Waves and Wave Properties

Why are we able to see?

Answer: Because there is light.

And…what is light?

Answer: Light is a wave.

So…what is a wave?

Answer: A wave is a disturbance that carries energy from place to place.

A wave does NOT carry matter with it! It just moves the matter as it goes through it.

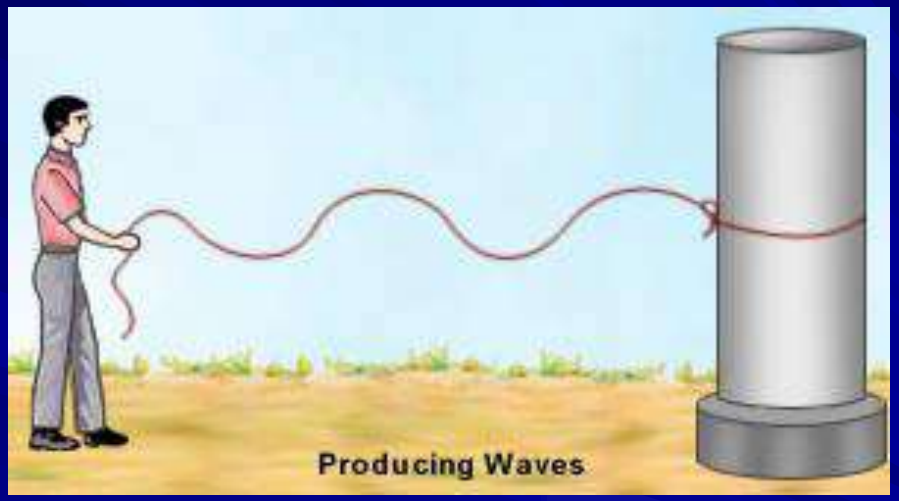
Some waves do not need matter (called a "**medium**") to be able to move (for example, through space).

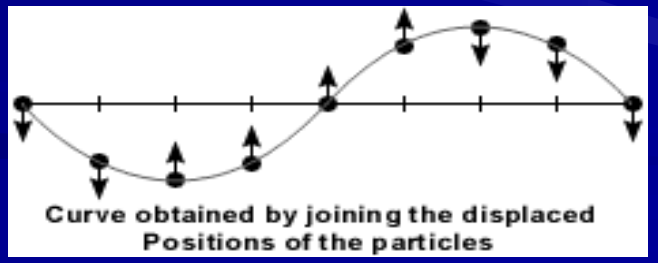
These are called **electromagnetic waves** (or EM waves).

Some waves MUST have a medium in order to move. These are called **mechanical waves.**

Wave Types

1. Transverse waves: Waves in which the medium moves at right angles to the direction of the wave

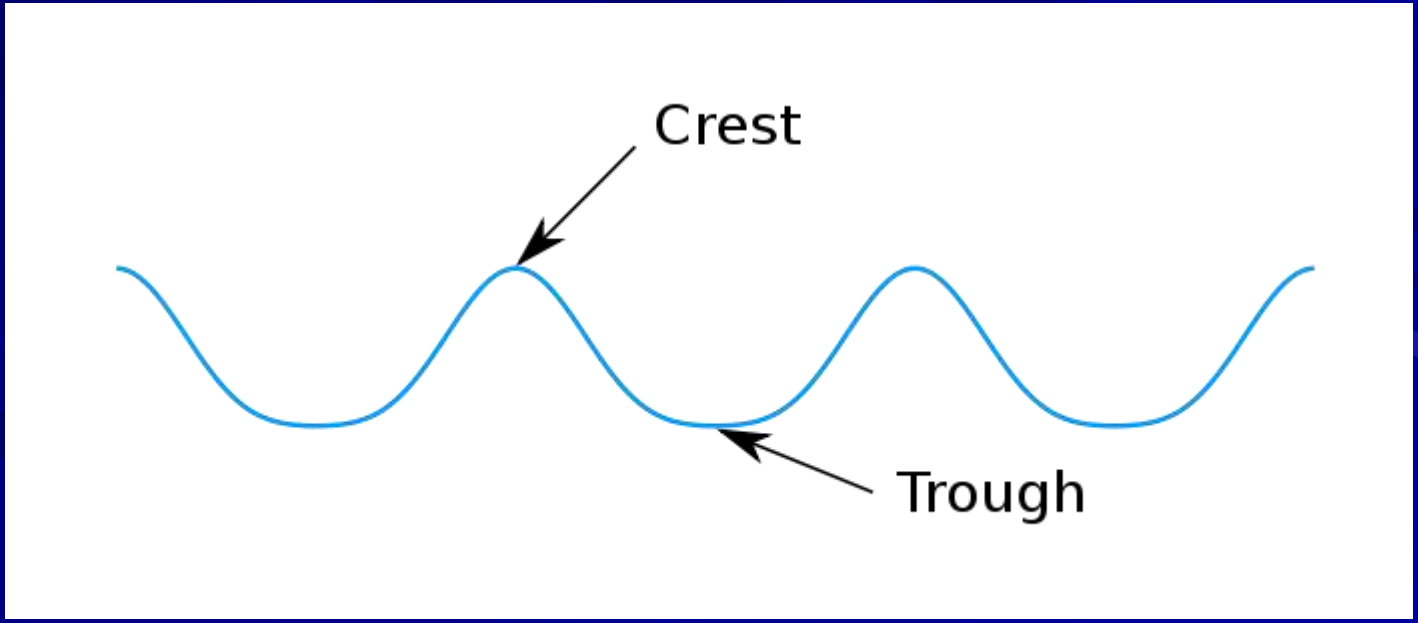




Parts of transverse waves:

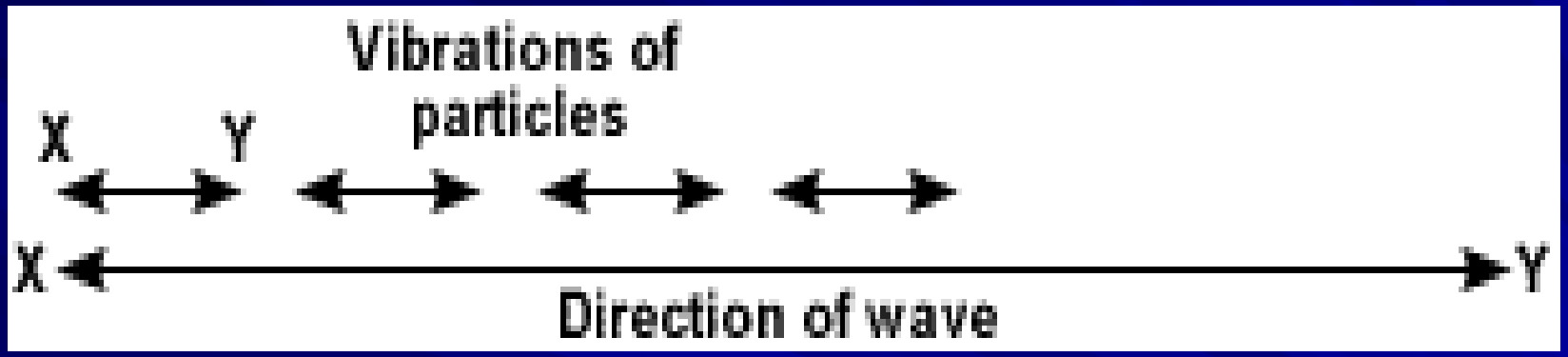
Crest: the highest point of the wave

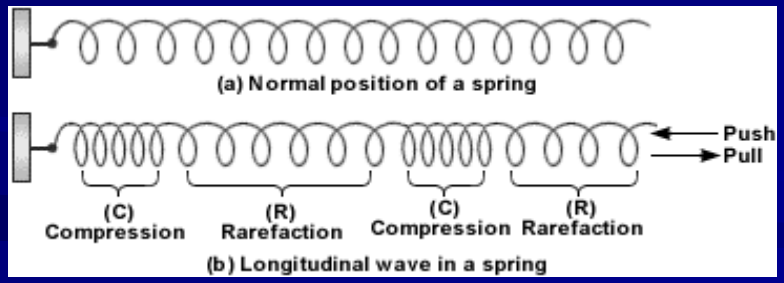
Trough: the lowest point of the wave

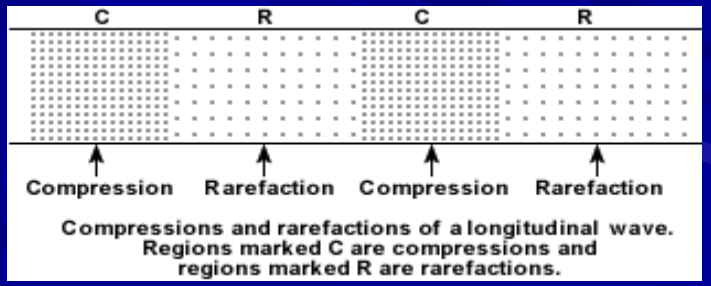


2. Compressional (or longitudinal) waves:

Waves in which the medium moves back and forth in the same direction as the wave



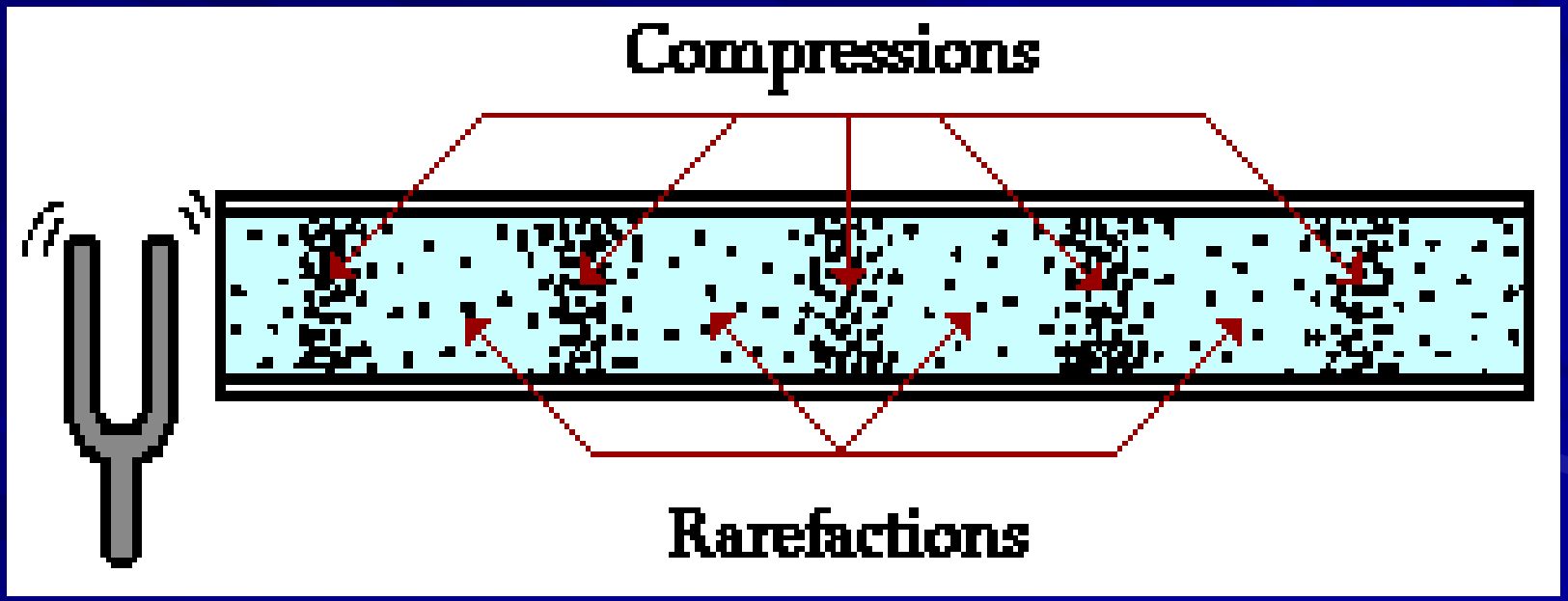




Parts of longitudinal waves:

Compression: where the particles are close together

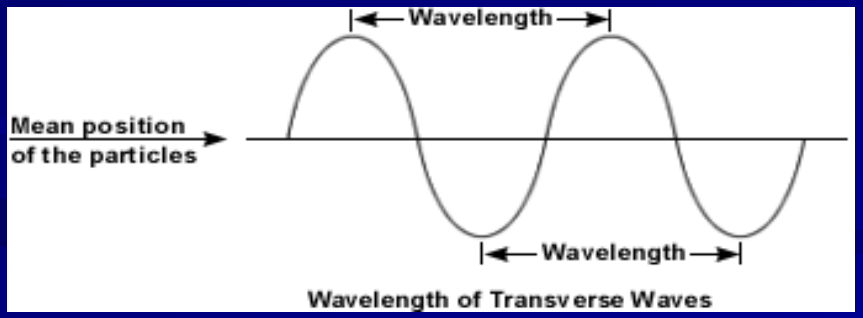
Rarefaction: where the particles are spread apart

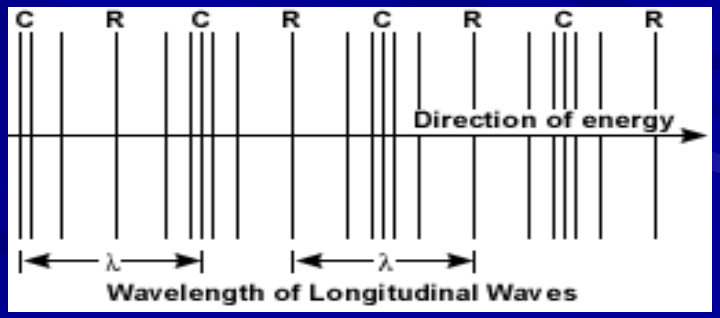


Wave Properties

Wave properties depend on what (type of energy) is making the waves.

1. Wavelength: The distance between one point on a wave and the exact same place on the next wave.





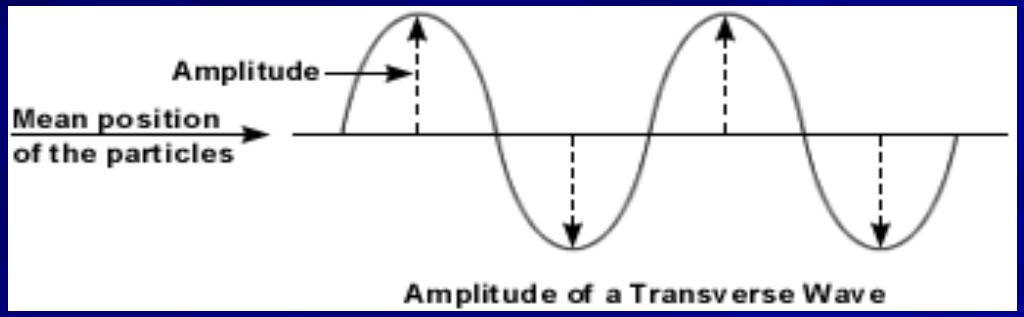
2. Frequency: How many waves go past a point in one second; unit of measurement is hertz (Hz).

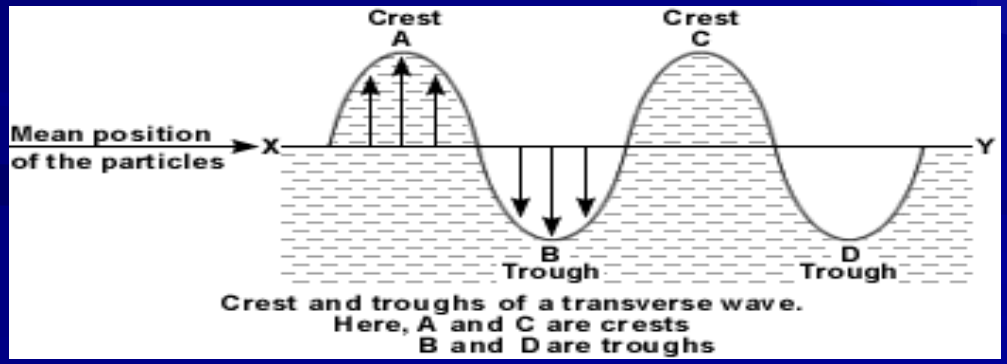
The higher the frequency, the more energy in the wave.

- 10 waves going past in 1 second = 10 Hz
- 1,000 waves go past in 1 second = 1,000 Hz
- 1 million waves going past = 1 million Hz

3. Amplitude: How far the medium moves from rest position (where it is when not moving).

Remember that for transverse waves, the highest point is the crest, and the lowest point is the trough.





Remember that for compressional waves, the points where the medium is close together are called compressions and the areas where the medium is spread apart are called rarefactions.

The closer together and further apart the particles are, the larger the amplitude.

compression

rarefaction

The energy of a wave is proportional to the square of its amplitude. Mathematically speaking . . .

$$E = CA^2$$

Where:

E = energy (the capacity to do work)
C = a constant (depends on the medium)
A = amplitude

For example:

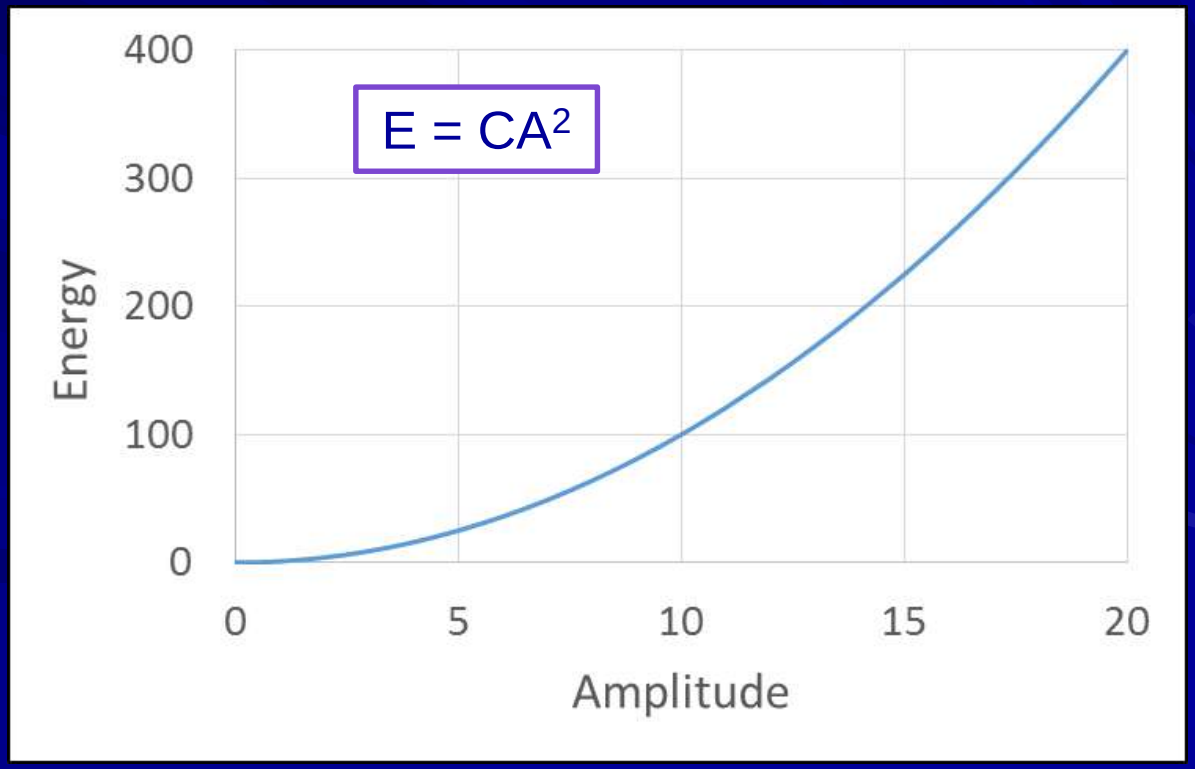
If the amplitude is equal to 3 units
(and we assume C = 1 for this case) . . .

$$E = (1)\ (3)^2 = (1)\ (9) = 9 \text{ units}$$

Note that when the amplitude of a wave is one unit, the energy is one unit.

- When the amplitude is doubled, the energy is quadrupled.
- When the energy is 10 times greater, the energy is 100 times greater!

Amplitude	Energy
1	1
2	4
3	9
4	16
5	25
6	36
7	49
8	64
9	81
10	100



4. Wave speed: Depends on the medium in which the wave is traveling. It varies in solids, liquids and gases.

A mathematical way to calculate speed:

wave speed = wavelength x frequency
(in meters) (in Hz)

OR

$$v = f \times \lambda$$

Problem: If a wave has a wavelength of 2 m and a frequency of 500 Hz, what is its speed?

Answer: speed = 2 m x 500 Hz = 1000 m/s

Changing Wave Direction

1. Reflection: When waves bounce off a surface.

   If the surface is flat, the angle at which the wave hits the surface will be the same as the angle at which it leaves the surface (angle in = angle out).

   This is the law of reflection.

2. Refraction: Waves can bend.

This happens when a wave enters a new medium and its SPEED CHANGES.

The amount of bending depends on the medium it is entering.

3. Diffraction: The bending of waves AROUND an object.

The amount of bending depends on the size of the obstacle and the size of the waves.

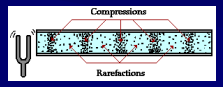
Large obstacle, small wavelength = low diffraction

Small obstacle, large wavelength = large diffraction

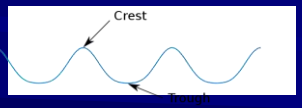
Image Sources



Denise W. Carlson. Used with permission.



Tom Henderson, The Physics Classroom
http://www.mwit.ac.th/~physicslab/applet_04/physics_classroom/Class/sound/u11l1c.html



Kraalennest, Wikipedia http://en.wikipedia.org/wiki/File:Crest_trough.svg