1. (a) We use Eq. 36-3 to calculate the separation between the first $(m_1 = 1)$ and fifth $(m_2 = 5)$ minima:

$$\Delta y = D\Delta \sin \theta = D\Delta \left(\frac{m\lambda}{a}\right) = \frac{D\lambda}{a} \Delta m = \frac{D\lambda}{a} (m_2 - m_1).$$

Solving for the slit width, we obtain

$$a = \frac{D\lambda(m_2 - m_1)}{\Delta y} = \frac{(400 \text{ mm})(550 \times 10^{-6} \text{ mm})(5-1)}{0.35 \text{ mm}} = 2.5 \text{ mm} .$$

(b) For $m = 1$,
$$\sin \theta = \frac{m\lambda}{a} = \frac{(1)(550 \times 10^{-6} \text{ mm})}{2.5 \text{ mm}} = 2.2 \times 10^{-4} .$$

The angle is $\theta = \sin^{-1} (2.2 \times 10^{-4}) = 2.2 \times 10^{-4}$ rad.

7. The condition for a minimum of a single-slit diffraction pattern is

 $a\sin\theta = m\lambda$

where *a* is the slit width, λ is the wavelength, and *m* is an integer. The angle θ is measured from the forward direction, so for the situation described in the problem, it is 0.60° for m = 1. Thus,

$$a = \frac{m\lambda}{\sin\theta} = \frac{633 \times 10^{-9} \text{ m}}{\sin 0.60^{\circ}} = 6.04 \times 10^{-5} \text{ m}.$$

13. (a) $\theta = \sin^{-1} (0.011 \text{ m/3.5 m}) = 0.18^{\circ}$.

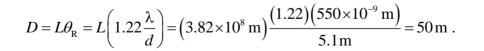
(b) We use Eq. 36-6:

$$\alpha = \left(\frac{\pi a}{\lambda}\right) \sin \theta = \frac{\pi (0.025 \,\mathrm{mm}) \sin 0.18^{\circ}}{538 \times 10^{-6} \,\mathrm{mm}} = 0.46 \,\mathrm{rad} \;.$$

(c) Making sure our calculator is in radian mode, Eq. 36-5 yields

$$\frac{I(\theta)}{I_m} = \left(\frac{\sin\alpha}{\alpha}\right)^2 = 0.93 \; .$$

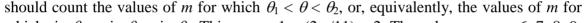
25. Using the notation of Sample Problem — "Pointillistic paintings use the diffraction of your eye," the minimum separation is



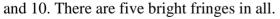
35. Bright interference fringes occur at angles θ given by $d \sin \theta = m\lambda$, where *m* is an integer. For the slits of this problem, we have d = 11a/2, so

 $a\sin\theta = 2m\lambda/11$.

The first minimum of the diffraction pattern occurs at the angle θ_1 given by $a \sin \theta_1 = \lambda$, and the second occurs at the angle θ_2 given by $a \sin \theta_2 = 2\lambda$, where a is the slit width. We







46. The angular location of the *m*th order diffraction maximum is given by $m\lambda = d \sin \theta$. To be able to observe the fifth-order maximum, we must let $\sin \theta_{m=5} = 5\lambda/d < 1$, or

$$\lambda < \frac{d}{5} = \frac{1.00 \text{ nm} / 315}{5} = 635 \text{ nm}.$$

Therefore, the longest wavelength that can be used is $\lambda = 635$ nm.

55. **THINK** If a grating just resolves two wavelengths whose average is λ_{avg} and whose separation is $\Delta\lambda$, then its resolving power is defined by $R = \lambda_{avg}/\Delta\lambda$.

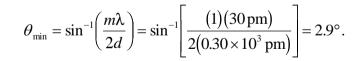
EXPRESS As shown in Eq. 36-32, the resolving power can also be written as *Nm*, where *N* is the number of rulings in the grating and *m* is the order of the lines.

ANALYZE Thus $\lambda_{avg}/\Delta\lambda = Nm$ and

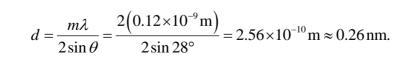
$$N = \frac{\lambda_{\text{avg}}}{m\Delta\lambda} = \frac{656.3 \,\text{nm}}{(1)(0.18 \,\text{nm})} = 3.65 \times 10^3 \,\text{rulings}.$$

LEARN A large N (more rulings) means greater resolving power.

64. We use Eq. 36-34. For smallest value of θ , we let m = 1. Thus,



where d is the spacing of the crystal planes and λ is the wavelength. The angle θ is measured from the surfaces of the planes. For a second-order reflection m = 2, so



69. Bragg's law gives the condition for diffraction maximum:



where *d* is the spacing of the crystal planes and λ is the wavelength. The angle θ is measured from the surfaces of the planes. For a second-order reflection *m* = 2, so

