Homework #10 Solutions

37.9 Location of A = central maximum,

Location of B = first minimum.

So,
$$\Delta y = [y_{\min} - y_{\max}] = \frac{\lambda L}{d}\left(0 + \frac{1}{2}\right) - 0 = \frac{1}{2}\frac{\lambda L}{d} = 20.0 \text{ m}$$

Thus, $$d = \frac{\lambda L}{2(20.0 \text{ m})} = \frac{(3.00 \text{ m})(150 \text{ m})}{40.0 \text{ m}} = \boxed{11.3 \text{ m}}$$

37.12 The path difference between rays 1 and 2 is: $\delta = d\sin\theta_1 - d\sin\theta_2$

For constructive interference, this path difference must be equal to an integral number of wavelengths: $d\sin\theta_1 - d\sin\theta_2 = m\lambda$, or

$$\boxed{d(\sin\theta_1 - \sin\theta_2) = m\lambda}$$

37.17 (a) From Equation 37.8,

$$\phi = \frac{2\pi d}{\lambda}\sin\theta = \frac{2\pi d}{\lambda}\cdot\frac{y}{\sqrt{y^2 + D^2}}$$

$$\phi \approx \frac{2\pi y d}{\lambda D} = \frac{2\pi(0.850 \times 10^{-3} \text{ m})(2.50 \times 10^{-3} \text{ m})}{(600 \times 10^{-9} \text{ m})(2.80 \text{ m})} = \boxed{7.95 \text{ rad}}$$

(b) $$\frac{I}{I_{\max}} = \frac{\cos^2\left(\frac{\pi d}{\lambda}\sin\theta\right)}{\cos^2\left(\frac{\pi d}{\lambda}\sin\theta_{\max}\right)} = \frac{\cos^2\frac{\phi}{2}}{\cos^2 m\pi}$$

$$\frac{I}{I_{\max}} = \cos^2\frac{\phi}{2} = \cos^2\left(\frac{7.95 \text{ rad}}{2}\right) = \boxed{0.453}$$

37.54 For Young's experiment, use $\delta = d\sin\theta = m\lambda$. Then, at the point where the two bright lines coincide,

$d\sin\theta = m_1\lambda_1 = m_2\lambda_2$ so $\dfrac{\lambda_1}{\lambda_2} = \dfrac{540}{450} = \dfrac{m_2}{m_1} = \dfrac{6}{5}$

$$\sin\theta = \frac{6\lambda_2}{d} = \frac{6(450\text{ nm})}{0.150\text{ mm}} = 0.0180$$

Since $\sin\theta \approx \theta$ and $L = 1.40\text{ m}$, $x = \theta L = (0.0180)(1.40\text{ m}) = \boxed{2.52\text{ cm}}$

38.2 The positions of the first-order minima are $y/L \approx \sin\theta = \pm\lambda/a$. Thus, the spacing between these two minima is $\Delta y = 2(\lambda/a)L$ and the wavelength is

$$\lambda = \left(\frac{\Delta y}{2}\right)\left(\frac{a}{L}\right) = \left(\frac{4.10\times10^{-3}\text{ m}}{2}\right)\left(\frac{0.550\times10^{-3}\text{ m}}{2.06\text{ m}}\right) = \boxed{547\text{ nm}}$$

38.28 $d = \dfrac{1}{800/\text{mm}} = 1.25 \infty 10^{-6}\text{ m}$

The blue light goes off at angles $\sin\theta_m = \dfrac{m\lambda}{d}$: $\theta_1 = \sin^{-1}\left(\dfrac{1 \infty 5.00 \infty 10^{-7}\text{ m}}{1.25 \infty 10^{-6}\text{ m}}\right) = 23.6$□

$\theta_2 = \sin^{-1}(2 \infty 0.400) = 53.1$□

$\theta_3 = \sin^{-1}(3 \infty 0.400) = \text{nonexistent}$

The red end of the spectrum is at $\theta_1 = \sin^{-1}\left(\dfrac{1 \infty 7.00 \infty 10^{-7}\text{ m}}{1.25 \infty 10^{-6}\text{ m}}\right) = 34.1$□

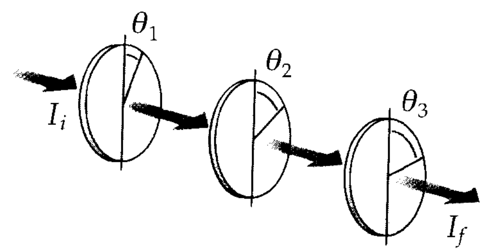
$\theta_2 = \sin^{-1}(2 \infty 0.560) = \text{nonexistent}$

So only the first-order spectrum is complete, and $\boxed{\text{it does not overlap}}$ the second-order spectrum.

38.32 $d\sin\theta = m\lambda$ and, differentiating, $d(\cos\theta)d\theta = md\lambda$ or $d\sqrt{1-\sin^2\theta}\,\Delta\theta \approx m\,\Delta\lambda$

$d\sqrt{1-m^2\lambda^2/d^2}\,\Delta\theta \approx m\,\Delta\lambda$ so $\boxed{\Delta\theta \approx \dfrac{\Delta\lambda}{\sqrt{d^2/m^2-\lambda^2}}}$

38.42 (a) θ_1 = 20.0□, θ_2 = 40.0□, θ_3 = 60.0□



$I_f = I_i\cos^2(\theta_1 - 0°)\cos^2(\theta_2 - \theta_1)\cos^2(\theta_3 - \theta_2)$

I_f = (10.0 units) $\cos^2$(20.0□) $\cos^2$(20.0□) $\cos^2$(20.0□) = $\boxed{\text{6.89 units}}$

(b) θ_1 = 0°, θ_2 = 30.0□, θ_3 = 60.0□

I_f = (10.0 units) $\cos^2$(0°) $\cos^2$(30.0□) $\cos^2$(30.0□) = $\boxed{\text{5.63 units}}$