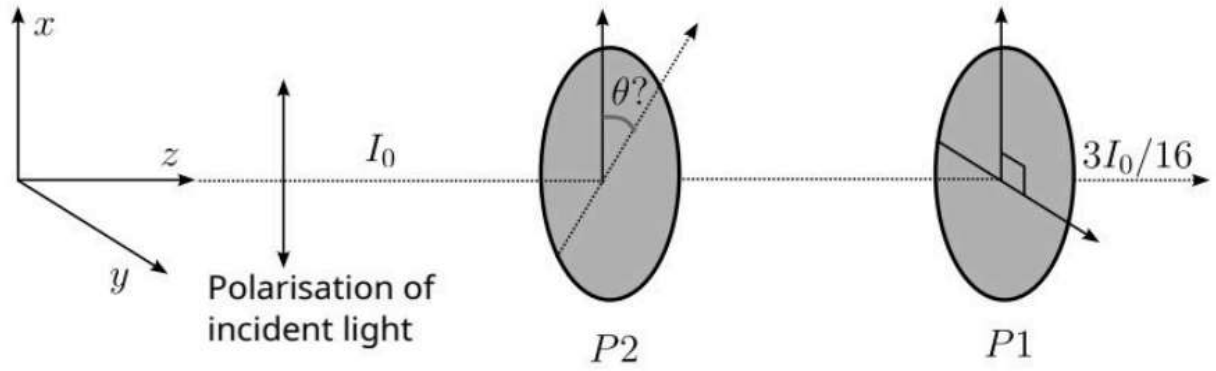
Wave Optics

Question1

A source produces a light beam of intensity I_0 polarized along the x-direction. The beam is sent along the z-direction. It enters a polaroid $P1$ with its polaroid axis aligned along the y-direction so that no light exits the polaroid. When another polaroid $P2$ is placed in between the source and $P1$, the intensity measured after $P1$ is $3I_0/16$. Which among the following is a possible value of θ, the angle of the polaroid axis measured from the x-axis?



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Options:

A.

60°

B.

15°

C.

45°

D.

75°

Answer: C

Solution:

Step 1: Understanding the Problem

The light initially polarized along the x-axis passes through polaroid P_2, which is oriented at an angle θ from the x-axis. The intensity after passing through polaroid P_1 is given as $\frac{3I_0}{16}$.

Step 2: Applying Malus' Law

Malus' Law tells us that when a light beam passes through a polaroid, the intensity I of the transmitted light is related to the initial intensity I_0 and the angle θ between the light's polarization and the polaroid's axis:

$$I = I_0 \cos^2(\theta)$$

First, after the light passes through P_2:
Since the intensity of light after passing through P_2 is measured, the intensity is:

$$I_2 = I_0 \cos^2(\theta)$$

Next, the intensity after P_1:
We are given that after P_1, the intensity is $\frac{3I_0}{16}$. This implies:

$$I_2 = \frac{3I_0}{16}$$

Step 3: Solving for θ

From the above, we can equate the two expressions for intensity:

$$I_0 \cos^2(\theta) = \frac{3I_0}{16}$$

Since I_0 appears on both sides, we can cancel it out:

$$\cos^2(\theta) = \frac{3}{16}$$

Step 4: Take the Square Root of Both Sides

To solve for θ, take the square root of both sides:

$$\cos(\theta) = \sqrt{\frac{3}{16}} = \frac{\sqrt{3}}{4}$$

Now, take the inverse cosine (arccos) to find θ:

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

Step 5: Final Calculation

Using a calculator to find θ:

$$\theta \approx 48.85^\circ$$

Step 6: Conclusion

The closest answer to 48.85° is **45°**, so the correct answer is **C) 45°**.
