

11-1. See Figure 11-18 that accompanies the problem in the text for a sketch of the setup. The minima are located as position, y_m determined as,

$$m \lambda = b \sin \theta_m = b y_m / f \Rightarrow y_m = m \lambda f / b$$

- (a) The first minimum occurs at $y_1 = \lambda f / b = (546.1 \times 10^{-6} \text{ mm})(60 \text{ cm}) / (0.015 \text{ cm}) = 2.18 \text{ mm}$.
 (b) The separation of the first and second minimum is

$$y_2 - y_1 = (2 - 1) \lambda f / b = 2.18 \text{ mm}$$

11-3. See Figure 11-19 that accompanies the problem in the text.

(a) The diffraction minima are located at angles $\theta_m = y_m / L$ where $L = 2 \text{ m}$ is the slit to screen distance. The positions of the minima are given by $m \lambda = b \sin \theta_m = b y_m / L \Rightarrow y_m = m \lambda L / b$. Then,

$$y_3 - y_{-3} = \Delta y = (3 - (-3)) \lambda L / b \Rightarrow b = \frac{6 \lambda L}{\Delta y} = \frac{6 (632.8 \times 10^{-7} \text{ cm})(200 \text{ cm})}{5.625 \text{ cm}} = 0.013 \text{ cm} = 0.13 \text{ mm}$$

(b) $L_{\min} = b^2 / 2\lambda$, so,

$$\frac{L}{L_{\min}} = \frac{200 \text{ cm}}{(0.0135 \text{ cm})^2 / (2 \cdot 632.8 \times 10^{-7} \text{ cm})} = 139$$

The screen is in the far field.

11-4. Let $m_1 = 5$ for λ_1 and $m_2 = 4$ for λ_2 . Then,

$$m_1 \lambda_1 = m_2 \lambda_2 = b \sin \theta$$

$$5 \lambda_1 = 4 \lambda_2 = 4 (620 \text{ nm}) \Rightarrow \lambda_1 = 496 \text{ nm}$$

11-5. Let the full angle breadth between the first minimum on either side of the central maximum be $\varphi = 2\theta$, where θ is the angle that locates the first minimum relative to the center of the pattern. For $m = 1$,

$$\lambda = b \sin \theta = b \sin (\varphi / 2) \Rightarrow b = \frac{\lambda}{\sin(\varphi/2)} = \frac{550 \text{ nm}}{\sin(\varphi/2)}$$

For $\varphi = 30^\circ$, $b = 2.125 \mu\text{m}$, for $\varphi = 45^\circ$, $b = 1.437 \mu\text{m}$, for $\varphi = 90^\circ$, $b = 0.778 \mu\text{m}$, for $\varphi = 180^\circ$, $b = 0.55 \mu\text{m}$.

11-10. $1.22 D \sin \theta = D y / f \Rightarrow y = R = 1.22 \lambda f / D = (1.22)(5.5 \times 10^{-5} \text{ cm})(150) / 12 = 8.39 \times 10^{-4} \text{ cm}$

11-11. Using Eq. (11-21) the angular half-width of the Airy disc formed on the moon will be,

$$\Delta\theta_{1/2} = \frac{1.22 \lambda}{D}$$

where D is the diameter of the circular aperture. The radius R of the airy disc formed on the moon, which is a distance L from the aperture is

$$R = L \tan \Delta\theta_{1/2} \approx L \Delta\theta_{1/2} = \frac{1.22 \lambda L}{D} = \frac{1.22 (10.6 \times 10^{-6} \text{ m})(3.76 \times 10^8 \text{ m})}{10^{-3} \text{ m}} = 4.86 \times 10^6 \text{ m}$$

The diameter of the laser spot on the moon is about $9.72 \times 10^6 \text{ m}$. The irradiance in the spot (assuming a nearly constant irradiance over the spot (this is not really the best approximation, but it gives an order of magnitude estimate),

$$I = \frac{\Phi}{A} = \frac{\Phi}{\pi R^2} = \frac{2000 \text{ W}}{\pi (4.86 \times 10^6 \text{ m})^2} = 2.7 \times 10^{-11} \text{ W/m}^2$$

11-13. The distance L for the headlights to be barely resolvable if they are separated by a distance y is given by Eq. (11-22), as,

$$\Delta\theta_{\min} = y / L = 1.22 \lambda / D \Rightarrow L = \frac{y D}{1.22 \lambda} = \frac{(45 \times 2.54 \text{ cm})(0.5 \text{ cm})}{1.22 (5.5 \times 10^{-5} \text{ cm})} = 8.517 \times 10^5 \text{ cm} = 27,900 \text{ ft} = 5.3 \text{ miles}$$