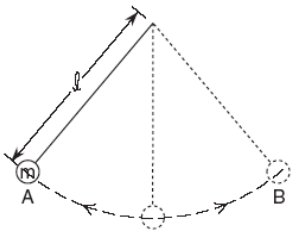
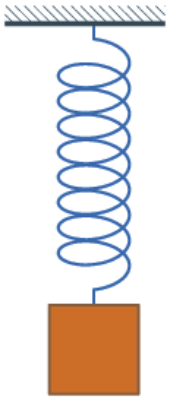
Lesson 1
Introduction to Waves

Vibration:
The periodic or repeated motion of a particle or mechanical system. Vibrations are the causes of waves.

Cycle:
One complete vibration.

Examples include a pendulum or a mass vibrating on a spring.





Amplitude:
The maximum displacement from the rest position. There are 4 amplitudes in one complete cycle.

Periodic waves are caused by vibrations. Vibrating sources have a frequency and a period and transfer energy along the wave. It is not the particles of the medium that are carried forward, but the energy.

Frequency:
The number of cycles that occur in a period of time.

$$frequency \quad f = \frac{cycles}{time}$$

Frequency is usually measured in Hertz (Hz) where,

$$f = \frac{cycles}{second}$$

Period:
The time required for one complete cycle.

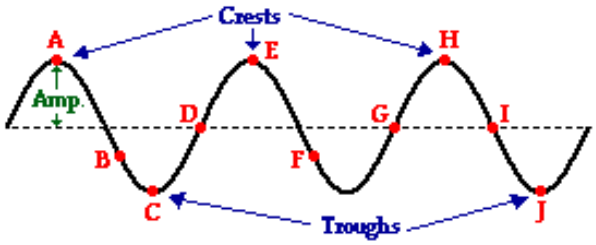
$$period \quad T = \frac{time}{cycles}$$

Period is usually measured in seconds.

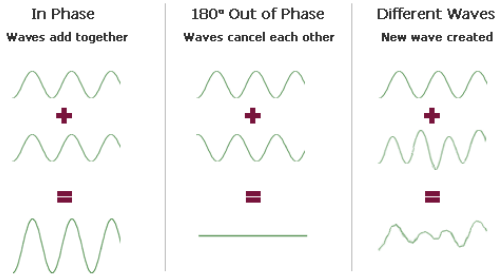
Note that $T = \frac{1}{f}$ *and* $f = \frac{1}{T}$.

Example:
A mass hung on a spring vibrates vertically 12 times in 3.0 s. Calculate the frequency and period of the vibration.

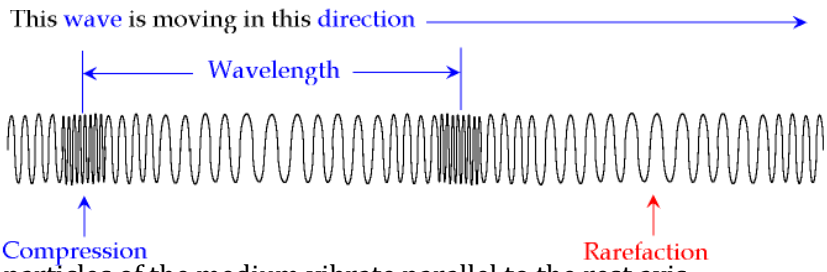
Transverse Pulse:



- In a transverse pulse, particles of the medium vibrate perpendicularly to the rest axis.
- Wavelength is the length of one complete wave cycle. The wavelength of a wave can be measured as the distance from a point on a wave to the corresponding point on the next cycle of the wave.
- Certain points on this transverse pulse are said to be in phase (eg. D and G), while other points are said to be out of phase (eg. F and G).
- Complete waves can also be in or out of phase.



Longitudinal Pulse:



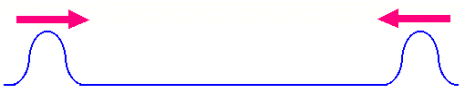
- In a longitudinal pulse particles of the medium vibrate parallel to the rest axis.

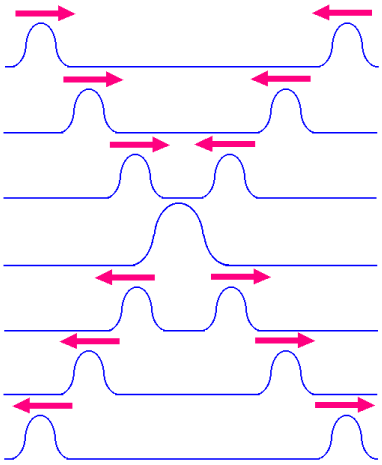
Superposition:

There are two types of wave interference:

1. **Constructive interference**

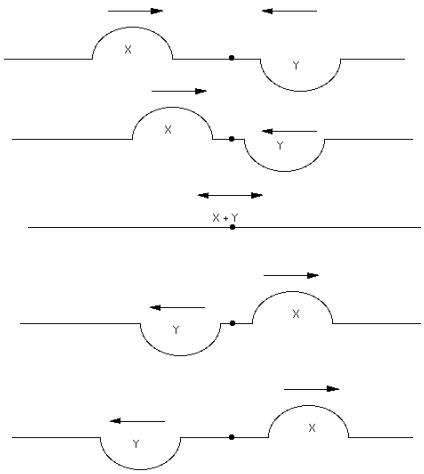
Occurs when wave pulses build each other up resulting in a larger amplitude. In a transverse pulse this occurs when a crest meets a crest (supercrest) or a trough meets a trough (supertrough).





2. **Destructive Interference**

Occurs when pulses cancel each other out as when a crest meets a trough. If the crest and trough have equal amplitude and shape their amplitudes cancel completely for an instant.



\The principle of superposition states that the resulting amplitude of two interfering pulses is the algebraic sum of the amplitudes of the individual pulses.

Examples:
Universal Wave Equation

Consider a periodic transverse wave travelling to the right past an observer.

Recall: $v = \frac{d}{t}$

For a travelling wave, distance is wavelength and time is period. So,

$$v = \frac{\lambda}{T}$$

And since $f = \frac{1}{T}$ we can write,

$$v = f\lambda$$

where

v = wave speed (m/s)
f = frequency (Hz)
λ = wavelength (m)

Example:
A wave machine vibrating at a frequency of 4.0 Hz makes water waves of wavelength 2.5 m. What is the speed of the water waves?

Example:
A periodic source produces a wave having wavelength 2.0 cm every 1.0 s. What is the speed of these waves?