



# 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.

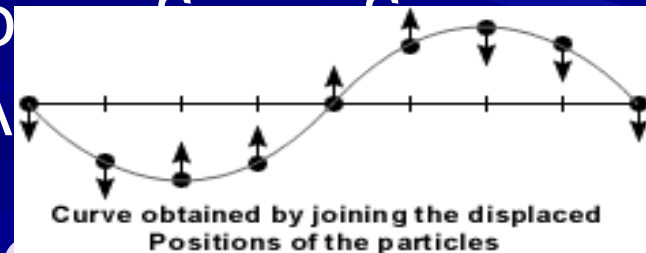
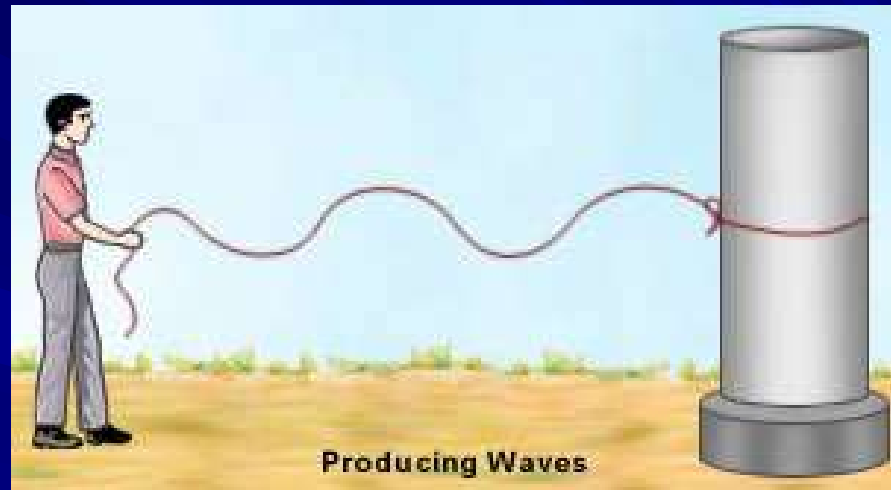




Some waves do not need matter (called a “**medium**”) to be able to move (for example, through space).

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

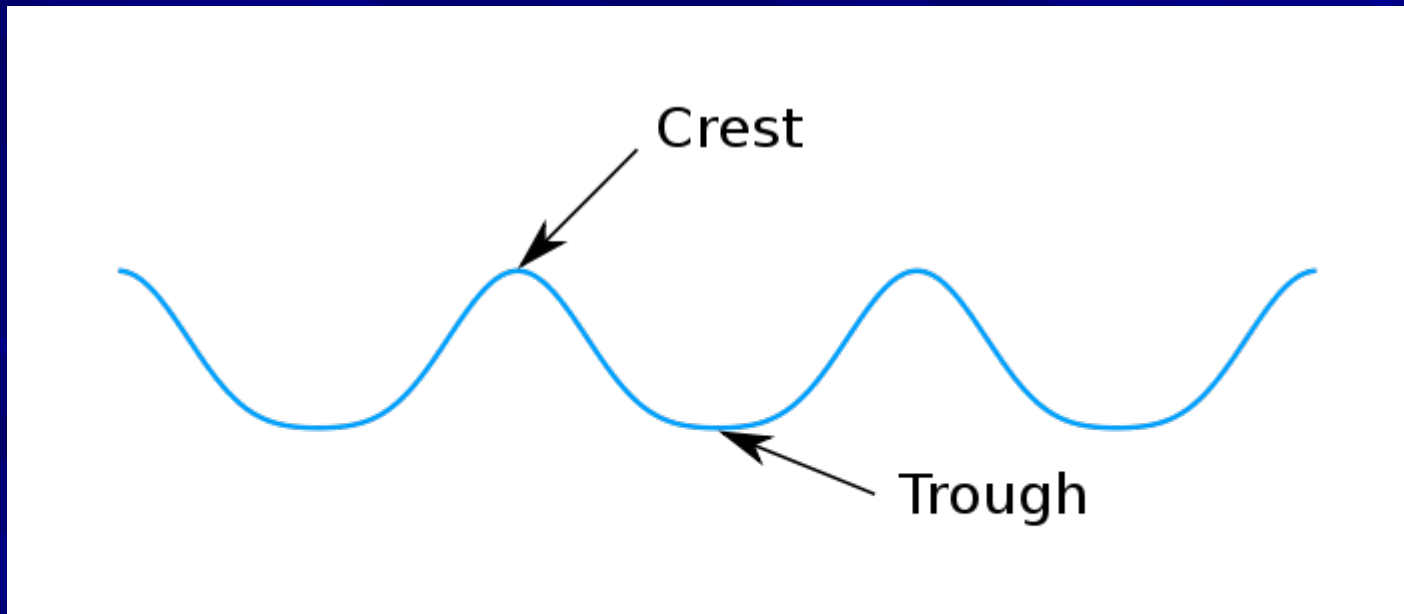
1. Transverse

movement of the particles is perpendicular to the direction of the wave

## Parts of transverse waves:

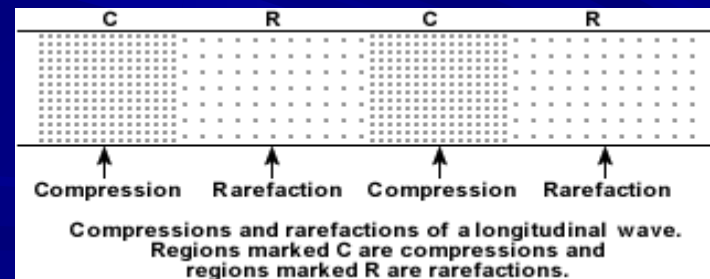
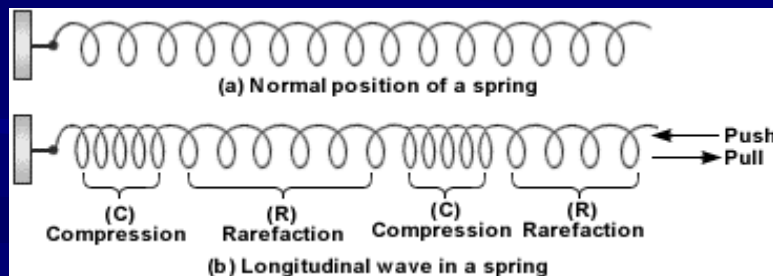
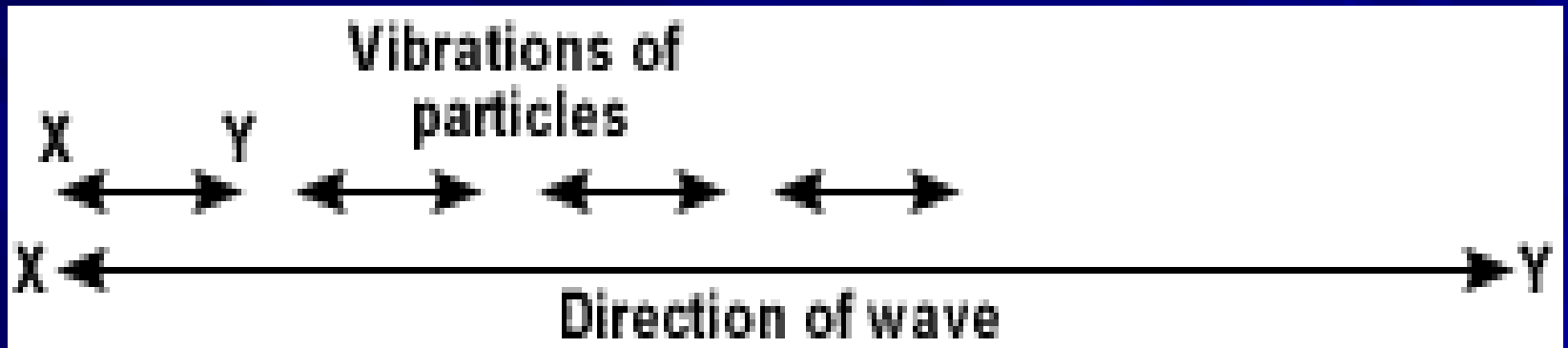
**Crest:** the highest point of the wave

**Trough:** the lowest point of the wave



## 2. Compressional (or longitudinal) waves:

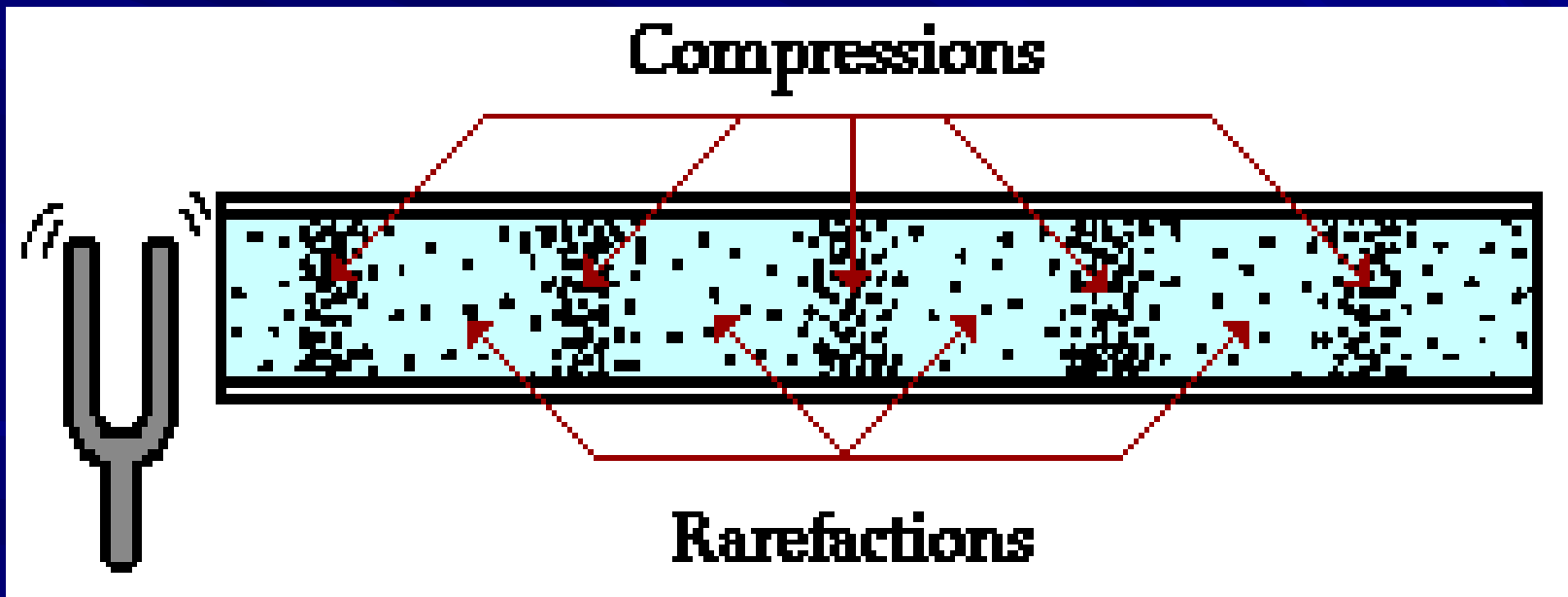
Waves in which the medium moves back and forth in the same direction as the wave



## Parts of longitudinal waves:

**Compression:** where the particles are close together

**Rarefaction:** where the particles are spread apart

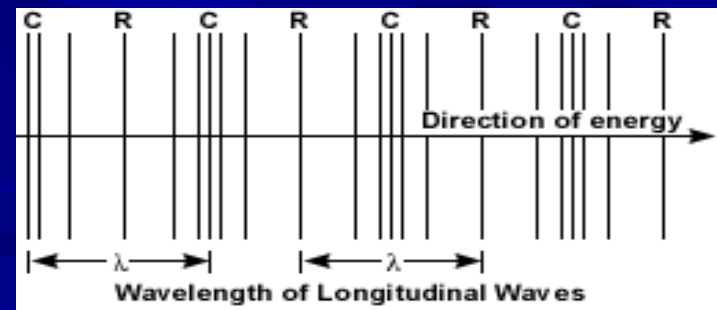
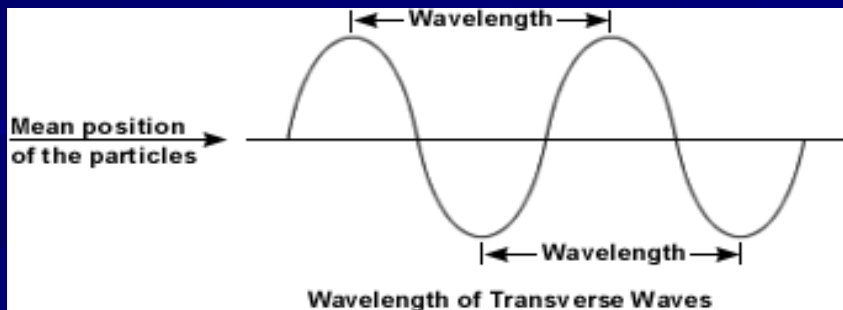




# Wave Properties

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

**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.

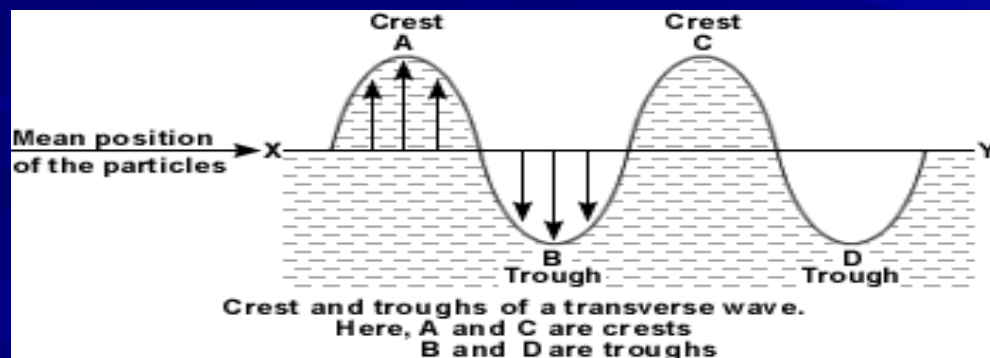
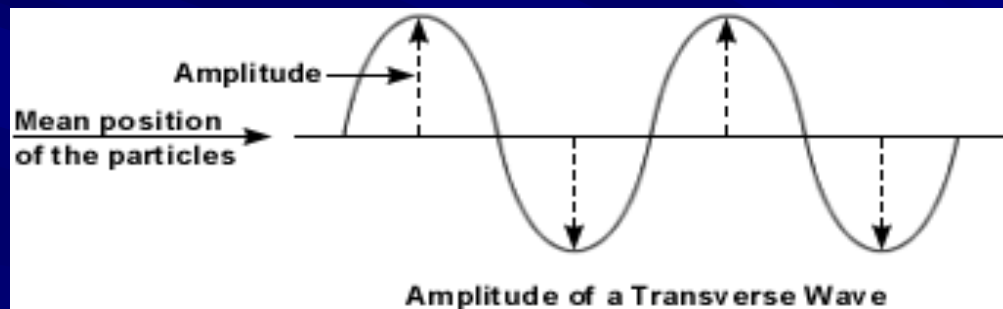
10 waves going past in 1 second = 10 Hz

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).

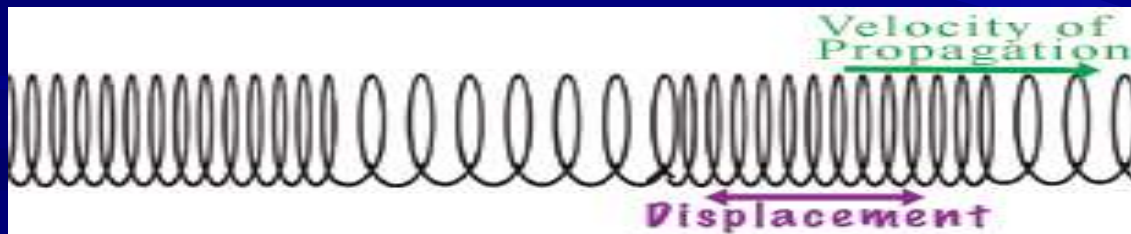
Remember that for transverse waves, the highest point is the **crest**, and the lowest point is the **trough**.



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) . . .

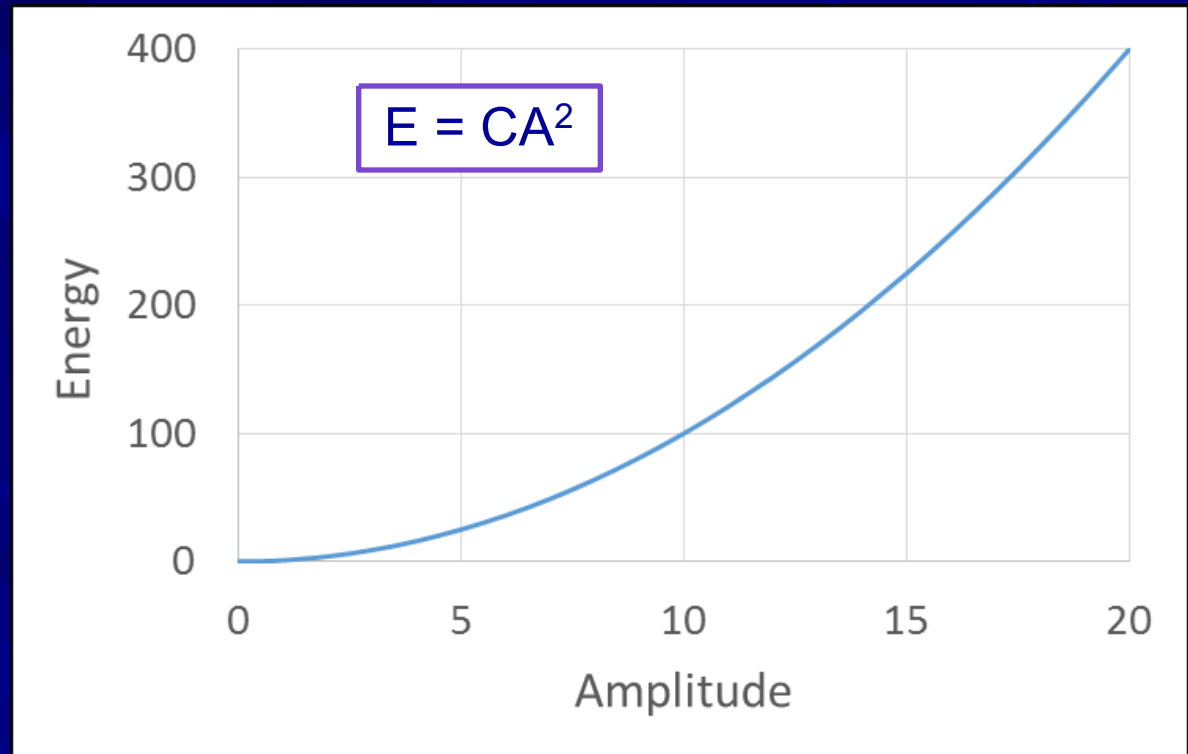
$$E = (1) (3)^2 = (1) (9) = 9 \text{ units}$$



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 amplitude 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:

$$\text{wave speed} = \text{wavelength} \times \text{frequency}$$

(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:  $\text{speed} = 2 \text{ m} \times 500 \text{ Hz} = 1000 \text{ m/s}$

## 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

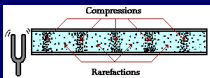
# Image Sources



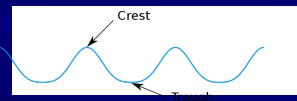
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Kraalennest, Wikipedia [http://en.wikipedia.org/wiki/File:Crest\\_trough.svg](http://en.wikipedia.org/wiki/File:Crest_trough.svg)