Chapter II: optic

2-Optics

2.1.1. Introduction: Optics is the branch of physics that studies the behaviour and properties of light, including its interactions with matter and the construction of instruments that use or detect it. Optics usually describes the behaviour of visible, ultraviolet, and infrared light. Light is a type of electromagnetic radiation, and other forms of electromagnetic radiation such as X-rays, microwaves, and radio waves exhibit similar properties.

Most optical phenomena can be accounted for by using the classical electromagnetic description of light, however complete electromagnetic descriptions of light are often difficult to apply in practice. Practical optics is usually done using simplified models. The most common of these, geometric optics, treats light as a collection of rays that travel in straight lines and bend when they pass through or reflect from surfaces. Physical optics is a more comprehensive model of light, which includes wave effects such as diffraction and interference that cannot be accounted for in geometric optics. Historically, the ray-based model of light was developed first, followed by the wave model of light. Progress in electromagnetic theory in the 19th century led to the discovery that light waves were in fact electromagnetic radiation.

2.1.2 Nature of light

2.1.2.1 Light is electromagnetic radiation that can be detected by the human eye. Electromagnetic radiation occurs over an extremely wide range of wavelengths, from gamma rays with wavelengths less than about 1×10^{-11} meters to radio waves measured in meters.

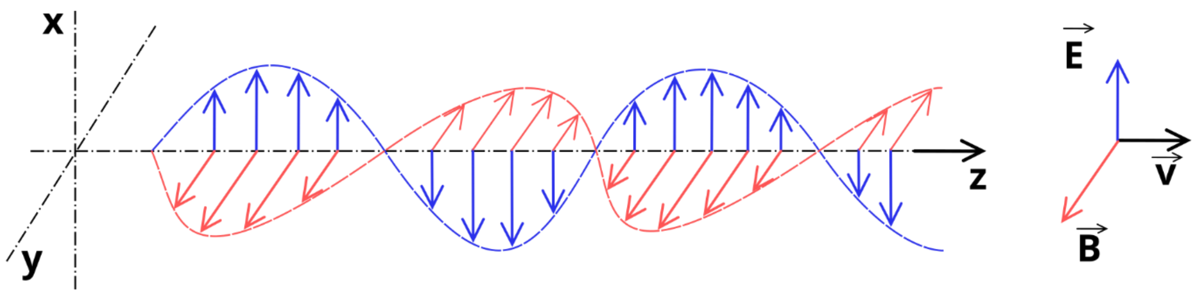
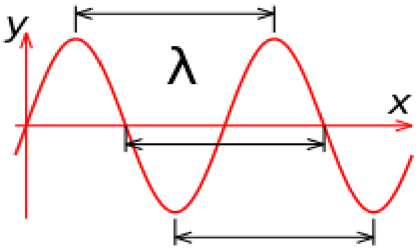


Figure 2.1: The wavelength

2.1.2.2 A wavelength is the distance between one point on a wave to the same point on the next wave, such as a crest or trough. Because it is a distance, it is usually reported in units of nm, mm, cm, or m.



The formula to convert wavelength to frequency is given by:

Speed = Frequency x Wavelength

Therefore, Wavelength = (Speed of the wave)/ (Frequency of the wave)

Symbolically, the formula is represented as:

$$C = f \times \lambda$$

Where,

λ is the wavelength of the wave (measured in meters),

C is the speed of the wave in a given medium (measured in m/s),

f, ν is the frequency of the wave (measured in Hertz or 1/s).

2.1.2.3 The photon: Planck's discoveries paved the way for the discovery of the photon. A photon is the elementary particle, or quantum, of light. Photons can be absorbed or emitted by atoms and molecules. When a photon is absorbed, its energy is transferred to that atom or molecule. Because energy is quantized, the photon's entire energy is transferred (remember that we cannot transfer fractions of quanta, which are the smallest possible individual "energy packets"). The reverse of this process is also true. When an atom or molecule loses energy, it emits a photon that carries an energy exactly equal to the loss in energy of the atom or molecule. This change in energy is directly proportional to the frequency of photon emitted or absorbed. This relationship is given by Planck's famous equation:

$$E = h\nu = \frac{hc}{\lambda}$$

where is the energy of the photon absorbed or emitted (given in Joules,), is frequency of the photon (given in Hertz,), and is Planck's constant,

2.1.2.4 **The Electromagnetic Spectrum**

The **electromagnetic spectrum** is the full range of electromagnetic radiation, organized by frequency or wavelength. The spectrum is divided into separate bands, with different names for the electromagnetic waves within each band. From low to high frequency these are: radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays. The electromagnetic waves in each of these bands have different characteristics, such as how they are produced, how they interact with matter, and their practical applications.

Radio waves, at the low-frequency end of the spectrum, have the lowest photon energy and the longest wavelengths—thousands of kilometers, or more. They can be emitted and received by antennas, and pass through the atmosphere, foliage, and most building materials.

Gamma rays, at the high-frequency end of the spectrum, have the highest photon energies and the shortest wavelengths—much smaller than an atomic nucleus. Gamma rays, X-rays, and extreme ultraviolet rays are called ionizing radiation because their high photon energy is able to ionize atoms, causing chemical reactions.

Visible light and radiation of longer wavelengths are nonionizing; their photons do not have sufficient energy to cause these effects.

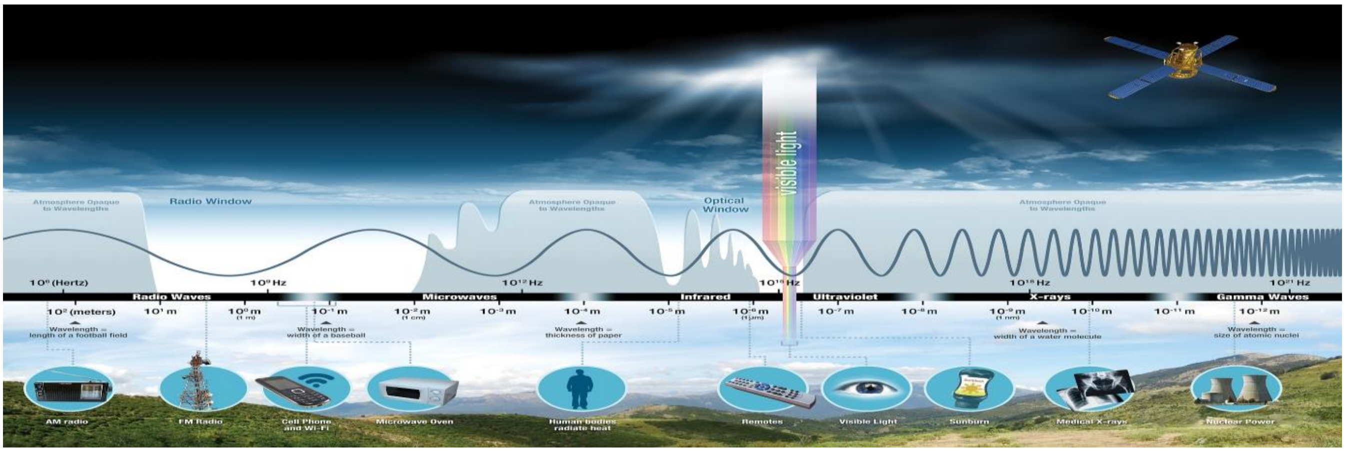
Throughout most of the electromagnetic spectrum, spectroscopy can be used to separate waves of different frequencies, so that the intensity of the radiation can be measured as a function of frequency or wavelength. Spectroscopy is used to study the interactions of electromagnetic waves with matter.

The types of electromagnetic radiation are broadly classified into the following classes (regions, bands or types):

1. Gamma radiation
2. X-ray radiation
3. Ultraviolet radiation
4. Visible light (light that humans can see)
5. Infrared radiation

6. Microwave radiation
7. Radio waves

This classification goes in the increasing order of wavelength, which is characteristic of the type of radiation.



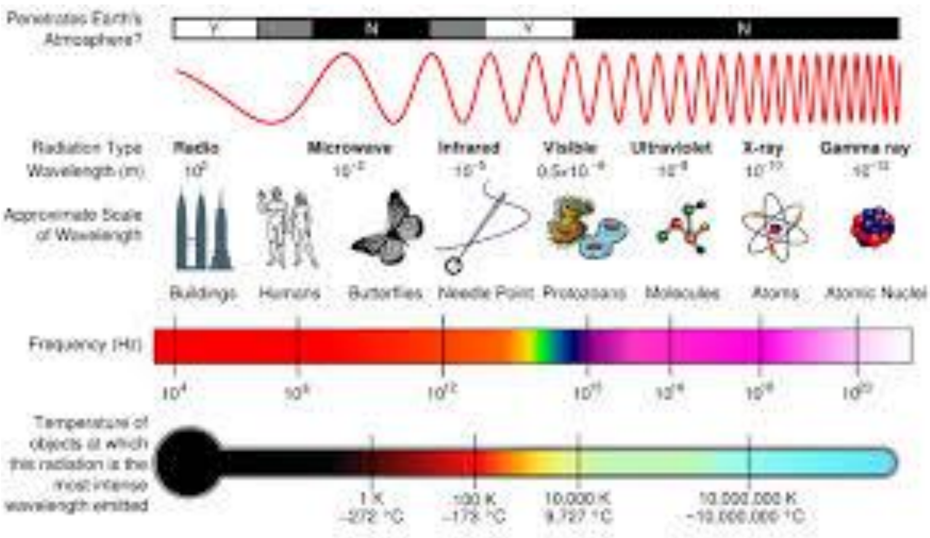


Figure 2.2 : The electromagnetic spectrum

References: Wikipedia