Waves

- A wave is a transfer of energy, in a form of a disturbance usually through a material substance, or medium.
  - Electromagnetic Waves
  - Sound waves
  - Water waves
  - Pressure waves
  - Gravity waves
  - Matter waves

- When objects repeat a pattern of motion (e.g. a pendulum), we say that object is vibrating or oscillating. (wiimote demo)
  - The oscillation is repeated over and over with the same time interval each time.
  - One complete oscillation is called a cycle.
  - The number of cycles per second is called the frequency, f. The frequency is measured in Hertz (Hz).

⇨ The period, T, usually measured in seconds, is the time required for one cycle. The frequency and period are reciprocals of each other.

$$\text{frequency} = \frac{\text{cycles}}{\text{time}} \qquad f = \frac{1}{T}$$

$$\text{period} = \frac{\text{time}}{\text{cycle}} \qquad T = \frac{1}{f}$$

Examples

1. A pendulum completes 30 cycles in 15 seconds. Calculate its frequency and period.

$$f = \frac{\#\text{cycles}}{\text{time}} = \frac{30}{15\text{s}} = \boxed{2\text{ Hz}}$$

$$T = \frac{\text{time}}{\text{cycles}} = \frac{15\text{s}}{30} = \boxed{0.5\text{s}}$$

$$T = \frac{\text{time}}{\#\text{waves}} = \frac{60\,s}{30} = 2\,s$$

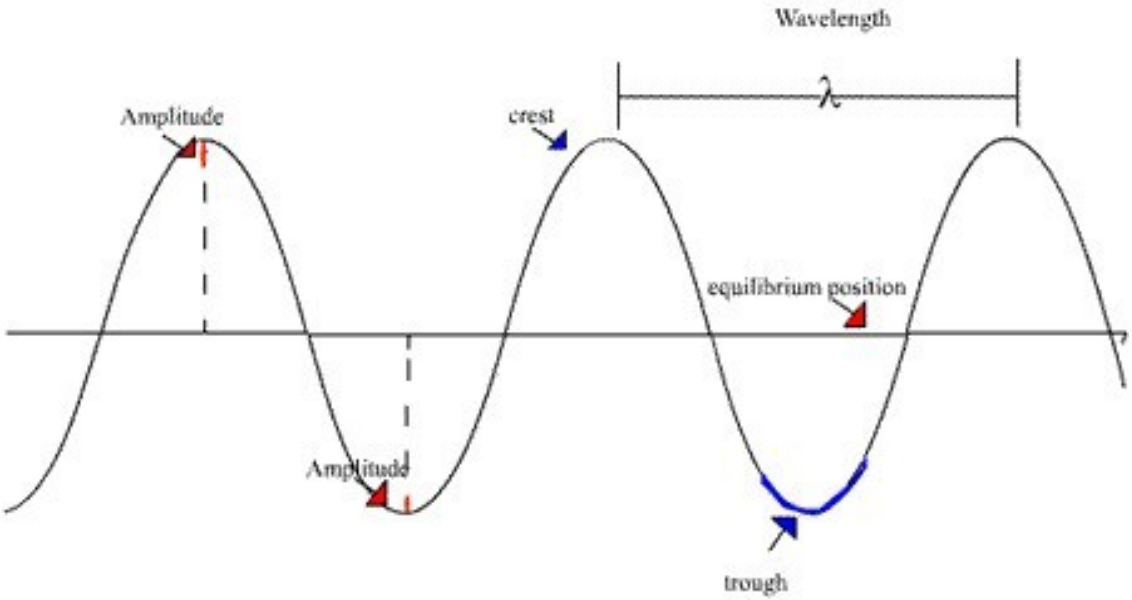
8 b) $$T = \frac{\text{time}}{\#\text{oscill}} = \frac{8\,s}{2048}$$

9 c) $2.50 \times 10^{-2}\,s$

$$f = \frac{1}{T} = \frac{1}{2.5 \times 10^{-2}\,s} = 40\,Hz$$

Transverse Waves

- The particles in the medium vibrate at right angles to the direction in which the wave travels.
  - The high section is called the crest, and the low section is called the trough.
  - The height of the crest or depth of the trough, from the equilibrium position is called the amplitude.
  - For periodic waves, the distance between successive crests and troughs is equal and is called the wavelength. The symbol for the wavelength is the Greek letter lambda, λ.
  - The period of a transverse wave is the time it takes for one wavelength (one cycle) to pass a fixed point.
  - The frequency is the number of wavelengths that passed a fixed point in one second.
  - Examples include water waves and making vibrations on a rope.



library.thinkquest.org/. ../Waves/basic.htm

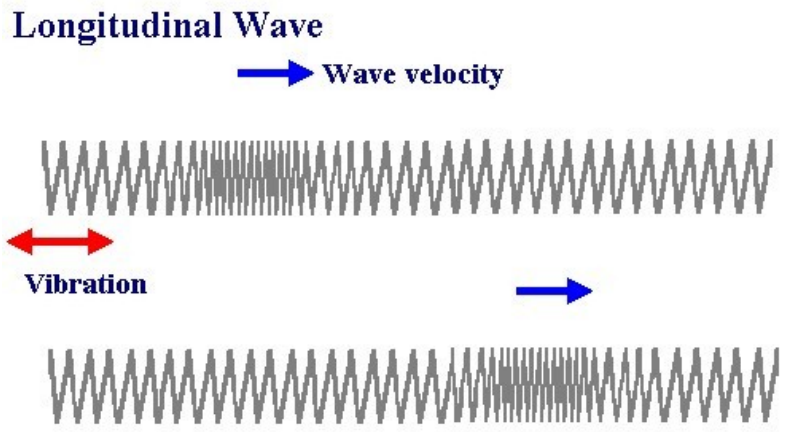
Longitudinal Waves

- ⇨ The vibrations of the particles are parallel to the direction of motion.
  - ⇨ There are a compressions and rarefactions created in longitudinal waves.
  - ⇨ One wavelength is the distance between the midpoints of successive compressions or rarefactions.
  - ⇨ The amplitude is the maximum displacement of the particles from their rest position. Amplitude is a measure of the wave's energy.

⇨ The period of a longitudinal wave is the time it takes for one wavelength (one cycle) to pass a fixed point.

⇨ The frequency is the number of wavelengths that passed a fixed point in one second.

⇨ Sound waves, pressure waves are examples.



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Transmission of Waves

⇨ When a wave is generated in a spring or a rope, the wave travels a distance of one

wavelength, λ, along the rope in the time required for one complete vibration of the source (the period). We can use the formula for velocity to derive the wave equation:

$$\text{velocity, } v = \frac{\text{change in position, } \Delta d}{\text{change in time, } \Delta t}$$

and $\Delta d = \lambda$, and $\Delta t = T$

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

but $f = \frac{1}{T}$

Therefore $v = f\lambda$

⇨ The wave equation, $v = f\lambda$, applies to all waves, visible and invisible.

Examples

1. The wavelength of a water wave in a ripple tank is 0.080 m. If the frequency of the wave is 2.5 Hz, what is its speed?

$v = f\lambda$

$= (2.5)(0.080)$

$= 0.2\ m/s$

Pg 17 #1-24 Pg 22 → answers.

2. The distance between successive crests in a series of water waves is 4.0 m, and the crests travel 9.0 m in 4.5 s. What is the frequency of the waves?

$\lambda = 4.0\ m$

$\Delta d = 9.0\ m$

$\Delta t = 4.5\ s$

$f = ?$

$v = \frac{\Delta d}{\Delta t}$

$= \frac{9.0\ m}{4.5\ s}$

$= 2.0\ m/s$

$v = f\lambda$

$2 = f(4.0)$

$0.5\ Hz = f$