University of Al-Mustaqbal
College of Science
Department of Medical Physics

Optics

Lecture 1: Nature and propagation of light

Second stage

Dr. Duaa jaafer Al-fayadh

2025 – 2026

Lecture 1: Nature and propagation of light

- **Optics**, the study of light, is conveniently divided into three fields are geometrical optics, physical optics and quantum optics.
- **Geometrical optics,** which includes the study of light propagation in straight lines, speed of light, properties of light, reflection, refraction, desperation, lenses and mirrors.
- **Physical optics,** which is concerned with the nature of light and involves primarily the theory of waves. This includes interference and diffraction.
- **Quantum optics,** which deals with the interaction of light with the atomic entities of matter and which for an exact treatment requires the methods of quantum mechanics.

1. Light and vision

- **Light or visible light** is electromagnetic radiation that is visible to the human eye, and is responsible for the sense of vision. It has a wavelength in a range from (400 - 700 nm).
- Light travels in straight lines and has the primary properties such as intensity, propagation direction, frequency or wavelength and polarization.
- Light is a form of energy, which is emitted and absorbed in tiny "packets" called photons, the smallest unit of light. Photons are emitted when electrons in an atom jump from one orbit to another, exhibits properties of both waves and particles. This property is referred to as the wave–particle duality.
- For a given frequency *f* of the radiation, each photon has a fixed amount of energy *E* which is

$$E = hf \text{ .....} (1)$$

Where *h* is **Planck's constant**, equal to (**6.63×10^{-34} joul.sec**)

- The wavelength (λ) is the distance between 2 peaks of the wave.
- Frequency (*f*) is the number of wave/second.
- The relationship between wavelength and frequency is given by:

Speed of light = wavelength × frequency

$$c = \lambda \times f \text{ .....} (2)$$ where $c = 3\times10^{8}\ m.s^{-1}$

- Light is faster than sound and can travel through a vacuum.

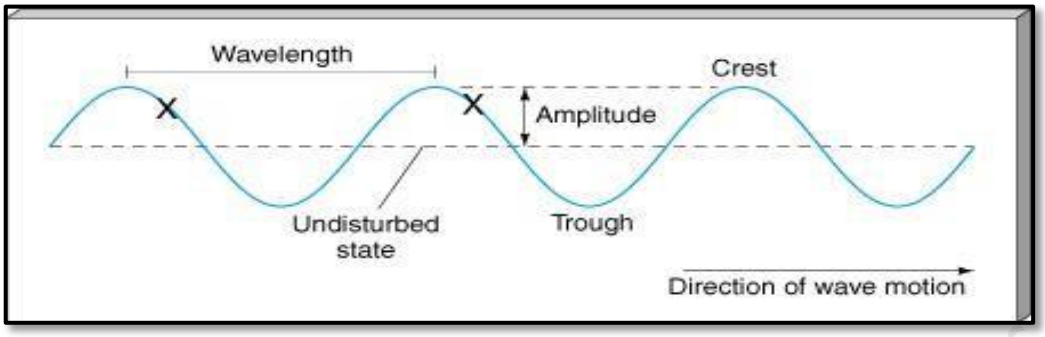

Figure 1: Motion of the light wave

2. Electromagnetic spectrum

- Electromagnetic (EM) radiation is classified by wavelength into radio, microwave, infrared, the visible region we perceive as light, ultraviolet, X-ray and gamma (γ) ray.
- The behavior of EM radiation depends on its wavelength. Higher frequencies have shorter wavelengths, and lower frequencies have longer wavelengths as shown in Fig 1.
- Light is a form of electromagnetic waves- travels through space, each colour is associated with a different wavelength as shown in Table 1.
- White light is a mixture of the colors of the rainbow; a prism splits white light into the various colors.

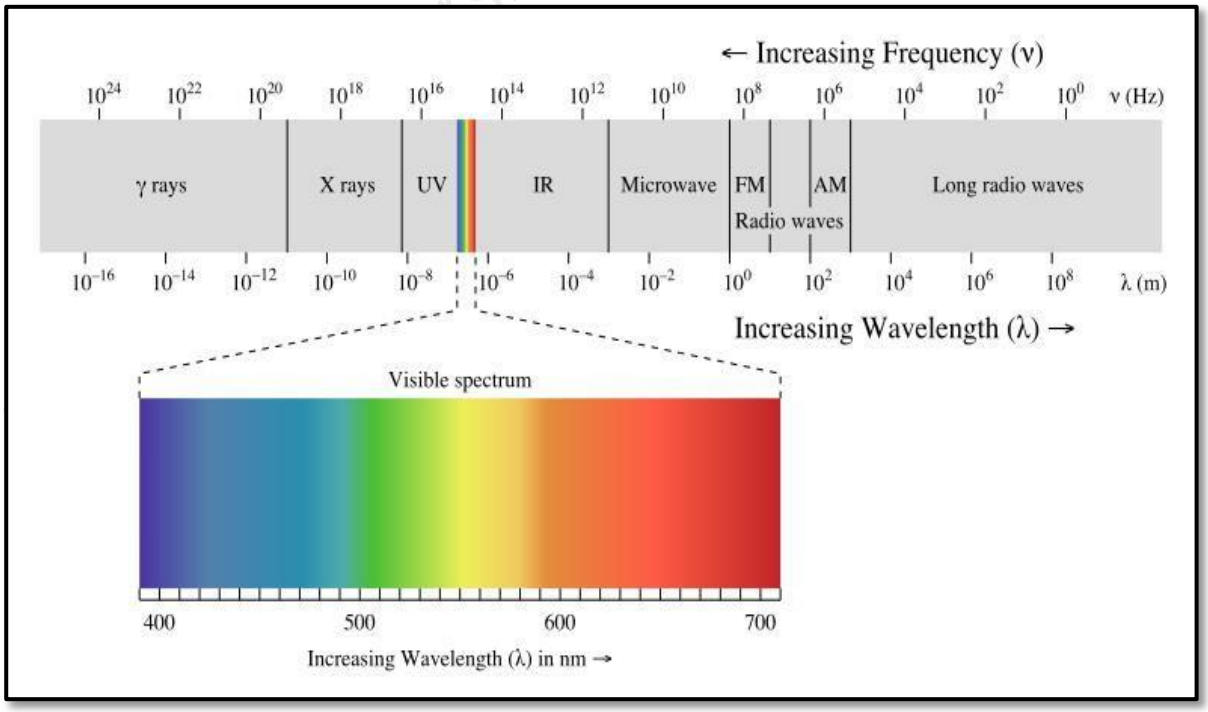

Figure 2: Electromagnetic spectrum

Table 1: The range of the wavelength for colours of visible light

Colour	Range of wavelength (λ) nm
Violet	400 – 450
Blue	450 – 520
Green	520 – 560
Yellow	560 – 600
Orange	600 – 625
Red	625 – 700

3. Light rays and beams

- A ray of light is the direction along which the light energy travels, while the beam of light is a collection of rays.
- Substances like wood which do not allow light to pass through them are called opaque.
- Transparent substance, like glass, which allows some of light energy incident on it to pass through, the remainder of the energy being absorbed or reflected.

4. Index of refraction (refractive index)

- Definition- is defined as a ratio of the speed of light in vacuum or air relative to the speed of light in a considered medium. This can be written as:

$$n = \frac{velocity\ of\ light\ in\ vacum}{velocity\ of\ light\ in\ medium} = \frac{c}{v} \quad \text{..... (3)}$$

- Refractive index describes how light or other radiation propagates through that medium and it has no units.
- Refractive index of air and water is 1 and 1.33 respectively, meaning that light travels 1.33 times as fast in vacuum as it does in water.
- When light travels from one medium to another, its **wavelength (λ) changes** but its **frequency (*f*) remains constant**.

Example 1: The wavelength of green light is *522 nm*, what is the frequency of this radiation?

Solution:

$\lambda = 522\ nm = 522 \times 10^{-9}\ m, \quad c = 3\times10^{8}\ m.s^{-1}$

$c = \lambda \times f$

$f = c / \lambda$

$f = 3\times10^{8}\ m.s^{-1} / 522 \times 10^{-9}\ m = 5.47 \times 10^{14}\ Hz.$

Example 2: A light beam travels at $1.94 \times 10^{8}\ m.s^{-1}$ in quartz. Find the index of refraction of quartz at this wavelength?

Solution:

$v = 1.94 \times 10^{8}\ m.s^{-1}, \quad c = 3\times10^{8}\ m.s^{-1}$

$n = c / v$

$n = 3\times10^{8}\ m.s^{-1} / 1.94 \times 10^{8}\ m.s^{-1} = 1.55.$

Example 3: The wavelength of green light is *522 nm*, what is the Energy of this radiation?

Solution:

$\lambda = 522\ nm = 522 \times 10^{-9}\ m, \quad c = 3\times10^{8}\ m.s^{-1}$

$c = \lambda \times f$

$f = c / \lambda$

$f = 3\times10^{8}\ m.s^{-1} / 522 \times 10^{-9}\ m = 5.47 \times 10^{14}\ sec^{-1}$

$E = hf$

$E = 6.6 \times 10^{-34}\ joul.sec \times 5.47 \times 10^{14}\ sec^{-1} = 36.1 \times 10^{-24}\ joul$

- ***Home works about lecture 1***

Q1: Find the speed of light in the glass if the refractive index of the glass is 1.45?

(A) 4×10^{8} m.s^{-1} (B) 3×10^{8} m.s^{-1} (C) 2×10^{8} m.s^{-1} (D) 1×10^{8} m.s^{-1}

Q2: The range of visible light in the electromagnetic filed is:

(A) 100 – 300 nm (B) 400 – 700 nm (C) (800 – 1100 nm) (D) (1200 – 1500 nm)

Q3: The range of weave length of violet colour is:

(A) (560 – 600 nm) (B) (520 – 560 nm) (C) (450 – 520 nm) (D) (400 – 450 nm)

Q4: Defined as a ratio of the speed of light in air relative to the speed of light in a considered medium?

(A) Refractive index (B) frequency (C) wave length (D) ray

Q5: The formula of frequency (f) expressed as:

(A) $f = \lambda / c$ (B) $f = c / \lambda$ (C) $f = c \times \lambda$ (D) $f = \lambda \times c$