B.Sc. Part (II) Hons.

optics

Brewster's law :→ "The tangent to the angle of polarisation for a given medium is numerically equal to the refractive index of the medium."

i.e. $\boxed{\mu = \tan i_p}$

This is called Brewster's law. He also found an interesting result. At the polarising angle the reflected and refracted rays are perpendicular to each other. To show this let a beam of unpolarised light be incident at an angle equal to the polarisation angle of the surface of a transparent substance. The beam is reflected along in one direction and refracted along other direction. Let 'r' be the angle of refraction.

From Brewster's law we have

$$\mu = \tan i_p = \frac{\sin i_p}{\cos i_p} \quad \text{---------} \quad (i)$$

From snell's law, we have

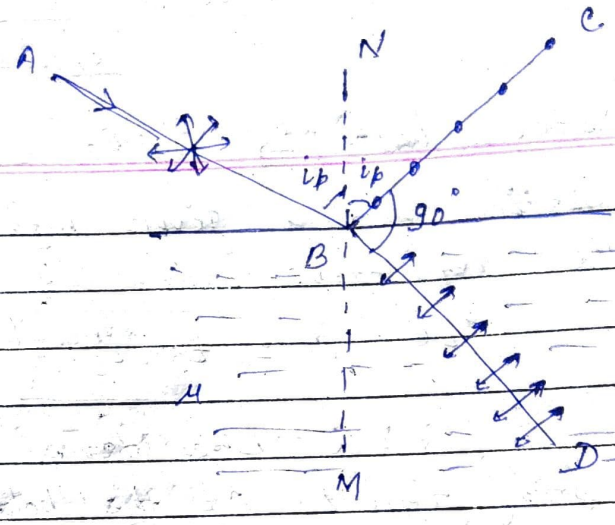
$$\mu = \frac{\sin i_p}{\sin r} \quad \text{---------} \quad (ii)$$

comparing (i) & (ii), we get

$$\cos i_p = \sin r = \cos\left(\frac{\pi}{2} - r\right)$$

$$\therefore i_p = \frac{\pi}{2} - r$$

or, $i_p + r = \frac{\pi}{2}$ ..... (iii)



We know that $\angle NBM = \pi$

$\therefore \quad i_p + \angle CBD + r = \pi$

or, $\angle CBD + (i_p + r) = \pi$

$\therefore \quad \angle CBD = \pi/2 \quad$ (using iii)

Thus when the ray is incident at polarising angle the reflected and refracted rays are perpendicular to each other.

Numerical :

Q → A ray of light is incident on the surface of a glass plate of refractive index 1.732 at the polarising angle. Calculate the angle of refraction of the rays.

Ans → According to Brewster's law, we know that

$$\mu = \tan i_p$$

Here $\mu = 1.732$, $\therefore 1.732 = \tan i_p$

or, $i_p = \tan^{-1} 1.732$

$= \tan^{-1} \sqrt{3}$

$= 60°$

If γ is the angle of refraction, we have

$$\gamma + r_p = 90^\circ$$

$$\therefore \gamma = 90^\circ - i_p$$

$$= 90^\circ - 60^\circ$$

$$\therefore \gamma = 30^\circ \quad \text{Ans.}$$

29 → A beam of light travelling in water strikes a glass plate which is also immersed in water. When the angle of incidence is 51°, the reflected beam is found to be plane polarised. calculate the refractive index of glass. (r.I. of water = $\frac{4}{3}$).

Ans → By Brewster's law $\mu = \tan i_p$

Here $i_p = 51^\circ$ and the beam of light is travelling from water to glass.

$\therefore$ r.i. of glass w.r. to water

$$_w\mu_g = \tan i_p = \tan 51^\circ = 1.235$$

Also, $_w\mu_g = \frac{\mu_g}{\mu_w}$

$\therefore$ Refractive index of glass, $\mu_g = \mu_w \times {}_w\mu_g$

$$= \frac{4}{3} \times 1.235$$

$$= 1.646 \quad \text{Ans.}$$