Recitation Problems (Week 7)

All problems taken from *University Physics,* Young and Freedman, 12th Ed.

35.35. **IDENTIFY:** Require destructive interference between light reflected from the two points on the disc.
SET UP: Both reflections occur for waves in the plastic substrate reflecting from the reflective coating, so they both have the same phase shift upon reflection and the condition for destructive interference (cancellation) is $2t = (m + \frac{1}{2})\lambda$, where t is the depth of the pit. $\lambda = \frac{\lambda_0}{n}$. The minimum pit depth is for $m = 0$.

EXECUTE: $2t = \frac{\lambda}{2}$. $t = \frac{\lambda}{4} = \frac{\lambda_0}{4n} = \frac{790 \text{ nm}}{4(1.8)} = 110 \text{ nm} = 0.11\ \mu\text{m}$.

EVALUATE: The path difference occurs in the plastic substrate and we must compare the wavelength in the substrate to the path difference.

36.13. **IDENTIFY:** Calculate the angular positions of the minima and use $y = x\tan\theta$ to calculate the distance on the screen between them.

(a) SET UP: The central bright fringe is shown in Figure 36.13a.

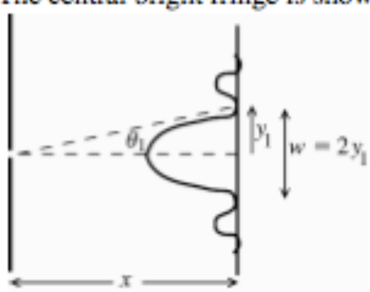

Figure 36.13a

EXECUTE: The first minimum is located by $\sin\theta_1 = \frac{\lambda}{a} = \frac{633\times10^{-9} \text{ m}}{0.350\times10^{-3} \text{ m}} = 1.809\times10^{-3}$

$\theta_1 = 1.809\times10^{-3}$ rad

$y_1 = x\tan\theta_1 = (3.00 \text{ m})\tan(1.809\times10^{-3} \text{ rad}) = 5.427\times10^{-3} \text{ m}$

$w = 2y_1 = 2(5.427\times10^{-3} \text{ m}) = 1.09\times10^{-2} \text{ m} = 10.9 \text{ mm}$

(b) SET UP: The first bright fringe on one side of the central maximum is shown in Figure 36.13b.

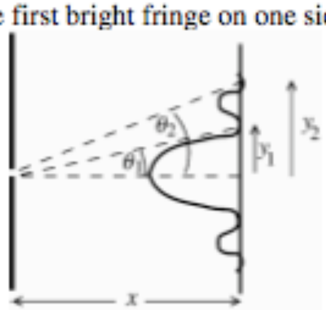

Figure 36.13b

EXECUTE: $w = y_2 - y_1$

$y_1 = 5.427\times10^{-3}$ m (part (a))

$\sin\theta_2 = \frac{2\lambda}{a} = 3.618\times10^{-3}$

$\theta_2 = 3.618\times10^{-3}$ rad

$y_2 = x\tan\theta_2 = 1.085\times10^{-2}$ m

$w = y_2 - y_1 = 1.085\times10^{-2} \text{ m} - 5.427\times10^{-3} \text{ m} = 5.4 \text{ mm}$

EVALUATE: The central bright fringe is twice as wide as the other bright fringes.

36.23. **(a) IDENTIFY and SET UP:** If the slits are very narrow then the central maximum of the diffraction pattern for each slit completely fills the screen and the intensity distribution is given solely by the two-slit interference. The maxima are given by

$d\sin\theta = m\lambda$ so $\sin\theta = m\lambda/d$. Solve for θ.

EXECUTE: 1st order maximum: $m = 1$, so $\sin\theta = \dfrac{\lambda}{d} = \dfrac{580\times10^{-9}\text{ m}}{0.530\times10^{-3}\text{ m}} = 1.094\times10^{-3}$; $\theta = 0.0627°$

2nd order maximum: $m = 2$, so $\sin\theta = \dfrac{2\lambda}{d} = 2.188\times10^{-3}$; $\theta = 0.125°$

36.34. **IDENTIFY:** The maxima are located by $d\sin\theta = m\lambda$.

SET UP: $5000\text{ slits/cm} \Rightarrow d = \dfrac{1}{5.00\times10^{5}\text{ m}^{-1}} = 2.00\times10^{-6}\text{ m}.$

EXECUTE: **(a)** $\lambda = \dfrac{d\sin\theta}{m} = \dfrac{(2.00\times10^{-6}\text{ m})\sin 13.5°}{1} = 4.67\times10^{-7}\text{ m}.$

(b) $m = 2$: $\theta = \arcsin\left(\dfrac{m\lambda}{d}\right) = \arcsin\left(\dfrac{2(4.67\times10^{-7}\text{ m})}{2.00\times10^{-6}\text{ m}}\right) = 27.8°.$

EVALUATE: Since the angles are fairly small, the second-order deviation is approximately twice the first-order deviation.

38.2. **IDENTIFY and SET UP:** $c = f\lambda$ relates frequency and wavelength and $E = hf$ relates energy and frequency for a photon. $c = 3.00\times10^{8}\text{ m/s}$. $1\text{ eV} = 1.60\times10^{-16}\text{ J}$.

EXECUTE: **(a)** $f = \dfrac{c}{\lambda} = \dfrac{3.00\times10^{8}\text{ m/s}}{505\times10^{-9}\text{ m}} = 5.94\times10^{14}\text{ Hz}$

(b) $E = hf = (6.626\times10^{-34}\text{ J}\cdot\text{s})(5.94\times10^{14}\text{ Hz}) = 3.94\times10^{-19}\text{ J} = 2.46\text{ eV}$

(c) $K = \frac{1}{2}mv^2$ so $v = \sqrt{\dfrac{2K}{m}} = \sqrt{\dfrac{2(3.94\times10^{-19}\text{ J})}{9.5\times10^{-15}\text{ kg}}} = 9.1\text{ mm/s}$

38.43. **(a)** $H = Ae\sigma T^4$; $A = \pi r^2 l$

$$T = \left(\frac{H}{Ae\sigma}\right)^{1/4} = \left(\frac{100\text{ W}}{2\pi(0.20\times10^{-3}\text{ m})(0.30\text{ m})(0.26)(5.671\times10^{-8}\text{ W/m}^2\cdot\text{K}^4)}\right)^{1/4}$$

$T = 2.06\times10^{3}\text{ K}$

(b) $\lambda_m T = 2.90\times10^{-3}\text{ m}\cdot\text{K}$; $\lambda_m = 1410\text{ nm}$

Much of the emitted radiation is in the infrared.