8-9. (a) The coefficient of finesse is,
\[ F = \frac{4r^2}{(1 - r^2)^2} = \frac{4(0.999)}{(1 - 0.999)^2} = 3.996 \times 10^6 \]
(b) The frequency separation between the laser modes is related to the wavelength separation,
\[ |\Delta \nu| = \frac{3 \times 10^4 (150 \times 10^6) (632.8 \times 10^{-9})}{2} = 2.00 \times 10^{-13} \text{ m} \]
The resolving power required is then,
\[ R = \frac{\lambda}{\Delta \lambda} = \frac{632.8 \times 10^{-9}}{2.00} = 3.16 \times 10^6 \]
(c) The mode number is,
\[ m = \frac{2R}{\nu F} = \frac{2(3.16 \times 10^6)}{2} = 1006 \]
The plate spacing is,
\[ d = \frac{m \lambda}{2} = \frac{(1006)(0.328 \times 10^{-5})}{2} = 0.0318 \text{ cm} \]
(d) The free spectral range is,
\[ \nu_{fsr} = \frac{c}{2d} = \frac{3 \times 10^8 \text{ m/s}}{2(5.18 \times 10^{-4})} = 4.72 \times 10^{11} \text{ Hz} \]
Expressed as a wavelength range,
\[ \lambda_{fsr} = \frac{c}{\nu_{fsr}} = \frac{(632.8 \times 10^{-9})}{3 \times 10^8} = 4.72 \times 10^{11} \text{ m} = 6.300 \times 10^{-10} \text{ m} = 0.63 \text{ nm} \]
(e) The minimum resolvable wavelength difference is
\[ \Delta \lambda_{min} = \frac{\lambda^2}{2d F} = \frac{\lambda^2}{2d \left( \pi \sqrt{F/2} \right)} = \frac{632.8 \times 10^{-9}}{(3.18 \times 10^{-4})(3.996 \times 10^6)} = 2.00 \times 10^{-13} \text{ m} \]

8-10. (a) The mode number is,
\[ m = \frac{2n d}{\lambda} = \frac{(2)(4.5)(2)}{5.46 \times 10^{-5}} = 330,000 \]
(b) From Eqs. (8-27) and (8-28),
\[ F = \frac{T_{max} - T_{min}}{T_{min}} = \frac{T_{max}}{T_{min}} - 1 \Rightarrow \frac{T_{max}}{T_{min}} = 1 + F = 1 + \frac{4r^2}{(1 - r^2)^2} = 1 + \frac{4(0.9)}{(1 - 0.9)^2} = 361 \]
(c) The resolving power is
\[ R = \frac{2d F}{\lambda} = m \frac{\pi}{\sqrt{F}} / 2 = (330,000) \frac{\pi}{\sqrt{361}} / 2 = 9.84 \times 10^6 \]

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,
\[ m \lambda = b \sin \theta_m = b y_m / \bar{f} \Rightarrow y_m = m \lambda f / b \]
(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 \( m \lambda = b \sin \theta_m = b y_m / \bar{f} \Rightarrow y_m = m \lambda L / b \). Then,
\[ y_0 - y_{-3} = \Delta y = (3 - (3)) \lambda L / b = b = \frac{6 \lambda L}{5625} \text{ cm} \]
(b) \( L_{min} = b^2 / 2 \lambda \), so,
\[ \frac{L}{L_{min}} = \frac{200 \text{ cm}}{(0.0335 \text{ cm})^2 / (2 \times 632.8 \times 10^{-7} \text{ cm})} = 139 \]
The screen is in the far field.
11-4. Let \( m_1 = 5 \) for \( \lambda_1 \) and \( m_2 = 4 \) for \( \lambda_2 \). 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 minima on either side of the central maximum be \( \varphi = 2 \theta \), where \( \theta \) is the angle that locates the first minimum relative to the center of the pattern. For \( m = 1 \),
\[
\lambda = b \sin \theta = b \sin \left( \frac{\varphi}{2} \right) = \frac{\lambda}{\sin(\varphi/2)} = \frac{550 \text{ nm}}{\sin(\varphi/2)}
\]
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. \( 1.22 D \sin \theta = D y / f \Rightarrow y = R = 1.22 \lambda / D = (1.22)(5.5 \times 10^{-5} \text{ cm})(150)/12 = 8.39 \times 10^{-4} \text{ cm} \)

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
\[
R = L \tan \Delta \theta_{1/2} = L \Delta \theta_{1/2} = \frac{1.22 \lambda L}{D} = \frac{1.22 (10.6 \times 10^{-6} \text{ m})(3.76 \times 10^6 \text{ m})}{10^{-3} \text{ m}} = 4.80 \times 10^6 \text{ m}
\]
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),
\[
I = \frac{\Phi}{A} = \frac{\Phi}{\pi R^2} = \frac{2000 \text{ W}}{\pi (4.86 \times 10^6 \text{ m})^2} = 2.7 \times 10^{-11} \text{ W}/\text{m}^2
\]

11-13. The distance \( L \) for the headlights to be barely resolvable if they are separated by a distance \( y \) is given be Eq. (11-22), as,
\[
\Delta \theta_{\text{min}} = y / L = 1.22 \lambda / D \Rightarrow L = \frac{y D}{1.22 \lambda} = \frac{(45 \times 2.54 \text{ cm})(0.5 \text{ cm})}{1.22 (5.5 \times 10^{-5} \text{ cm})} = 8.517 \times 10^7 \text{ cm} = 27,900 \text{ ft} = 5.3 \text{ miles}
\]