Parts of a Wave

Crest and Trough

The section of the wave that rises above the undisturbed position is called the **crest**. That section which lies below the undisturbed position is called the **trough**.

Amplitude

The term **amplitude** can have slightly different meanings depending upon the context of the situation.

Its most general definition is that the amplitude is the maximum positive displacement from the undisturbed position of the medium to the top of a crest. This is shown in the following diagram:

In some discussions it is important to distinguish between positive and negative amplitudes.

Sometimes it is necessary to discuss an amplitude at a certain point along the wave.

In general, if the question simply is 'What is the amplitude of the wave?', the answer follows the description of amplitude shown in the first of the above four amplitude diagrams. It is the maximum positive displacement of the medium from its undisturbed position to the top of a crest.

In many discussions, though, the term amplitude takes on a slightly more complicated meaning. For example, in a discussion about wave interference the later descriptions of positive and negative amplitudes at certain points would surface. In such contexts, amplitude means the displacement of the medium from its undisturbed position to its disturbed position at a certain point along the wave.

All of this becomes clear as you study waves further and understand the context of your situation.

To sum up amplitude, we would say:

- It is the displacement of the medium from its normal position.
- Usually this simply means the maximum positive displacement.
- Often, especially in discussions about interference, amplitude means the displacement of the medium from its normal position at certain points, and this displacement can be positive or negative.

Wavelength

The wavelength of a wave is the distance between any two adjacent corresponding locations on the wave train. This distance is usually measured in one of three ways: crest to next crest, trough to next trough, or from the start of a wave cycle to the next starting point.

Actually, the a wavelength exists between any point on a wave and the corresponding point on the next wave in the wave train.

Frequency

Frequency is often not termed as a part of a wave, but it makes sense to introduce its meaning in this section.

Frequency refers to how many waves are made per time interval. This is usually described as how many waves are made per second, or as cycles per second.

If ten waves are made per second, then the frequency is said to be ten cycles per second, written as 10 cps.

Usually, we use the unit Hertz to state frequency. A frequency of 10 cps is noted as a frequency of 10 Hertz. So, one cycle per second is one Hertz, as in:

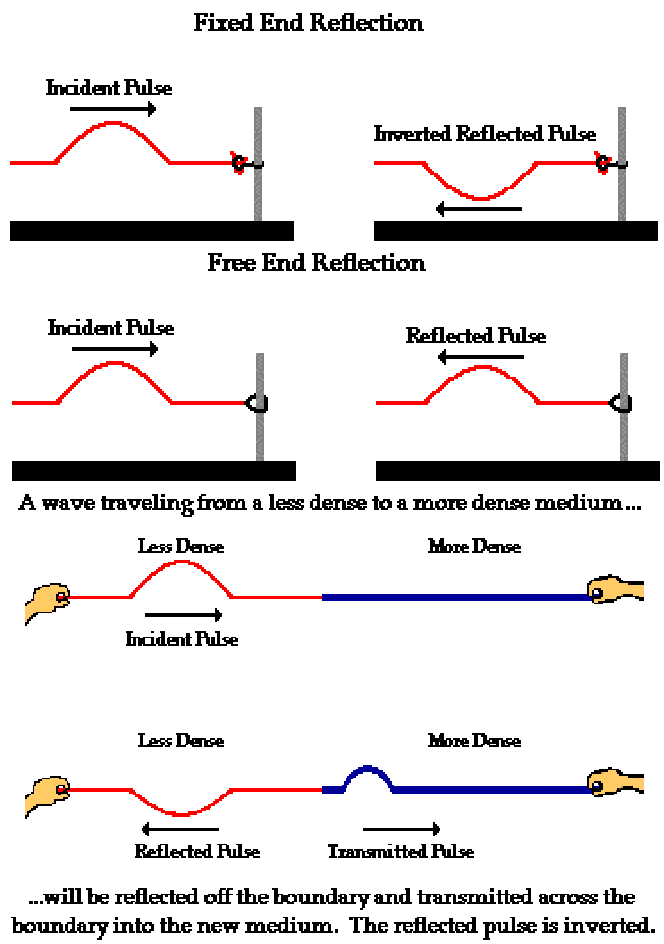
1 cps = 1 Hertz

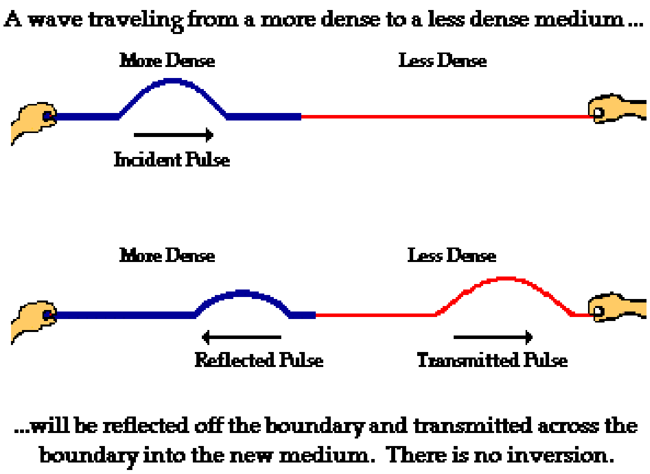
The unit Hertz is abbreviated this way:

1 Hertz = 1 Hz

To find the speed of a wave, use the equation $v = \lambda \times f$ or $v = \lambda / p$ where v is the speed, lambda is the wavelength, f is the frequency, and p is the wave period.

Boundary Behavior





Refraction, Reflection, and Diffraction

Refraction is a change of direction of waves as they pass from one medium to another.

To calculate the refraction angle, use the equation: $n_1 \times \sin\theta_1 = n_2 \times \sin\theta_2$ where theta$_1$ is the angle of incidence and n is the refraction index of the medium.

Reflection is the changing of direction of waves as they encounter a barrier.

To calculate the reflection angle, use the equation $\theta_1 = \theta_2$ where theta$_1$ is the angle of incidence.

Diffraction is the change of direction of waves as they encounter an obstacle. Waves pass beyond a barrier to the area behind it.

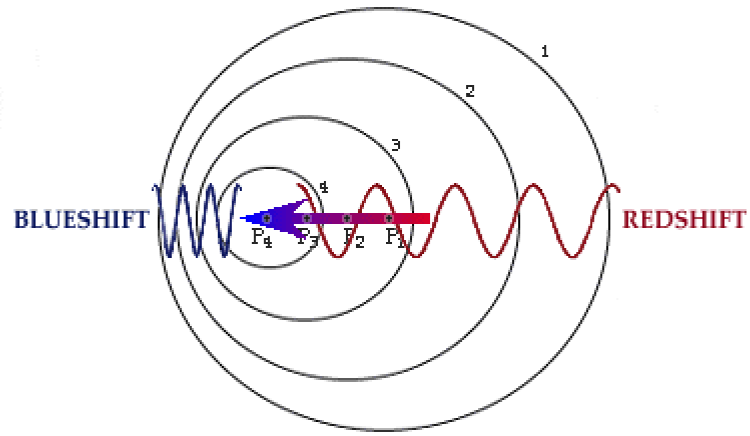
To calculate diffraction, use the equation $X_m = \frac{m\lambda l}{d}$ where X is the distance between antinodes (dots), m is the dot you use, lambda is the wavelength, l is the distance to the surface that you are observing the wave on, and d is the slit distance.

Wave Interference

Wave interference occurs when two waves meet each other. You calculate the height of the new wave or pulse by adding the values of the wave heights along the intersection. When waves or pulses collide, they do not stop, but go on with their original amplitude as if nothing had happened.

Doppler Effect

The Doppler Effect is an observed change in frequency of a wave due to a moving source.



The observed frequency can be modeled by the equation $f' = f + \frac{fv}{c}$ where f ' is the observed frequency, f is the original frequency, v is the velocity of the transmitter, and c is the speed of the wave. The speed of light is generally equal to 3×10^8 m/second, and the speed of sound through air is equal to $332(1 + \frac{T}{273})^{1/2} m/s$ where T is equal to the degrees Celsius.

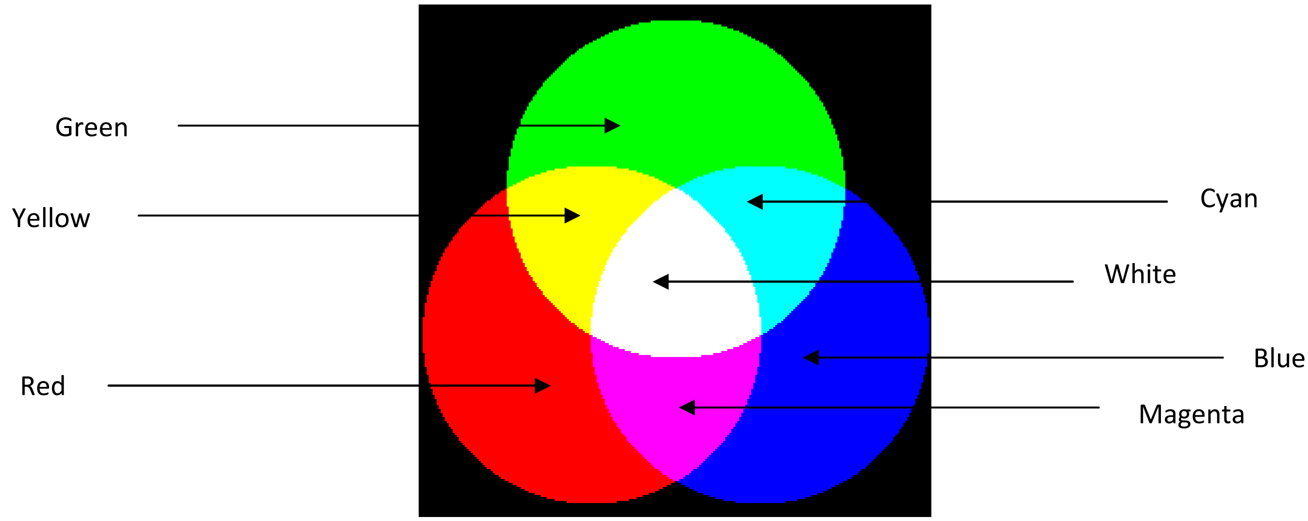
Wavelengths of the Electromagnetic Spectrum

Wave Type	**Wavelength**	**Frequency**
Radio	$> 10^{10}$ Å	$< 3 \times 10^8$ Hz
Microwave	$10^{10} – 10^6/10^7$ Å	$3 \times 10^8 – 3 \times 10^{11(12)}$ Hz
Terahertz	$10^7 – 10^5$ Å	$3 \times 10^{11} – 3 \times 10^{12}$ Hz
Infrared	$10^6/10^7$ – 7500 Å	$3 \times 10^{12} – 4 \times 10^{14}$ Hz
Visible Light	7500 – 3800 Å	$4 \times 10^{14} – 7.9 \times 10^{14}$ Hz
Ultraviolet	4000 – 100 Å	$7.9 \times 10^{14} – 3 \times 10^{16}$ Hz
X-Rays	100 – 0.1 Å	$3 \times 10^{16} – 3 \times 10^{20}$ Hz
Gamma Rays	< 0.1 Å	$> 3 \times 10^{20}$ Hz

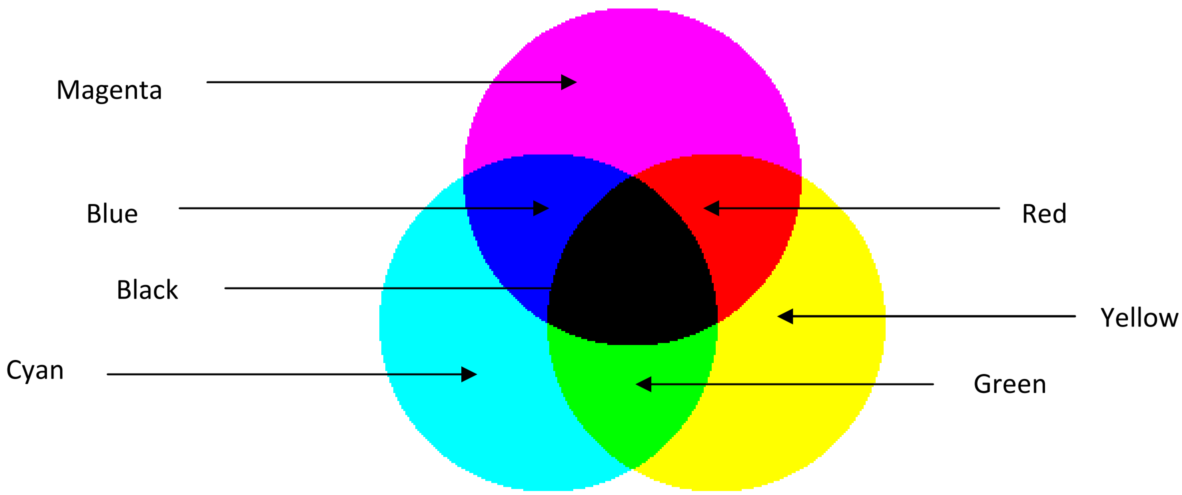
Note: 1 Å (angstrom) = 10^{-8} m

Note: Values may overlap

Primary Colors of Light:



Primary Colors of Pigments:



Types of Seismic Waves

There are several different kinds of seismic waves, and they all move in different ways. The two main types of waves are **body waves** and **surface waves**. Body waves can travel through the earth's inner layers, but surface waves can only move along the surface of the planet like ripples on water. Earthquakes radiate seismic energy as both body and surface waves.

Body Waves

Traveling through the interior of the earth, **body waves** arrive before the surface waves emitted by an earthquake. These waves are of a higher frequency than surface waves.

P Waves

The first kind of body wave is the **P wave** or **primary wave**. This is the fastest kind of seismic wave, and, consequently, the first to 'arrive' at a seismic station. The P wave can move through solid rock and fluids, like water or the liquid layers of the earth. It pushes and pulls the rock it moves through just like sound waves push and pull the air. Have you ever heard a big clap of thunder and heard the windows rattle at the same time? The windows rattle because the sound waves were pushing and pulling on the window glass much like P waves push and pull on rock. Sometimes animals can hear the P waves of an earthquake. Dogs, for instance, commonly begin barking hysterically just before an earthquake 'hits' (or more specifically, before the surface waves arrive). Usually people can only feel the bump and rattle of these waves.

P waves are also known as **compressional waves**, because of the pushing and pulling they do. Subjected to a P wave, particles move in the same direction that the the wave is moving in, which is the direction that the energy is traveling in, and is sometimes called the 'direction of wave propagation'.

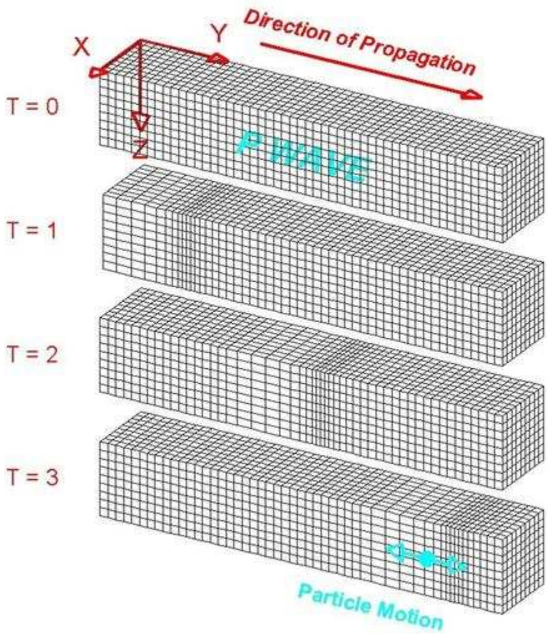


Figure 1 - A P wave travels through a medium by means of compression and dilation. Particles are represented by cubes in this model. Image ©2000-2006 Lawrence Braile, used with permission.

S Waves

The second type of body wave is the **S wave** or **secondary wave**, which is the second wave you feel in an earthquake. An S wave is slower than a P wave and can only move through solid rock, not through any liquid medium. It is this property of S waves that led seismologists to conclude that the Earth's **outer core** is a liquid. S waves move rock particles up and down, or side-to-side--perpindicular to the direction that the wave is traveling in (the direction of wave propagation).

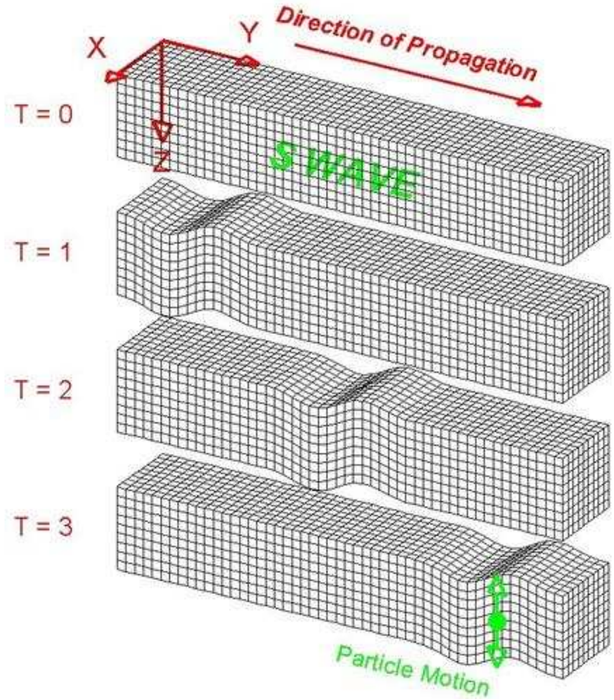


Figure 2 - An S wave travels through a medium. Particles are represented by cubes in this model. Image ©2000-2006 Lawrence Braile, used with permission.

Surface Waves

Travelling only through the crust, **surface waves** are of a lower frequency than body waves, and are easily distinguished on a seismogram as a result. Though they arrive after body waves, it is surface waves that are almost enitrely responsible for the damage and destruction associated with earthquakes. This damage and the strength of the surface waves are reduced in deeper earthquakes.

Love Waves

The first kind of surface wave is called a **Love wave**, named after A.E.H. Love, a British mathematician who worked out the mathematical model for this kind of wave in 1911. It's the fastest surface wave and moves the ground from side-to-side. Confined to the surface of the crust, Love waves produce entirely horizontal motion.

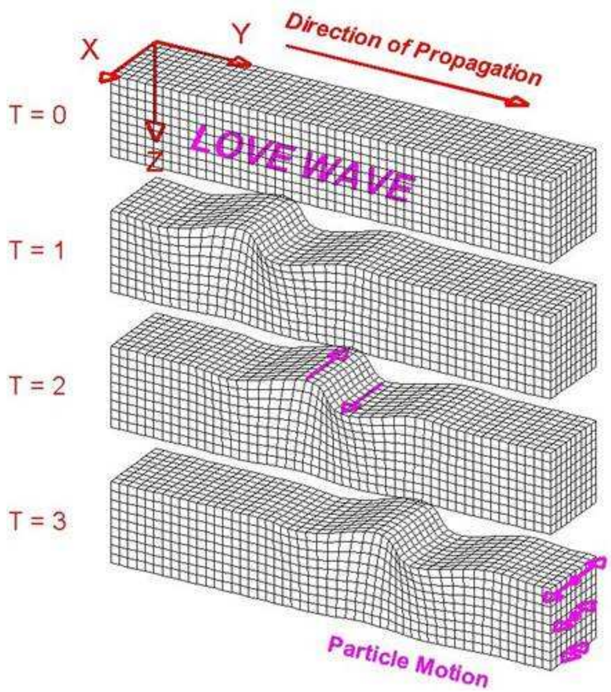


Figure 3 - A Love wave travels through a medium. Particles are represented by cubes in this model. Image ©2000-2006 Lawrence Braile, used with permission.

Rayleigh Waves

The other kind of surface wave is the **Rayleigh wave**, named for John William Strutt, Lord Rayleigh, who mathematically predicted the existence of this kind of wave in 1885. A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean. Because it rolls, it moves the ground up and down, and side-to-side in the same direction that the wave is moving. Most of the shaking felt from an earthquake is due to the Rayleigh wave, which can be much larger than the other waves.

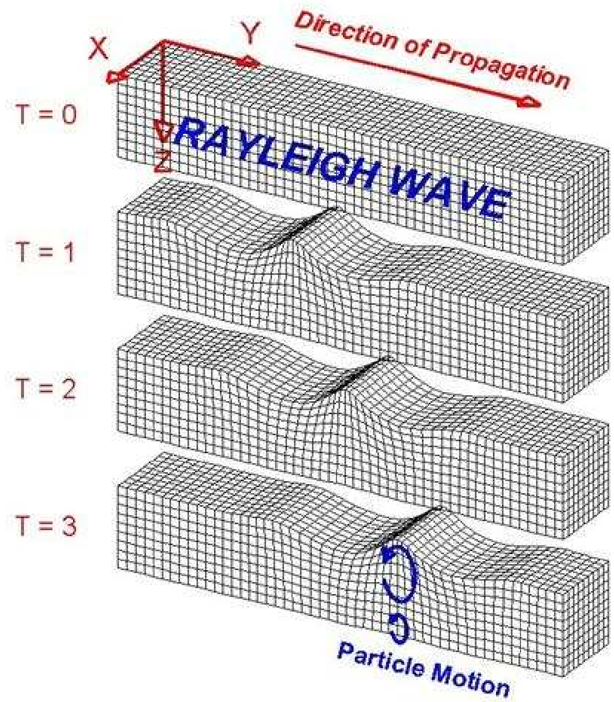


Figure 4 - A Rayleigh wave travels through a medium. Particles are represented by cubes in this model. Image ©2000-2006 Lawrence Braile, used with permission.