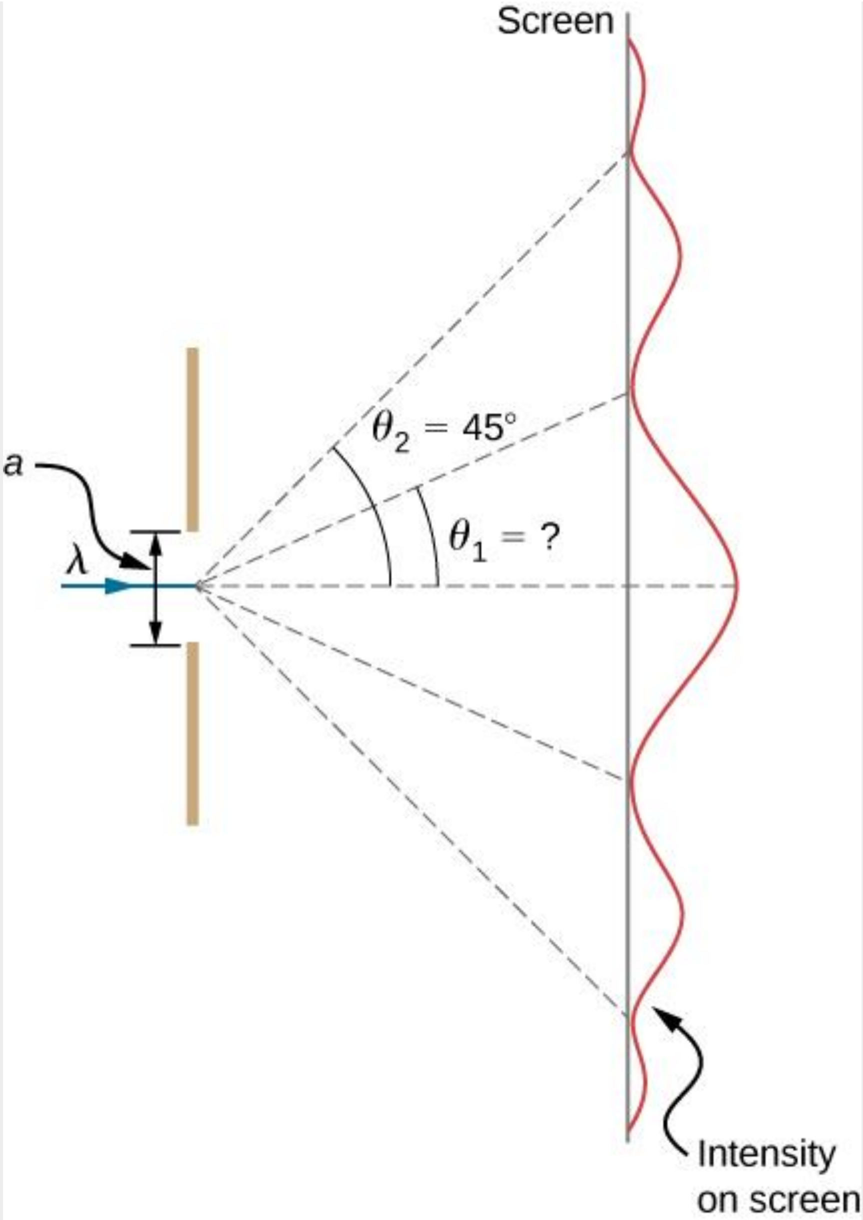
Related Problems

Visible light of wavelength 550 nm falls on a single slit and produces its second diffraction minimum at an angle of $45.0°$ relative to the incident direction of the light, as in Figure 4.6. (a) What is the width of the slit? (b) At what angle is the first minimum produced?



Solution

a. We are given that $\lambda=550nm$, $m=2$, and $\theta_2=45.0°$. Solving the equation $a\sin\theta=m\lambda$ for *a* and substituting known values gives

$$a = \frac{m\lambda}{\sin\theta_2} = \frac{2(550\,\text{nm})}{\sin 45.0°} = \frac{1100 \times 10^{-9}\,\text{m}}{0.707} = 1.56 \times 10^{-6}\,\text{m}.$$

b. Solving the equation $a\sin\theta = m\lambda$ for $\sin\theta_1$ and substituting the known values gives

$$\sin\theta_1 = \frac{m\lambda}{a} = \frac{1(550 \times 10^{-9}\,\text{m})}{1.56 \times 10^{-6}\,\text{m}}.$$

Thus the angle θ_1 is

$$\theta_1 = \sin^{-1} 0.354 = 20.7°.$$

Significance

We see that the slit is narrow (it is only a few times greater than the wavelength of light). This is consistent with the fact that light must interact with an object comparable in size to its wavelength in order to exhibit significant wave effects such as this single-slit diffraction pattern. We also see that the central maximum extends $20.7°$ on either side of the original beam, for a width of about $41°$. The angle between the first and second minima is only about $24°$ $(45.0° - 20.7°)$. Thus, the second maximum is only about half as wide as the central maximum.