# ELECTROMAGNETIC WAVES

## Electromagnetic Waves and Their Properties

## Electromagnetic Waves (EM waves) or Radiant Energy/Electromagnetic Radiation

- Energy is conveyed between bodies through waves known as electromagnetic waves or radiant energy. These waves travel through space at the speed of light ($3\times10^8\ \frac{m}{s}$).
- Radiant energy propagates without requiring any medium for transmission.

### Their properties:

(I) Traveling at the Speed of Light: These waves exhibit a velocity equivalent to that of light.

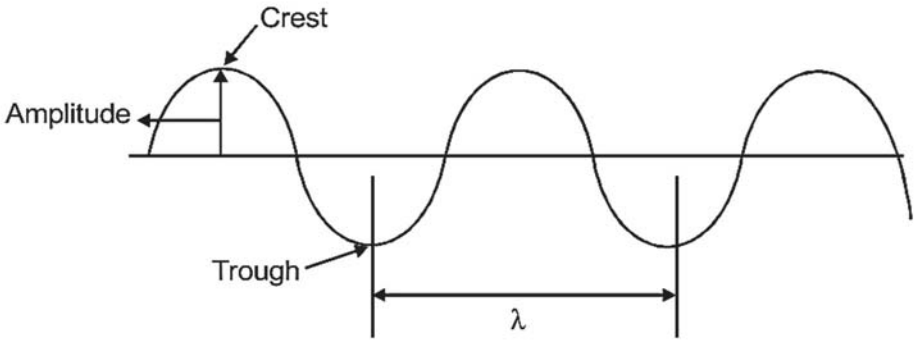
(II) Lack of Deflection in Electric and Magnetic Fields: These rays do not experience deflection when subjected to electric or magnetic fields.

Components of Electromagnetic Waves:

Electromagnetic waves are characterized by two distinct components:

(A) Electric Component: One of the integral constituents of electromagnetic waves is the electric component.

(B) Magnetic Component: The other essential component inherent in electromagnetic waves is the magnetic component.




1. **Wavelength (λ):** Wavelength represents the spatial measurement between two successive crests or troughs of a wave. The symbol used to denote wavelength is λ.

2. **Frequency (ν):** Frequency pertains to the quantity of waves traversing a designated point within one second. The unit of frequency is expressed in hertz (Hz) or cycles per second.

3. **Wave number ($\bar{\nu}$):** Wave number signifies the quantity of waves within a specified unit length. For instance, it can be expressed as 1 cm divided by the wavelength (in cm).

4. **Amplitude:** The amplitude denotes the height of a crest or the depth of a trough in a wave. The intensity of the wave is directly proportional to the square of its amplitude.

$$\text{Intensity} \propto (\text{Amplitude})^2$$

5. **Velocity:** Velocity represents the distance covered by a single wave in one second. The relationship between velocity (C), frequency, and wavelength is given by the equation:

$$C = \text{Frequency} \times \text{Wave length}$$

- For vacuum, the velocity is determined by $\frac{1}{\sqrt{\mu_0\varepsilon_0}}$, where $\varepsilon_0$ is the permittivity of free space, and $\mu_0$ is the permeability of free space.

- In a medium, the velocity is given by $\frac{1}{\sqrt{\mu\varepsilon}}$.
- When light transitions from one medium to another, the velocity changes while the frequency remains constant.
- Initially, it was believed that the motion of atoms and subatomic particles could be described using classical mechanics, Newton's laws of motion. However, as more research was conducted on subatomic particles and atomic motion, these laws were found inadequate. This led to the development of a new branch of mechanics known as quantum mechanics.

**Ex:** Radio waves, micro waves, Infra-red rays, visible rays, ultraviolet rays, x–rays, gama rays and cosmic rays.

| S.No. | Name | Wavelength (Å) | Frequency (Hz) | Source |
|---|---|---|---|---|
| 1. | Radio wave | $3 \times 10^{14} - 3 \times 10^{7}$ | $1 \times 10^{5} - 1 \times 10^{9}$ | Alternating current of high frequency |
| 2. | Micro Wave | $3 \times 10^{7} - 6 \times 10^{6}$ | $1 \times 10^{9} - 5 \times 10^{11}$ | Klystron tube |
| 3. | Infrared (IR) | $6 \times 10^{6} - 7600$ | $5 \times 10^{11} - 3.95 \times 10^{16}$ | Incandescent Objects |
| 4. | Visible | 7600 – 3800 | $3.95 \times 10^{16} - 7.9 \times 10^{14}$ | Electric bulbs, sun rays |
| 5. | Ultraviolet (UV) | 3800 – 150 | $7.9 \times 10^{14} - 2 \times 10^{16}$ | Sun rays, arc lamps with mercury vapours |
| 6. | X-Rays | 150 – 0.1 | $2 \times 10^{16} - 3 \times 10^{19}$ | Cathode rays striking metal plate |
| 7. | y- Rays | 0.1 – 0.01 | $3 \times 10^{19} - 3 \times 10^{20}$ | Secondary effect of radioactive decay |
| 8. | Cosmic Rays | 0.01-0(Zero) | $3 \times 10^{29}$ – Infinity | Outer space |