## UNIT 9 – WAVES

A **wave** is described as a disturbance or vibration that transmits energy from one point to another.

The material through which a wave moves is called a medium.

Examples: air , water , ground , slinky , rope

If there is no disturbance, the medium will be at rest or remain in its equilibrium position.

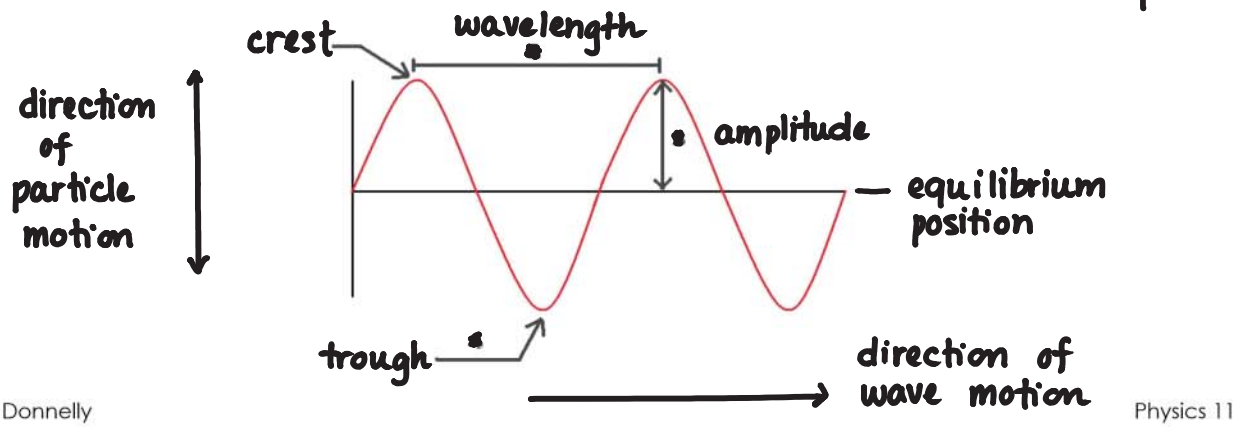
### Waves Categories

1) **Electromagnetic Waves**
- Capable of transmitting energy through a vacuum (empty space - no medium needed)
- they travel through space at the **speed of light** , $c = 3.0 \times 10^8$ m/s
- they cannot be observed directly
- Examples: ultraviolet (UV) rays, gamma rays , x-rays

2) **Mechanical Waves**
- Require a medium to transmit energy from one location to another.
- 3 classification of mechanical waves: transverse, longitudinal and surface waves

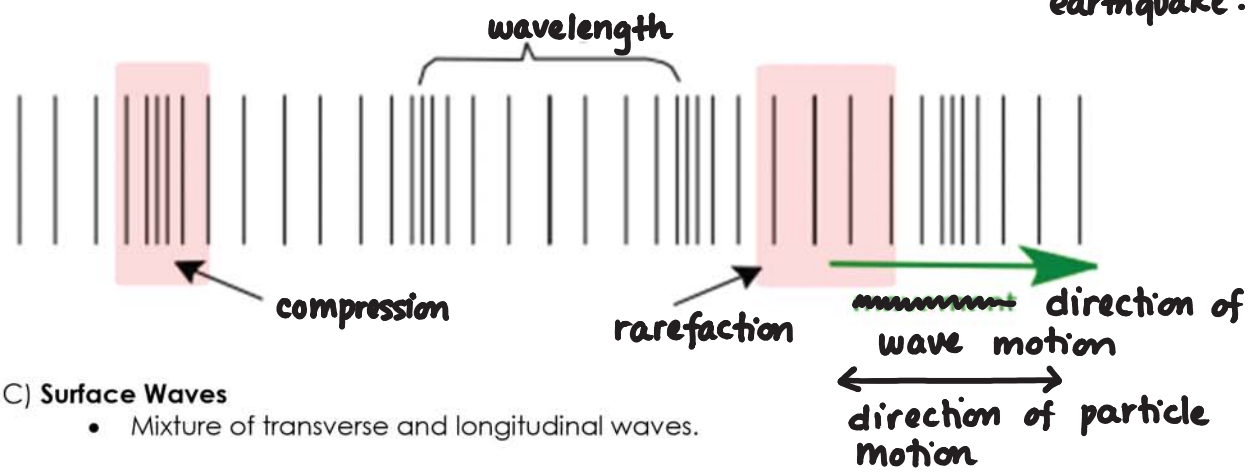
A) **Transverse Waves**

- The particles of the medium move perpendicularly to the direction of the wave motion.
- Examples: guitar string , secondary (S-) wave released during an earthquake.



B) **Longitudinal Waves**

- The particles of the medium move parallel to the direction of the wave motion. The molecules are being compressed and then stretched apart to move the energy from place to place.
- Examples: sound wave, primary (p) wave released during an earthquake.




C) **Surface Waves**

- Mixture of transverse and longitudinal waves.

## Properties of Waves

**1) Wavelength**

- length for one complete wave cycle
- the distance between adjacent points on a wave (between two crests or troughs)
- symbol $\lambda$ (lambda)
- measured in m, cm, mm, .... nm (nanometer) $\hookrightarrow 10^{-9}$ } measure for electromagnetic waves.

**2) Frequency**

- Often refered to as how often something happens
- Since all waves are caused by vibrations, we can describe frequency as:

$$\frac{\#\text{ of vibrations}}{\text{second}} \quad \text{or} \quad \frac{\#\text{ of cycles}}{\text{second}}$$

- symbol f
- measured in Hz (hertz) ; 1 Hz = $\frac{1 \text{ cycle}}{1 \text{ sec.}}$

**3) Period**

- Often refers to the time it takes for something to happen.
- Time required for one complete cycle or rotation
  - Example: Earth takes 24 hours for one complete rotation
- symbol T
- measured in seconds (typically)

**Frequency** refers to how often something happens and **period** refers to the time it takes for something to happen.

Relationship between Frequency and Period: $f = \frac{1}{T}$ or $T = \frac{1}{f}$ } T and f are inversely proportional to each other.

**4) Wave Speed**

- How fast a crest/trough moves past a fixed point.

$v = \frac{\lambda}{T}$ ("distance") / ("time") or $v = \lambda f$ Universal Wave Equation

**Example 1:** Freddy the fly flaps his wings back and forth 121 times each second. What is the frequency and period of the wing?

$f = \frac{\#\text{ of flaps}}{\text{sec}} = \frac{121 \text{ flaps}}{1 \text{ sec}} = 121 \text{ Hz}$

$T = \frac{1}{f} = \frac{1}{121} = 0.00826 \text{ sec}$ It takes 0.008 sec to flap his wing one.

**Example 2**: A sound wave has a frequency of 262 Hz. What is the time between successive wave crests (ie: What is the period)?

$f = 262 \text{ Hz}$

$T = ?$ $T = \frac{1}{f} = \frac{1}{262} = 0.0038 \text{ sec}$

**Example 3:** What is the frequency of a blue light which has a wavelength of 410 nm?

electromagnetic wave, so, $v = 3.0 \times 10^8$ m/s

$\lambda = 410 \text{nm} = 410 \times 10^{-9}$ m

$v = \lambda f$

$\frac{3.0 \times 10^8}{410 \times 10^{-9}} = \frac{(410 \times 10^{-9}) f}{410 \times 10^{-9}}$

$f = 7.32 \times 10^{14}$ Hz

**Practice**: p.293 #1 – 4; p.332 #1 – 4 (EM Spectrum Diagram p.330); p. 304 # 1 – 10 (omit #7)

Mrs. Donnelly Physics 11