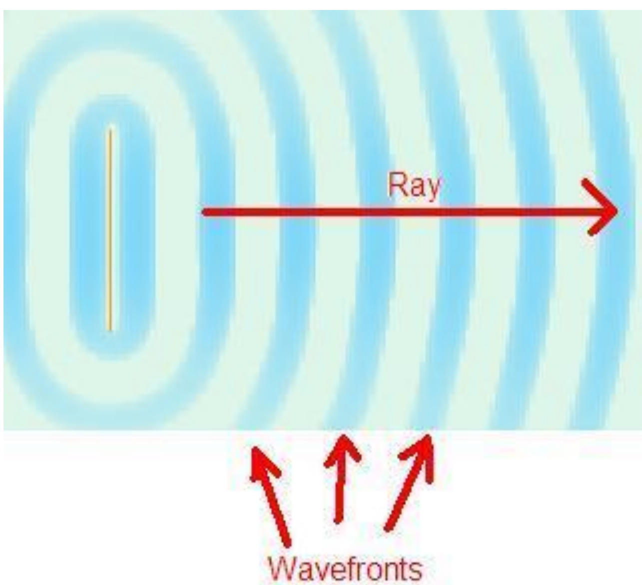
4.1.3 Describe and give examples of transverse and longitudinal waves.

In general we talk about two different types of waves, transverse and longitudinal. We can distinguish the two types by which direction the oscillations is relative to the motion of the wave. If the oscillations are parallel to the direction of wave motion, we call the wave a longitudinal wave. If the oscillations are perpendicular to the direction of wave motion, we call the wave a transverse wave. Both types of waves can be seen in a spring…

Example of a transverse wave is light. Radio signals are light and are generated by electrons moving back and forth in antenna. The electrons move parallel to the antenna and the wave will propagate perpendicular to the antenna, this is why many antennae are point up!

An example of a longitudinal wave is sound. Take for instance a drum. When you pound a drum the skin of the drum impacts the layer of air directly in front, which then impacts the next layer of air. The wave propagates away from the drum perpendicular to the surface of the drum.

4.1.4 Describe wave motion in two dimensions, including the concepts of wave fronts and rays.



As described by Kerr,

> *" Quite simply a wave is a means by which energy is transferred between two points in a medium without any net transfer of the medium itself."*

Waves always travel outward from the source of the oscillation. In two dimensions waves can be easily observed by making waving on a surface of water. As the wave travels the crests or the peaks of the wave travel as well the crests stay evenly spaced, one wavelength apart. We can represent a wave simply by drawing the crest, when we do this we can the lines wavefronts. We can also represent waves by rays, which are lines perpendicular to the wavefronts. When you hear the term "light ray" this is what is being talked about, a line that represents the wave and points in the direction of the propagation.

4.1.5 Define displacement, amplitude, period, frequency, wavelength and wave speed.

Displacement – the distance from equilibrium of the medium as is waves

Amplitude – the maximum displacement of the medium

Period – the amount of time for two successive wavefronts or crests to pass a stationary point, it is also the amount of time for a particle in the medium to complete one full cycle (up-down, left-right), i.e. the number of seconds per oscillation.

Frequency – the number of oscillations per second or the inverse of the period.

Wavelength – the distance between successive crests or wavefronts

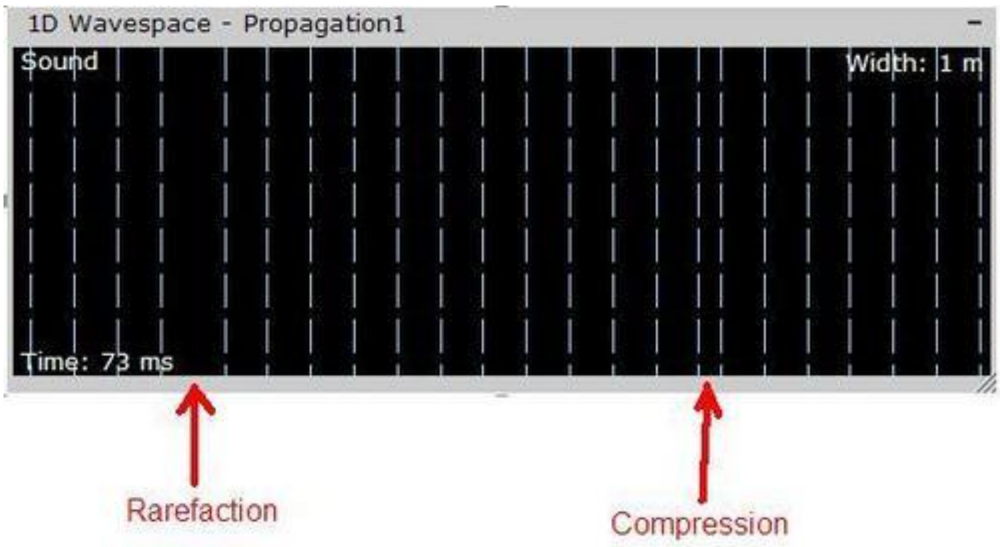
Wave speed – the speed at which the energy in the wave is propagate in the medium, is medium dependent

4.1.6 Describe the terms crest, trough, compression and rarefaction.

Crest – refers to water waves, the maximum height of the water, the amplitude.

Trough – again refers to water waves, the minimum height of the water.

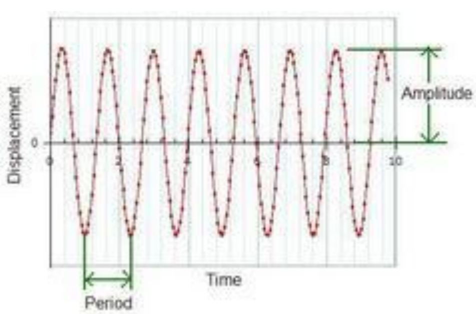
Compression – refers to longitudinal waves, an area where the medium is "bunched up" is said to be compressed or an area of compression.



Rarefaction – refers to longitudinal waves, an area where the medium is "spread out" is said to be rarefied or an area of rarefaction.

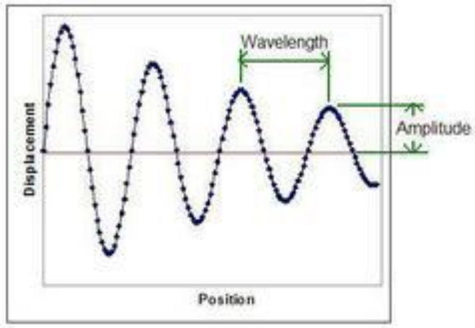
In the diagram to the right the vertical lines are the medium through which a longitudinal wave is propagating. The areas of rarefaction and compression are clearly seen.

4.1.7 Draw and explain displacement-time and displacement-position graphs for transverse and longitudinal waves.



To the left is a displacement vs. time graph for a wave. The displacement is measured at the same position but at different times. From this graph we can measure or approximate the period of the wave and the amplitude of the wave at the position of measurement. Notice that the amplitude is constant.

Note: We can not measure the wavelength from a displacement vs. time graph.



To the right is a displacement vs. position graph. In this case we are measuring the displacement at many points but all at the same point in time. From this graph we can measure the wavelength and the amplitude at given points. We can not measure the period or frequency directly from this graph. Notice that the amplitude decreases

4.1.8 Derive and apply the relationship between wave speed, wavelength and frequency.

We can see from the displacement vs. position graph that the wavelength of a wave is not dependent on the position (or distance from the source). This would suggest that the wave is traveling at a constant speed, if the wave was not traveling at a constant speed peaks would either bunch up or spread out. Therefore if we measure the wavelength and the time for two successive peaks to pass we should be able to calculate the speed of the wave…

(1)

$$velocity = wavelength \ / \ period$$

(2)

$$v = \lambda \ / \ T$$

(3)

$$v = \lambda f$$

The frequency of a wave in the inverse of the period, so we can write the velocity as a function of the frequency and wavelength.

Source: http://ibphysicsstuff.wikidot.com/traveling-waves