656.

Problem 46.11 (RHK)

Monochromatic light with wavelength 538 nm *falls on a slit of width* $25.2\ \mu\text{m}$. *The distance from the slit to a screen is* 3.48 m. *We consider a point on the screen* 1.13 cm *from the central maximum*. (a) *We have to calculate* θ; (b) α; (c) *and the ratio of the intensity at this point to the intensity at the central maximum*.

Solution:

(a)

The distance D of the screen from the slit is 3.48 m. That is

$D = 3.48\ \text{m}$.

The angle θ subtended by the point P at a distance 1.13 cm from the central maximum on the screen with the line joining the midpoint of the slit with the screen normally will be approximately given by

$$\theta = \frac{1.13\times10^{-2}}{3.48}\ \text{rad} = 3.25\times10^{-3}\ \text{rad}$$

$$= 0.186^{0}.$$

(b)

If the slit width is denoted by a and the wavelength of the light used for producing the diffraction pattern is denoted by λ, the variable α ,which determines the intensity of diffraction, is defined as

$$\alpha = \frac{\pi a \sin\theta}{\lambda} .$$

The wavelength of the monochromatic light used in the experiment is $\lambda = 538 \text{ nm}$. Therefore, the value of α at the point *P* on the screen will be

$$\alpha = \frac{\pi a \sin\theta}{\lambda} = \frac{\pi \times 25.2 \times 10^{-6} \times \sin\left(0.186^0\right)}{538 \times 10^{-9}} \text{ rad}$$

$$= \frac{\pi \times 25.2 \times 10^{-6} \times 3.25 \times 10^{-3}}{538 \times 10^{-9}} \text{ rad}$$

$$= 0.478 \text{ rad.}$$

(c)

The intensity at a point *P* subtending an angle θ relative to the intensity of the central maximum is given by the relation

$$\frac{I_\theta}{I_0} = \left(\frac{\sin\alpha}{\alpha}\right)^2 = \left(\frac{\sin 0.478}{0.478}\right)^2 = 0.926.$$