Answer on Question #65194, Physics / Optics

A plane light wave of wavelength 580 nm falls on a long narrow slit of width 0.5 mm. (i) Calculate the angles of diffraction for the first two minima. (ii) How are these angles influenced if the width of slit is changed to 0.2 mm? (iii) If a convex lens of focal length 0.15 m is now placed after the slit, calculate the separation between the second minima on either side of the central maximum.

Solution:

The general condition for a minimum for a single slit is:

$$m\lambda = a\sin\theta$$

where m = 1, 2, 3, 4 and so on

- *a* is the width of the slit,
- θ is the angle of incidence at which the minimum intensity occurs, and
- λ is the wavelength of the light

(i)

The angle of diffraction for the first minimum:

$$\theta_1 = \sin^{-1}\left(\frac{\lambda}{a}\right) = \sin^{-1}\left(\frac{580\times10^{-9}}{0.5\times10^{-3}}\right) = \mathbf{0.0665^\circ}$$

The angle of diffraction for the second minimum:

$$\theta_1 = \sin^{-1}\left(\frac{2\lambda}{a}\right) = \sin^{-1}\left(\frac{2\times580\times10^{-9}}{0.5\times10^{-3}}\right) = \mathbf{0.1329^\circ}$$

(ii)

The angle of diffraction for the first minimum:

$$\theta_1 = \sin^{-1}\left(\frac{\lambda}{a}\right) = \sin^{-1}\left(\frac{580\times10^{-9}}{0.2\times10^{-3}}\right) = \mathbf{0.1662^\circ}$$

The angle of diffraction for the second minimum:

$$\theta_1 = \sin^{-1}\left(\frac{2\lambda}{a}\right) = \sin^{-1}\left(\frac{2\times580\times10^{-9}}{0.2\times10^{-3}}\right) = \mathbf{0.3323^\circ}$$

(iii) Distance of nth secondary minima from central maxima

$$y_n = \frac{n\lambda f}{a}$$

where f is focal length of converging lens.

$$y_2 = \frac{2\times580\times10^{-9}\times0.15}{0.2\times10^{-3}} = 0.87\times10^{-3}\text{ m}$$

Thus, the separation between the second minima on either side of the central maximum is

$$\Delta y = 2y_2 = \mathbf{1.74\times10^{-3}\ m}$$