8. Refraction of Light

Refraction

- It is the phenomenon of the change in the path of light when it passes from one medium to another.
- Refractive index:
    - Absolute refractive index of a medium = velocity oflight in vacuumvelocity of light in the medium
    - Refractive index of medium 1 with respect to medium 2 is equal to the reciprocal of the refractive index of medium 1 with respect to medium 2.
    - According to principle of reversibility, the path of light is reversible.
- Laws of refraction:
    - On going from a rarer medium to a denser medium, a ray bends towards the normal.
    - On going from a denser medium to a rarer medium, a ray bends away from the normal.

Snell's law (for interface between medium 1 and 2)**:**

μ12=μ2μ1=sin isin r

- On account of refraction of light, a tank of water appears to be less deep than it actually is.
    - μ=real depthapparent depth, where μ is refractive index of water with respect to air.
- **Condition for total internal reflection:**

If a ray of light travelling from an optically denser medium to an optically rarer medium is incident at an angle greater than the critical angle for the pair of media in contact, the ray is totally reflected back into the denser medium, thereby causing total internal reflection.

μba=1sinC

- **Applications of total internal reflection:**

Multiple internal reflections in diamond ($i_c \cong 24.4°$), totally reflecting prisms and mirage are some examples of total internal reflection.

Optical fibres

- Optical fibres consist of glass fibres coated with a thin layer of material with a lower refractive index 1.5; this is called **cladding**.
- The central part of the fibres,called **core**, is made up of material with refractive index 1.7.
- Any light that is incident at an angle at one end comes out from the other after multiple internal reflections, even if the fibre is bent.
- Optical fibres are used for transmitting audio and video signals to long distances.
- They are used in endoscopes for medical examinations of inner parts of the body of a patient.

Refraction through a Prism

- When light passes through a prism , it suffers two refractions .
- The net deviation suffered by the ray when it passes through the prism of angle *A* is given by *δ*.
- Relation between the angle of incidence *i* , angle of emergence *e*, the angle of prism and the net deviation is given by $A+\delta=i+e$.
- The deviation of the light ray through the prism is minimum when angle of incidence (i) is $i=A+\delta m2$.
  - For the minimum deviation, angle of incidence at both the surfaces of the prism are equal.
- The prism formula is given as $\mu=\sin(A+\delta m)/2\sin A/2$.

  where δ_m is the minimum deviation of the light when passed through prism.

Factors affecting angle of deviation

- Angle of incidence (*i*)
- Angle of prism (*A*)
- Refractive index (μ) of the material of the prism
- Colour or wavelength (λ) of light

Dispersion through Prism

- It is the phenomenon of splitting of light into its constituent colours.
- A band of seven colours is obtained; it is known as visible spectrum.
- The reason for the dispersion is the difference in the refractive index of components of different wavelengths.
  - The component with less wavelength bends more.
  - The component with high wavelength bends less.

Scattering of Light

- Scattering of light takes place when the size of the scattering object is smaller compared to the wavelength of the light.
- Amount of scattering: $\propto \frac{1}{\lambda^4}$
- Blue colour has the smallest wavelength in the visible range, so it has the maximum scattering.
- The blue colour of sky is because of the scattering of blue light by the air molecules in the Earth's atmosphere. Blue light gets scattered very easily because of its shorter wavelength.
- At sunrise or sunset, the Sun looks almost reddish. This is because at the time of sunset or sunrise, the Sun is near the horizon. Blue- and violet-coloured rays are scattered in a large amount than the red-coloured rays.

Angular Dispersion

- Angular dispersion of two extreme colours violet and red:

$$\delta_v - \delta_r = A(\mu_v - \mu_r)$$

Dispersive Power

- Dispersive power of a prism:

$$\omega=\mu v-\mu r \ \mu y-1$$

• When a beam of light is passed through organic liquids, like benzene, toluene, etc., the scattered light is found to be no longer monochromatic. The scattered light has higher and lower frequencies in addition to the frequency of the incident light. This phenomenon is known as the Raman effect.