L16- Light in Medicine

Properties of light

What is Light?

Light is part of the electromagnetic spectrum; the electromagnetic spectrum can be divided into several bands based on the wavelength (which ranges from radio waves to gamma rays).

The three general categories of light-UV, Visible, and IR- are defined in terms of their wavelengths

- Ultraviolet light has wavelengths from 100 to 400nm

- Visible light has wavelengths 400 to 700nm

- IR light has wavelengths from 700 to 1040nm.

Measurement of light and its units

• Wavelength of light used to be measured in

- **Microns 1 μ = 10^{-6}m , Angstroms 1 A° = 10^{-10}m , Nanometer 1 nm= 10^{-9}m**

Visible light is measured in photometric units

UV and IR radiation can be measured in radiometric units

- **The measurement of light is done in terms of measuring the intensity of light, flux, efficiency, light speed etc. similar the intensity of light is measured by photometry.**
- **The measurement of light occurs with the use of two units that physical and subjective units.**
- **When light is measured in terms of energy units because it is also considered as energy then it's a physical unit.**
- **When it is measured on the bases of its brightness then it is done with subjective unit's candles or lux etc.**

What are Properties of light?

Light is Transverse wave, has some interesting properties:

1- Velocity of Light and Refractive Index

The energy of light is related to its frequency and velocity as follows:

$$E = h\nu = hC/\lambda$$

where E = energy ,h = Planck's constant, 6.62517 x 10-27 erg.sec

ν= frequency ,C = velocity of light = 2.99793 x 10^{10} cm/sec

λ = wavelength

The velocity of light, C, in a vacuum is 2.99793 x 10^{10}cm/sec. Light cannot travel faster than this, but if it travels through a substance, its velocity will decrease. Note that from the equation given above -

$$C = \lambda\nu$$

Refractive Index

The frequency of vibration ν, remains constant when the light passes through a substance. Thus, if the velocity, C, is reduced on passage through a substance, the wavelength, λ, must also decrease.

***Refractive index*, n, of a material or substance as the ratio of the speed of light in a vacuum, C, to the speed of light in a material through which it passes, C_m.**

$$n = C/C_m$$

Note that the value of refractive index will always be greater than 1.0, since C_m can never be greater than C. In general, C_m depends on the density of the material, C_m decreasing with increasing density. Thus, higher density materials will have higher refractive indices.

The refractive index of any material depends on the wavelength of light because different wavelengths are interfered with to different extents by the atoms that make up the material. In general refractive index varies linearly with wavelength.

Snell's Law

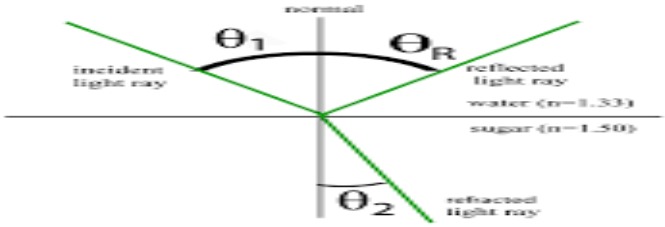
Refraction is described by Snell's Law:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

***n* = 1 in a vacuum and**

***n* > 1 in a transparent substance.**

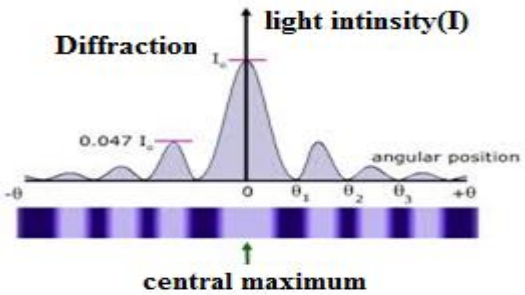
- **The refracted angle may be larger or smaller than the incident angle**
- **The incident angle and the reflected angle are equal.**

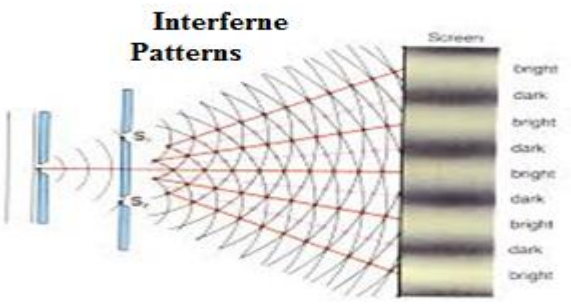


2- Behaviors of Light

Light behaves both as a wave and a particle.

a. As a wave, it produces interference and diffraction.





b. As a particle it can be absorbed by a single molecule.

- **When a light photon is absorbed its energy is used in a various way. It can cause a chemical change in the molecule that in turn can cause an electrical change (as in a sensitive cells of the retina).**

The chemical point of the retina triggers an electrical signal to the brain to inform it that a light photon has been absorbed at that point

- **When light is absorbed, its energy generally appears as heat. This property is the basis for the use IR light to heat tissues.**
- **Also the heat produced by laser beams is used to weld a detached retina to the back of eyeball and to coagulate small blood vessels in retina.**

- **Sometime when a light photon is absorbed, a lower energy light photon is emitted. This property is known as fluorescence.**

3. **Light reflected to some extent from all surfaces. There are two types of reflection**

A- Diffuse reflection: occurs when rough surface scatter the light in many directions.

B- Specular reflection: it is obtained from very smooth surface such as mirrors where the light is reflected at angle that is equal to the angle at which it strikes the surface.

Mirrors are used in many medical instrument.

One simple instrument is a mirror that is held at the back of a patient's throat to look at his vocal folds.

Applications of visible light in medicine

1. **An obvious use of visible light in medicine is to permit the physician to obtain visual information about the patient regarding, for example, the color of his skin and the presence of abnormal structures in or on his body. For example;**
   (Shine light into the bodies of infants (Collapsed lung , Water – head)) .
2. **Light therapy or phototherapy consists of exposure to daylight or to specific wavelengths of light using lasers, LEDs, fluorescent lamps, dichroic lamps or very bright, full-spectrum light, for a prescribed amount of time and, in some cases, at a specific time of day. It has proven effective in treating several diseases. Light therapy is used to bring down the level of bilirubin in jaundiced newborns, light therapy can be used as a non-invasive treatment for pain relief**

- **Normal light to examine the skin, Ophthalmoscope for looking into eyes, the otoscope for looking into ears , Endoscope.**

Applications of UV light in medicine

- **UV produces more reaction in the skin some of these reactions are beneficial, and some are harmful.**
- **One of the major beneficial effect of UV light from the sun is the conversion of molecular products in the skin into vitamin D.**
- **UV light from the sun effects the melanin in the skin to cause tanning, and can produce sunburn as well as tan the skin at wavelengths around 300nm.**
- **Solar UV is also the major cause of skin cancer in humans because very well absorbed by the DNA in the cell.**
- **UV light cannot be seen by the eye because it is absorbed before it reaches the retina.**
- **The ultraviolet light used to kill microorganisms.**
- **The medical industry uses ultraviolet light to sterilize rooms, equipment and medical instruments. It is also used as a medical treatment.**

Applications of IR in medicine

About half of the energy from the sun is in the IR region. When the people looking at the sun during a solar eclipse they have damaged their eye.

- **Heat lamps that produce a large percentage of IR light with wavelengths of 1000 to 2000 nm are often used for physical therapy purposes.**
- **IR light penetrates further into the tissues than visible light and thus is better able to heat deep tissues.**
- **Infrared thermal-imaging cameras are used to detect heat loss in insulated systems, to observe changing blood flow in the skin,**
- **Near-infrared light, or photobiomodulation, is used for treatment of chemotherapy-induced oral ulceration as well as wound healing.**

- **Strong infrared radiation in certain industry high-heat settings may be hazardous to the eyes, resulting in damage or blindness to the user.**
- **One way fluorescence is used in medicine is in the detection of porphyria, a condition in which the teeth fluoresce red when irradiated with UV light.**
- **Another important application is in fluorescent microscopes**
  - **To identify structures in fixed and live biological samples.**
  - **Fluorescence microscopy is a common tool for today's life science research because it allows the use of multicolor staining, labeling of structures within cells, and the measurement of the physiological state of a cell.**