Optics

Second Year /1st semester

1st lecture (Nature of light)

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Optics

Optics: the study of light, is conveniently divided into three fields are (*geometrical optics*, *physical optics* and *quantum optics*).

1. Geometrical optics: which includes the study of **(light propagation in straight lines, speed of light, properties of light, reflection, refraction, desperation, lenses and mirrors).**

2. Physical optics: which includes the study of **(interference and diffraction).**

3. Quantum optics: which deals with **(the interaction of light with the atomic entities of matter).**

Nature and propagation of light

The light has **a natural duality**, meaning that in some cases it acts (as a wave and as a particle).

1. The wave nature of Light:

i. Huygens theory →(Light is waves and every point on the front of the wave is a source of secondary interference).

This theory explained → reflection and refraction

ii. Maxwell's theory → (the light is a form of electromagnetic waves have a speed equal to 3×10^{8}m/s).

2. The particle nature of Light:

i. Isaac Newton theory → (the light was particles that emanated from a light source).

This theory explained → reflection

ii. Einstein's theory → (the energy of a light wave is collected in energy packets called photons).

This theory explained → photoelectric phenomenon

Electromagnetic spectrum

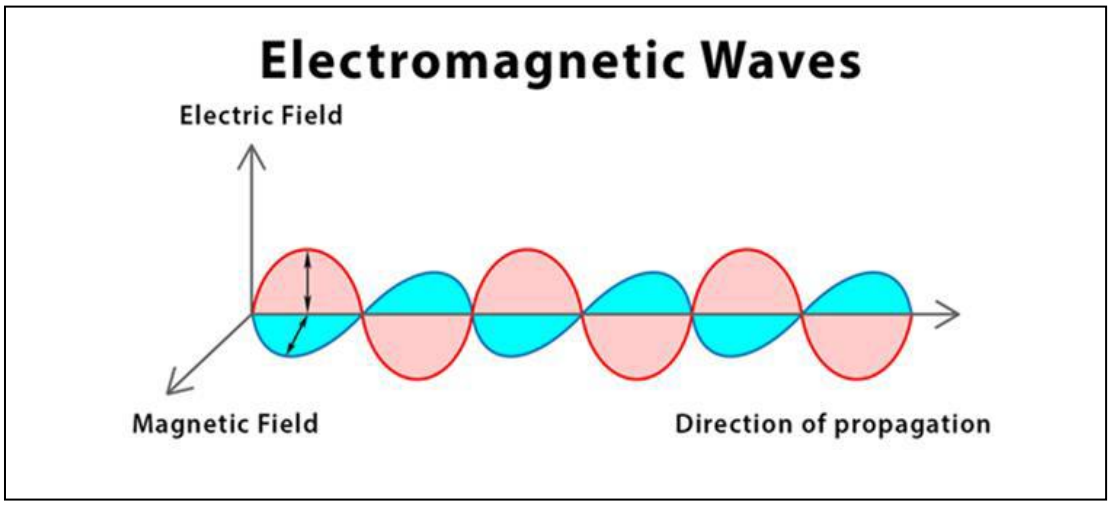


Fig 1: Electromagnetic Waves

- Light (visible light) is electromagnetic radiation, It has a wavelength in a range from (400 - 700 nm)
- Light is associated with a different wavelength
- Light has the primary properties such as:

i. Intensity
ii. Propagation direction,
iii. Frequency or wavelength

iv. Polarization
v. Phase

❖ **Electromagnetic (EM) radiation:** classified by wavelength into [radio, microwave, infrared, the visible region, ultraviolet, X-ray and gamma (γ) ray].

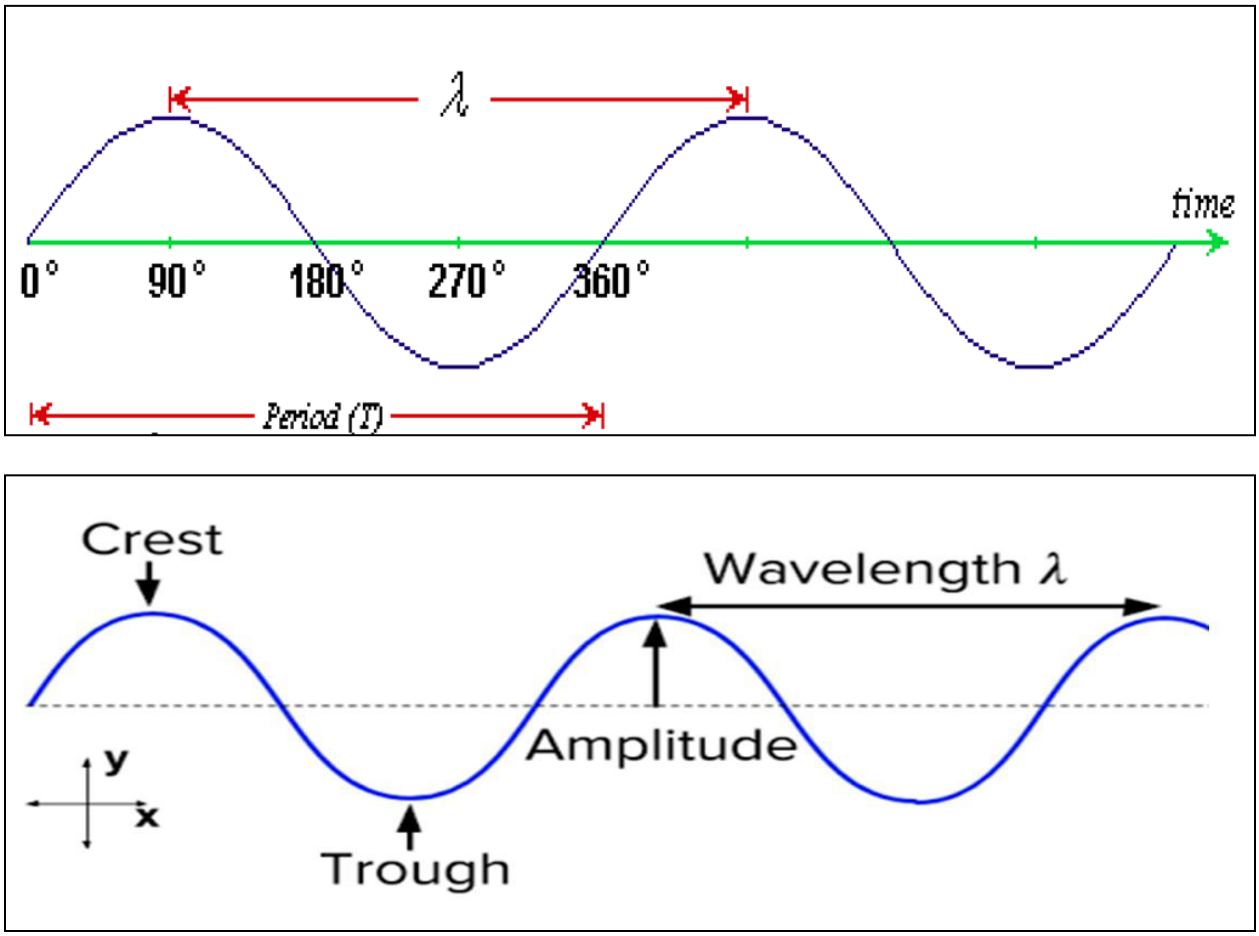


Fig 2: motion of light waves

- The behavior of EM radiation depends on its **wavelength**.
- The relationship between wavelength and frequency is an inverse relationship , and is given by:

$$\lambda = \frac{c}{\nu}$$

Speed of light = wavelength × frequency

$$c = \lambda \nu$$

- **The wavelength (λ):** is the distance between 2 peaks of the wave.
- **The frequency (ν):** is the number of peaks that will travel past a point in one second.
- For a given frequency v of the radiation, each photon has a fixed amount of energy E which is:

$$E = h\nu$$

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

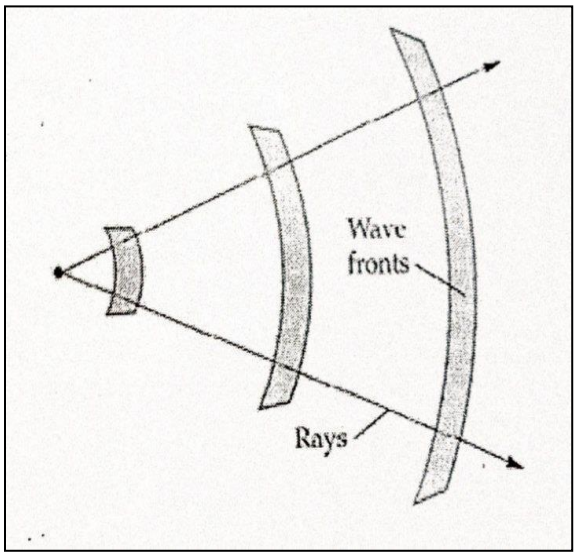
- **The period (T):** of the waveform is one full) 0 to 360 degree (sweep. The relationship of frequency and the period is given by the equation :

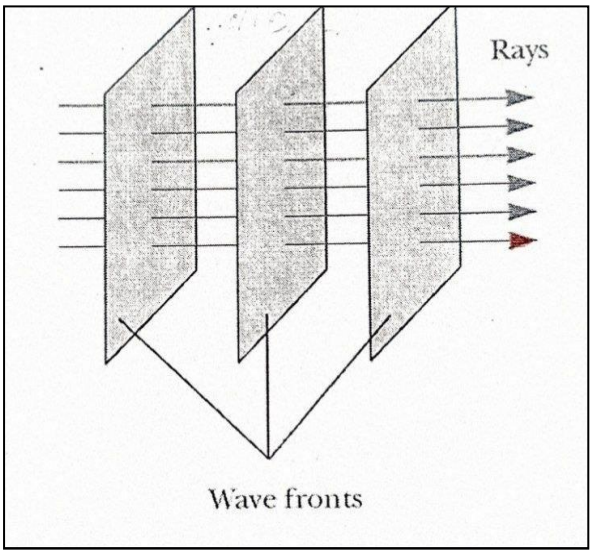
$$\lambda = \frac{1}{\nu}$$

Wave front and Rays

❖ **Wave front:** is a surface passing through the points of a wave that have the same phase and amplitude.

❖ **Ray:** is a line perpendicular (normal) to the surfaces of the constant phase of the wave – wave fronts.





Laws Lecture 1

1. The photon energy :

$$E = h\nu$$

2. The wavelength of light :

$$\lambda = \frac{c}{\nu}$$

3. The frequency :

$$\nu = \frac{c}{\lambda}$$

4. The period (T) of the waveform :

$$T = \frac{1}{\nu}$$

E : energy of photon (J)
h : plancks constant (J .sec)
λ : wavelength of light (m)
c : speed of light (m/sec)
ν: frequency (Hz) ,(sec^{-1})

Proplems

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

Solution

$\lambda = 522nm = 522 \times 10^{-9}\, m$
c = $3 \times 10^{8}\, m/sec$
ν = ?

$$\nu = \frac{c}{\lambda} = \frac{3 \times 10^{8}}{522 \times 10^{-9}} = 57.4 \times 10^{13}\ Hz$$

EX 2 The frequency of light is $57.4 \times 10^{13} Hz$, what is the wavelength of this radiation?

Solution

$\nu = 57.4 \times 10^{13} Hz$

c = $3 \times 10^{8} m/sec$

$\lambda = ?$

$$\lambda = \frac{c}{\nu} = \frac{3 \times 10^{8}}{57.4 \times 10^{13}} = 5.22 \times 10^{-7} = 522 \times 10^{-9} m = 522 nm$$

EX 3 The frequancy of green light is $57.4 \times 10^{13} Hz$, what is the Energy of this radiation?

Solution

$\nu = 57.4 \times 10^{13}\ Hz$, $E = ?$

$$E = h\nu = 6.63 \times 10^{-34} \times 57.4 \times 10^{13} = 3.8 \times 10^{-19} J$$

EX 4 The wavelength of green light is 522 nm, what is the Energy of this radiation?

Solution

$\lambda = 522nm = 522 \times 10^{-9} m$, $E = ?$

$$E = h\nu$$

$$E = h\frac{c}{\lambda}$$

$$E = 6.63 \times 10^{-34} \times \frac{3 \times 10^{8}}{522 \times 10^{-9}} = 3.81 \times 10^{-19}\ J$$

Homework

1) The wavelength of red light is 650 nm, what is the frequency of this radiation?

2) Determine the wavelength of the microwave radiation if it emitted by a microwave oven (ν = 2.45×10^{9} Hz) ?

3) The frequancy of red light is $46.1 \times 10^{6}\ MHz$, what is the Energy of this radiation.