Chapter 36

2. From Eq. 36-3,

$$\frac{a}{\lambda} = \frac{m}{\sin\theta} = \frac{1}{\sin 45.0^\circ} = 1.41.$$

4. (a) Equations 36-3 and 36-12 imply smaller angles for diffraction for smaller wavelengths. This suggests that diffraction effects in general would decrease.

(b) Using Eq. 36-3 with $m = 1$ and solving for 2θ (the angular width of the central diffraction maximum), we find

$$2\theta = 2\sin^{-1}\left(\frac{\lambda}{a}\right) = 2\sin^{-1}\left(\frac{0.50\,\text{m}}{5.0\,\text{m}}\right) = 11^\circ.$$

(c) A similar calculation yields 0.23° for $\lambda = 0.010$ m.

8. Let the first minimum be a distance y from the central axis that is perpendicular to the speaker. Then

$$\sin\theta = y/\left(D^2 + y^2\right)^{1/2} = m\lambda/a = \lambda/a \text{ (for } m = 1).$$

Therefore,

$$y = \frac{D}{\sqrt{(a/\lambda)^2 - 1}} = \frac{D}{\sqrt{(af/v_s)^2 - 1}} = \frac{100\,\text{m}}{\sqrt{\left[(0.300\,\text{m})(3000\,\text{Hz})/(343\,\text{m/s})\right]^2 - 1}} = 41.2\,\text{m}.$$

18. Using the notation of Sample Problem — "Pointillistic paintings use the diffraction of your eye," the maximum distance is

$$L = \frac{D}{\theta_R} = \frac{D}{1.22\lambda/d} = \frac{\left(5.0\times10^{-3}\,\text{m}\right)\left(4.0\times10^{-3}\,\text{m}\right)}{1.22\left(550\times10^{-9}\,\text{m}\right)} = 30\,\text{m}.$$

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

$$D = L\theta_R = L\left(\frac{1.22\lambda}{d}\right) = \left(6.2\times10^3\,\text{m}\right)\frac{(1.22)\left(1.6\times10^{-2}\,\text{m}\right)}{2.3\,\text{m}} = 53\,\text{m}.$$

28. Eq. 36-14 gives $\theta_R = 1.22\lambda/d$, where in our case $\theta_R \approx D/L$, with $D = 60\ \mu$m being the size of the object your eyes must resolve, and L being the maximum viewing distance in question. If $d = 3.00$ mm $= 3000\ \mu$m is the diameter of your pupil, then

$$L = \frac{Dd}{1.22\lambda} = \frac{(60\,\mu\text{m})(3000\,\mu\text{m})}{1.22(0.55\,\mu\text{m})} = 2.7\times10^5\ \mu\text{m} = 27\,\text{cm}.$$