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:

Parameter	Description	Value
$y_i(t)$	Equation of light from $S_{i^{\text{th}}}$	$A\sin(\omega t - kx_i)$
I_{res}	Intensity of light at $\Delta x = \lambda$	K
k	Wave number	$\frac{2\pi}{\lambda}$
I	Intensity of wave	kA^2
$\Delta x = x_1 - x_2$	Path difference	λ
		$\frac{\lambda}{3}$

TABLE 1
Parameters

The superposition of the two waves is the sum of two individual waves:
From table (1) $\implies$

$$y(t) = A\sin(\omega t - kx_1) + A\sin(\omega t - kx_2) \tag{1}$$

$$y(t) = 2A\cos\left(\frac{k\Delta x}{2}\right)\sin\left(\omega t - \frac{k(x_1 + x_2)}{2}\right) \tag{2}$$

From table (1) & equation(2) $\implies$

$$\therefore I_{res} = 4I_o\cos^2\left(\frac{k\Delta x}{2}\right) \tag{3}$$

From table(1)& equation(3) $\implies$
(i) When $\Delta x = \lambda$:

$$K = 4I_1\cos^2\left(\frac{2\pi}{2}\right) \tag{4}$$

$$\therefore I_1 = \frac{K}{4} \tag{5}$$

(ii) When $\Delta x = \frac{\lambda}{3}$:

$$I_r = 4I_1\cos^2\left(\frac{2\pi}{3}\right) \tag{6}$$

From equation (5) $\implies$

$$\therefore I_r = I_1 = \frac{K}{4} \tag{7}$$

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

Parameter	Description	Value
I_1	Intensity of light at individual slits	$\frac{K}{4}$
I_r	Net Intensity of light at $\Delta x = \frac{\lambda}{3}$	$\frac{K}{4}$

TABLE 2
Intensities