BM-3252 MEDICAL PHYSICS

UNIT-1

1.1 PHYSICS OF LIGHT

- Light propagated through space and exhibited the properties of electromagnetic radiation. The wavelength of EM radiation ranges from 10^{-14}m to about 10^{8}m. Visible light occupies only a narrow band from about 400-700nm.
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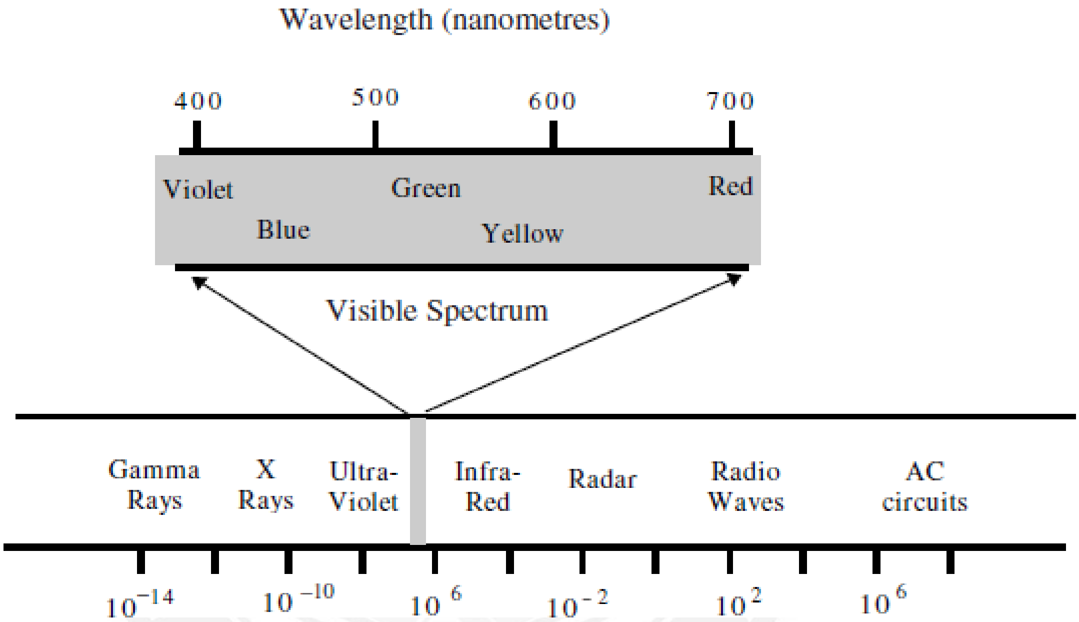


Fig 1.1

Speed of light

- The speed at which light travels in a vacuum is approximately 3×10^{8} m s^{-1}, or 186000 miles per second. Its speed in a transparent medium is always less than this, and the ratio of the speed in vacuum to that in the medium is known as its index of refraction.

$$n = \text{index of refraction} = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}} = \frac{c}{v}.$$

Table 3.4. *Typical index of refraction of some common media.*

Medium	Index of refraction
Air	1.0003
Water	1.3
Glass	1.5

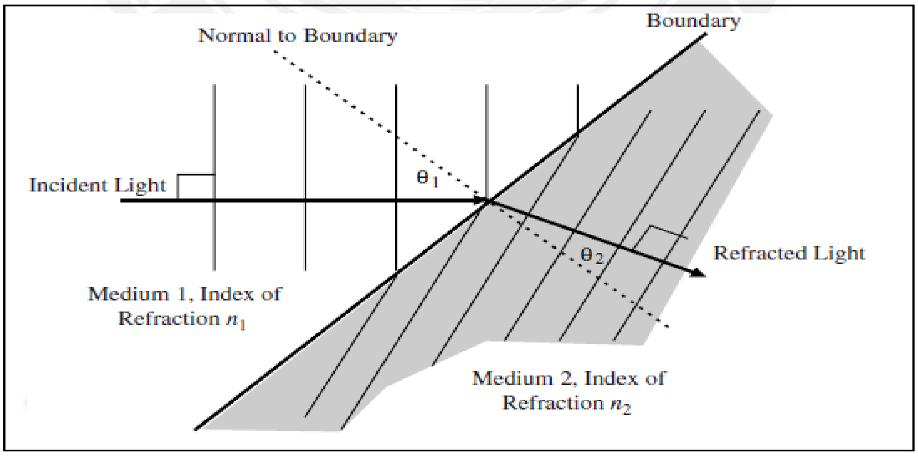
Refraction and Reflection at boundary

- When light travels from one medium into another its frequency cannot change but its velocity must. The wavelength changes to accommodate the change in velocity.
- At a fixed frequency, wavelength is proportional to speed and therefore the ratio of the wavelength in vacuum to the wavelength in a medium is also equal to the index of refraction.
- If the light meets a boundary at an oblique angle then its direction must change if the wavelength is to change by the appropriate factor.
- The angle through which the light is refracted can be calculated from simple geometry, and the relationship between the angle of incidence and the angle of refraction

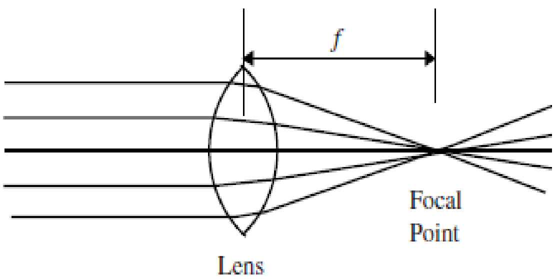
is determined by Snell's law

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

- The relative intensities of the incident, reflected and refracted light depend on the properties of the media and on the angle of incidence.
- If the angle at which the light strikes its surfaces is greater than the critical angle, it is called total internal reflection.



- A consequence of Snell's law is that a spherical boundary will focus parallel light rays onto a single point.
- This property is the basis of the geometrical optics of the eye, and of our design of corrective optical devices for defective vision.



- Two portions of spherical boundaries, as represented by a simple biconvex lens, will also focus parallel incident light rays to a point.

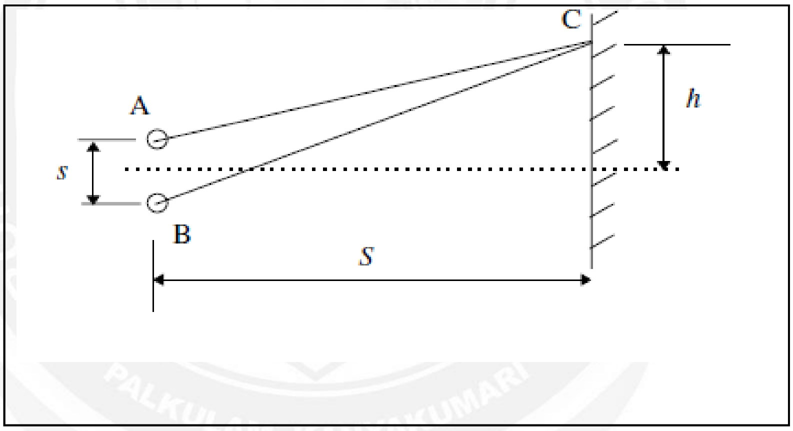
- If the index of refraction of the material of a thin lens is n2 and that of the surrounding medium is n1, the focal length, f, of the lens is given by

$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_a} - \frac{1}{R_b}\right)$$

- where Ra is the radius of curvature of the first surface of the lens and Rb is that of the second surface, measured from the same side of the lens. This equation is known as the lens-makers' equation.

Interference of light waves

- Light waves interact and interfere with each other in just the same way as do sound waves. The relative phase of the waves determines whether the interference is



constructive, increasing the intensity, or destructive, reducing the intensity.

- The point sources are at A and B, and they are separated by a distance s. A screen is placed parallel to and at a distance S from the line connecting the two sources.

- Light falling at a point C on the screen has to travel a different distance from each source.

- From simple geometry, assuming that the distance of the screen from the sources is large compared to all other distances, the difference in lengths of the paths BC and AC is

$$\delta = \mathrm{BC} - \mathrm{AC} \approx \frac{hs}{S}.$$

- There will be constructive interference when this distance represents a whole number of wavelengths of the light. Hence the conditions for constructive interference are

$$\frac{hs}{S} = n\lambda.$$

- This implies that the distance between bright peaks will be $S\lambda/s$. Dark troughs corresponding to destructive interference lie half-way between the bright peaks.

Diffraction

- The spreading of the light from the slit is called diffraction, and the pattern of fringes on the screen is the diffraction pattern.
- The width of the bright central fringe can be taken as a measure of the diffraction. The half-angle, θ, at which the beam appears to diverge can be approximated by the relationship

$$\theta = \sin^{-1}\left(\frac{\lambda}{w}\right)$$

- where λ is the incident wavelength and w is the width of the slit.
- Complete diffraction occurs when the width of the slit approaches the wavelength of the incident wave.
- The physical process of diffraction does have consequences for our acuity of vision. The pupil is an aperture of finite size, and diffraction occurs as light passes through it.
- Consequently, there will always be some diffusion of the intensity of ‘a light ray’ about the nominal point at which it strikes the retina.
- Diffraction at a circular aperture produces a similar effect, but with rings rather than parallel fringes.