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 $y_1 = \lambda\,f/b = (546.1\times10^{-6}\,\mathrm{mm})\,(60\,\mathrm{cm})/(0.015\,\mathrm{cm}) = 2.18\,\mathrm{mm}$.
(b) The separation of the first and second minimum is

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

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 $L = 2$ m is the slit to screen distance, The positions of the minima are given by $m\,\lambda = b\sin\theta_m = by_m/L \Rightarrow y_m = m\lambda L/b$. Then,

$$y_3 - y_{-3} = \Delta y = (3-(-3))\lambda\,L/b \Rightarrow b = \frac{6\,\lambda\,L}{\Delta y} = \frac{6\,(632.8\times10^{-7}\,\mathrm{cm})\,(200\,\mathrm{cm})}{5.625\,\mathrm{cm}} = 0.013\,\mathrm{cm} = 0.13\,\mathrm{mm}$$

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

$$\frac{L}{L_{\min}} = \frac{200\,\mathrm{cm}}{(0.0135\,\mathrm{cm})^2/(2\cdot 632.8\times10^{-7}\,\mathrm{cm})} = 139$$

The screen is in the far field.

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

$$m_1\,\lambda_1 = m_2\,\lambda_2 = b\sin\theta$$
$$5\,\lambda_1 = 4\,\lambda_2 = 4\,(620\,\mathrm{nm}) \Rightarrow \lambda_1 = 496\,\mathrm{nm}$$

11-5. Let the full angle breadth between the first minim 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 $m = 1$,

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

For $\varphi = 30°$, $b = 2.125\,\mu$m, for $\varphi = 45°$, $b = 1.437\,\mu$m, for $\varphi = 90°$, $b = 0.778\,\mu$m, for $\varphi = 180°$, $b = 0.55\mu$m.

11-10. $1.22\,D\sin\theta = D\,y/f \Rightarrow y = R = 1.22\,\lambda\,f/D = (1.22)(5.5\times10^{-5}\,\mathrm{cm})(150)/12 = 8.39\times10^{-4}\,\mathrm{cm}$

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

$$R = L\tan\Delta\theta_{1/2} \approx L\,\Delta\theta_{1/2} = \frac{1.22\,\lambda\,L}{D} = \frac{1.22\,(10.6\times10^{-6}\,\mathrm{m})(3.76\times10^{8}\,\mathrm{m})}{10^{-3}\,\mathrm{m}} = 4.86\times10^{6}\,\mathrm{m}$$

The diameter of the laser spot on the moon is about 9.72×10^6 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),

$$I = \frac{\Phi}{A} = \frac{\Phi}{\pi\,R^2} = \frac{2000\,\mathrm{W}}{\pi\,(4.86\times10^{6}\,\mathrm{m})^2} = 2.7\times10^{-11}\,\mathrm{W/m^2}$$

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

$$\Delta\theta_{\min} = y/L = 1.22\,\lambda/D \Rightarrow L = \frac{y\,D}{1.22\,\lambda} = \frac{(45\times2.54\,\mathrm{cm})(0.5\,\mathrm{cm})}{1.22\,(5.5\times10^{-5}\,\mathrm{cm})} = 8.517\times10^{5}\,\mathrm{cm} = 27,900\,\mathrm{ft} = 5.3\,\mathrm{miles}$$

11-15. (a) According to Eq. (11-30) the condition for missing orders is, $a=(p/m)\,b$. The fourth order interference maxima are missing so $p=4\,m$ and $a=4\,b=4\,(0.1\text{ mm})=0.4\text{ mm}$.
(b) The irradiance is given by,

$$I=4\,I_0\left(\frac{\sin\beta}{\beta}\right)^2\cos^2\alpha$$

In zeroth order $I=4\,I_0$. The interference maxima occur for,

$$p\,\lambda=a\sin\theta\Rightarrow\sin\theta=0,\pm\lambda/a,\pm2\,\lambda/a,\pm3\,\lambda/a,\ldots$$

Also $\cos^2\alpha=1$, so at the interference maxima

$$I=4\,I_0\left(\frac{\sin\beta}{\beta}\right)^2$$

where $\beta=(k\,b/2)\sin\theta=(\pi\,b/\lambda)\sin\theta$.Then:

$$p=1:\ \sin\theta=\lambda/a;\ \beta=\frac{\pi\,b}{\lambda}\frac{\lambda}{a}=\pi\,(b/a);\ \frac{I}{4\,I_0}=\left(\frac{\sin\beta}{\beta}\right)^2=\left(\frac{\sin\,(\pi/4)}{\pi/4}\right)^2=0.8106$$

$$p=2:\ \sin\theta=2\lambda/a;\ \beta=\frac{\pi\,b}{\lambda}\frac{2\lambda}{a}=2\pi\,(b/a);\ \frac{I}{4\,I_0}=\left(\frac{\sin\beta}{\beta}\right)^2=\left(\frac{\sin\,(\pi/2)}{\pi/2}\right)^2=0.4053$$

$$p=3:\ \sin\theta=3\lambda/a;\ \beta=\frac{\pi\,b}{\lambda}\frac{3\lambda}{a}=3\pi\,(b/a);\ \frac{I}{4\,I_0}=\left(\frac{\sin\beta}{\beta}\right)^2=\left(\frac{\sin\,(3\,\pi/4)}{3\,\pi/4}\right)^2=0.0.0901$$

11-20. The irradiance is given by,

$$I=I_0\left(\frac{\sin\beta}{\beta}\right)^2\left(\frac{\sin N\alpha}{\alpha}\right)^2$$

with $N=10$, $a=5\,b$, $b=10^{-4}$ cm, $\lambda=435.8$ nm. Recall that $\beta=\dfrac{\pi}{\lambda}\,b\sin\theta$, so $\alpha=4\,\beta$. For interference maxima,

$$\left(\frac{\sin N\alpha}{\alpha}\right)^2=1\Rightarrow I=I_0\left(\frac{\sin\beta}{\beta}\right)^2$$

Also, $\sin\theta=m\,\lambda/a$ and $\beta=\dfrac{\pi\,b}{\lambda}\left(\dfrac{m\,\lambda}{a}\right)=m\,\pi\,(b/a)=m\,\pi/5$. Then,

For $m=1$: $I/I_0=\left(\dfrac{\sin\beta}{\beta}\right)^2=\left(\dfrac{\sin(\pi/5)}{\pi/5}\right)^2=0.875$

For $m=2$: $I/I_0=\left(\dfrac{\sin(2\,\pi/5)}{2\,\pi/5}\right)^2=0.573$. For $m=3$: $I/I_0=\left(\dfrac{\sin(3\,\pi/5)}{3\,\pi/5}\right)^2=0.255$

For $m=4$: $I/I_0=\left(\dfrac{\sin(4\,\pi/5)}{4\,\pi/5}\right)^2=0.0547$. For $m=5$: $I/I_0=\left(\dfrac{\sin(5\,\pi/5)}{5\pi/5}\right)^2=0$.

12-4. $\Re=m\,N=\dfrac{\lambda\,a\,v}{\Delta\,\lambda}=\dfrac{589.2935}{0.597}=987$; $N=\dfrac{a}{m}$. So, for $m=1$, $N=987$ and for $m=2$, $N=494$.

12-6. See Figure 12-14 that accompanies the statement of this problem in the text.

$$\Re\,(m=3)=m\,N=(3)\,(16{,}000\times2.5)=120{,}000$$
$$\Re\,(m=2)=m\,N=(2)\,(16{,}000\times2.5)=80{,}000$$
$$\Delta\,\lambda=\lambda/\Re=550\,\text{nm}/80{,}000=0.006875\text{ nm}=0.069\text{ Å}$$