CHAPTER - 9

RAY OPTICS AND OPTICAL INSTRUMENTS

SYNOPSIS :

- Reflection is governed by the equation $\angle i = \angle r'$ and refraction by the Snell's law,

  $$\frac{\sin i}{\sin r} = n$$

  Where, i = incident ray
  r' = reflected ray
  r = refracted ray

  It normally lies in the same plain. Angle of incidence, reflection and refraction are i, r' and r respectively.

- The critical angle of incidence i_c for a ray incident from a denser to rarer medium, is that angle for which the angle of refraction is 90°.

- **New Cartesian sign conventions :**
  (1) All distances are measured from pole of spherical mirror.
  (2) The distances measured in the direction of incidence of light are taken as positive and vice-versa.

(3) The heights measured upwards and perpendicular to the mirror are taken as positive and vice-versa.

- **Mirror equation :**

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

Where u and v are object and image distance, respectively.

(1) f is the focal length of the mirror.

(2) f is (approximately) half the radius of curvature.

(3) f is negative for concave mirror, f is positive for convex mirror.

- μ is refractive index of material of prism, then Snell's law

$$\mu = \frac{\sin\ i}{\sin\ r} = \frac{\sin\ (A + \delta m)/2}{\sin\ A/2}$$

Where, δm is the angle of minimum deviation.

- For refraction through a spherical interface (from medium 1 to 2 of refractive index n_1 and n_2, respectively)

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

(1) Thin lens formula

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

(2) Lens maker's formula

$$\frac{1}{f} = \frac{(n_2 - n_1)}{n_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

R_1 and R_2 are the radii of curvature of the lens surfaces.

(3) The power of a lens,

$$P = \frac{1}{f}$$

The SI unit for power of a lens is dioptre (D)

$1D = 1m^{-1}$

(4) If several thin lenses of focal length f_1, f_2, f_3 ... are in contact, the effective focal length of their combination, is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \ldots\ldots\ldots$$

(5) The total power of a combination of several lenses is,

$$P = P_1 + P_2 + P_3 + \ldots..$$

- Dispersion is the splitting of light into its constituent colours.

- **The eye :** The eye has a convex lens of focal length 2.5 cm. This focal length can be varied somewhat. So, that the image is always formed on the retina. This ability of the eye is called 'accommodation'.

  (1) In a defective eye, if the image is focused before the retina (myopia), a diverging corrective lens is needed.

  (2) If the image is focused beyond the retina (hypermetropia), a converging corrective lens is needed.

  (3) Astigmatism is corrected by using cylindrical lenses.

- Magnifying power m of a simple microscope is given by

$$m = 1 + \frac{D}{f}$$

Where D = 25 cm is the least distance of distinct vision

f = is the focal length of the convex lens.

(1) The image is at infinity,

$$m = \frac{D}{f}$$

for the compound microscope.

(2) The magnifying power is given by

$$m = m_e \times m_o$$

Where $m_e = 1 \times D / f_e$, is the magnification due to the eye piece m_o = is the magnification produced by the objective

$$m = \frac{L}{f_o} \times \frac{D}{f_e}$$

Where, f_o and f_e are the focal lengths of the objective and eye piece respectively. L is the distance between their focal points.

- Magnifying power m of a telescope is the ratio of the angle β subtended at the eye by the image to the angle α subtended at the eye by the object.

$$m = \frac{\beta}{\alpha} = \frac{f_o}{f_e}$$

f_o = the focal length of object

f_e = the focal length of eye piece.

- **Refraction :** The phenomenon of change in path of light as it goes from one medium to another.

- **Laws of refraction :**

  (1) The **incident ray**, the normal to the refracting **surface of the point of incidence** and the **refracted ray** all **lie in the same plane.**

  (2) The ratio of sine of the angle of incidence to the sine of the angle of refraction is constant for any two given media.

  $$\frac{\sin i}{\sin r} = n$$

  (n = relative refractive index)