

1. By Brewster's law $\mu = \tan i_p \Rightarrow \frac{c}{v} = \tan 60^\circ = \sqrt{3}$

$$\Rightarrow v = \frac{c}{\sqrt{3}} = \frac{3 \times 10^8}{\sqrt{3}} = \sqrt{3} \times 10^8 \text{ m/sec}$$

2. By Malus law, $I = I_0 \cos^2 \theta$

Given, $I_0 = 3.3 \text{ W/m}^2$, $\omega = 31.4 \text{ rad/s}$

Area of cross section

$$A = 3 \times 10^{-4} \text{ m}^2$$

$$\therefore I_{\text{av}} = \int_0^{2\pi} I_0 \cos^2 \theta d\theta = \frac{I_0}{2}$$

$$\text{Energy } E = I_{\text{av}} \times A \times T = I_{\text{av}} \times A \times \frac{2\pi}{\omega}$$

$$= \frac{3.3}{2} \times 3 \times 10^{-4} \times \frac{2 \times 3.14}{31.4} = 0.99 \times 10^{-4} \text{ J} \approx 1.0 \times 10^{-4} \text{ J}$$

3. By Malus Law, $I = I_0 \cos^2 \theta \dots (i)$

From statement, $I = 10\% I_0 = \frac{I_0}{10}$

Using value of I in eqn. (i), we get

$$\frac{I_0}{10} = I_0 \cos^2 \theta \Rightarrow \cos \theta = \frac{1}{\sqrt{10}} = 0.31 \Rightarrow \theta = 71.6^\circ$$

$$\text{Angle rotated should be} = 90^\circ - 71.6^\circ = 18.4^\circ$$

4. $\mu = \tan \theta_p$

$$1.732 = \tan \theta_p$$

$$\Rightarrow \theta_p = \tan^{-1}(1.732) = 60^\circ$$

Since the angle between i_p and r is 90° when the ray is incident at polarizing angle, then

$$\theta_p + r = 90^\circ$$

$$r = 90 - \theta_p = 90^\circ - 60^\circ = 30^\circ$$

5. Polarizers A and B are oriented with parallel pass axis. Suppose polarizer C is at angle θ with A then it also makes angle θ with B,

$$\text{Using Malus' law, } I_C = \left(\frac{I}{2} \cos^2 \theta \right)$$

$$\text{and } I_B = I_C \cos^2 \theta = \frac{I}{2} \cos^4 \theta$$

$$\frac{I}{8} = \frac{I}{2} \cos^4 \theta \left(\because I_B = \frac{I}{8} \right)$$

$$\cos^4 \theta = \frac{1}{4} = \frac{1}{(\sqrt{2})^4}; \cos \theta = \frac{1}{\sqrt{2}} = \cos 45^\circ$$

$$\text{So, } \theta = 45^\circ$$

6. At polarizing angle, the reflected and refracted rays are mutually perpendicular to each other.
7. Polarizers A and B are oriented with parallel pass axis. Suppose polarizer C is at angle θ with A then it also makes angle θ with B.

By Malus' law,

$$I_C = \left(\frac{I}{2} \cos^2 \theta \right) \text{ and } I_B = I_C \cos^2 \theta = \frac{I}{2} \cos^4 \theta$$

$$\frac{I}{3} = \frac{I}{2} \cos^4 \theta \left(\because I_B = \frac{I}{3} \right)$$

$$\cos^4 \theta = \frac{2}{3}; \cos \theta = \left(\frac{2}{3} \right)^{\frac{1}{4}}$$

8. When a polaroid rotated through 30° with respect to beam A, then beam B is at 60° with it.

$$\text{So, } I_A \cos^2 30^\circ = I_B \cos^2 60^\circ$$

$$\Rightarrow I_A \left(\frac{3}{4} \right) = I_B \left(\frac{1}{4} \right) \Rightarrow \frac{I_A}{I_B} = \frac{1}{3}$$

9. Intensity of light after passing polaroid A is

$$I_1 = \frac{I_0}{2}$$

Now this light will pass through the second polaroid B whose axis is inclined at an angle of 45° to the axis of polaroid A. So by Malus law, the intensity of light emerging from polaroid B is

$$I_2 = I_1 \cos^2 45^\circ = \left(\frac{I_0}{2} \right) \left(\frac{1}{\sqrt{2}} \right)^2 = \frac{I_0}{4}$$

10. Intensity of polarized light = $I_0/2$

$$\text{Intensity of light not transmitted} = I_0 - \frac{I_0}{2} = \frac{I_0}{2}$$

11. By Brewster's law of polarization,

$$n = \tan i_p \text{ where } i_p \text{ is angle of incidence}$$

$$\therefore i_p = \tan^{-1}(n)$$