PHYS-1200 PHYSICS II

HOMEWORK #18 SOLUTIONS

7. (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

$$a = \frac{D\lambda(m_2 - m_1)}{\Delta y} = \frac{(400\,\text{mm})(550\times10^{-6}\,\text{mm})(5-1)}{0.35\,\text{mm}} = 2.5\,\text{mm} .$$

(b) For m = 1,

$$\sin\theta = \frac{m\lambda}{a} = \frac{(1)(550\times10^{-6}\,\text{mm})}{2.5\,\text{mm}} = 2.2\times10^{-4} .$$

The angle is $\theta = \sin^{-1}(2.2\times10^{-4}) = 2.2\times10^{-4}$ rad.

21. (a) We use the Rayleigh criteria. Thus, the angular separation (in radians) of the sources must be at least $\theta_R = 1.22\lambda/d$, where λ is the wavelength and d is the diameter of the aperture. For the headlights of this problem,

$$\theta_R = \frac{1.22\left(550\times10^{-9}\,\text{m}\right)}{5.0\times10^{-3}\,\text{m}} = 1.34\times10^{-4}\,\text{rad},$$

or 1.3×10^{-4} rad, in two significant figures.

(b) If L is the distance from the headlights to the eye when the headlights are just resolvable and D is the separation of the headlights, then $D = L\theta_R$, where the small angle approximation is made. This is valid for θ_R in radians. Thus,

$$L = \frac{D}{\theta_R} = \frac{1.4\,\text{m}}{1.34\times10^{-4}\,\text{rad}} = 1.0\times10^{4}\,\text{m} = 10\,\text{km} .$$

41. (a) The first minimum of the diffraction pattern is at 5.00°, so

$$a = \frac{\lambda}{\sin\theta} = \frac{0.440\,\mu\text{m}}{\sin 5.00^\circ} = 5.05\,\mu\text{m} .$$

(b) Since the fourth bright fringe is missing, $d = 4a = 4(5.05\ \mu\text{m}) = 20.2\ \mu\text{m}$.

(c) For the $m = 1$ bright fringe,

$$\alpha = \frac{\pi a \sin\theta}{\lambda} = \frac{\pi(5.05\,\mu\text{m})\sin 1.25^\circ}{0.440\,\mu\text{m}} = 0.787\ \text{rad} .$$

Consequently, the intensity of the $m = 1$ fringe is

$$I = I_m\left(\frac{\sin\alpha}{\alpha}\right)^2 = \left(7.0\,\text{mW/cm}^2\right)\left(\frac{\sin 0.787\ \text{rad}}{0.787}\right)^2 = 5.7\ \text{mW/cm}^2 ,$$

which agrees with Fig. 36-43. Similarly for $m = 2$, the intensity is $I = 2.9\ \text{mW/cm}^2$, also in agreement with Fig. 36-43.

87. Answer not provided.

Q38.3) Only “e.”

Q38.4) Only “b.”