NCERT 12.10 5Q

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Question: In Young's double-slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ, is K units. What is the intensity of light at a point where path difference is $\lambda/3$?

Solution:

Given,

Path difference = λ

Let I_1 and I_2 be the intensity of two coherent waves. The resultant intensity is given by:

$$I_{net} = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

Here, ϕ is the phase difference between two light waves.

Intensities are equal for monochromatic light waves.

$$I_1 = I_2$$

$$\therefore I_{net} = I_1 + I_1 + 2\sqrt{I_1 I_1}\cos\phi$$

$$I_{net} = 2I_1 + 2I_1\cos\phi$$

$$\because I_{net} = K$$

$$\mathrm{K} = 2I_1 + 2I_1\cos\phi$$

We know that,

Phase difference $= \frac{2\pi}{\lambda}$ x Path difference

$\because$ path difference = λ

$$\phi = \frac{2\pi}{\lambda} \text{ x } \lambda$$

Phase difference = $\phi = 2\pi$

$$\therefore K = 2I_1 + 2I_1\cos 2\pi$$

$$\mathrm{K} = 4I_1$$

$$\therefore I_1 = \frac{K}{4}$$

When path difference = $\frac{\lambda}{3}$

Phase difference = $\phi = \frac{2\pi}{3}$

Hence,

Resultant intensity,

$$I_R = 2I_1 + 2\sqrt{I_1 I_1}\cos\frac{2\pi}{3}$$

$$I_R = 2I_1 + 2I_1\left(\frac{-1}{2}\right)$$

$$I_R = I_1$$

From the above result,

$$I_1 = \frac{K}{4}$$

$$\therefore I_R = \frac{K}{4}$$

Hence, the Intensity of light at a point where path difference is $\frac{\lambda}{3}$ is $\frac{K}{4}$ units.