Physics 203 – Principles of Physics III
Homework Chapter 34, 35 and 36
Assignment #6
May 6, 2008

34-36: $\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}\Rightarrow\frac{1}{3.90m}+\frac{1}{s'}=\frac{1}{0.085m}\Rightarrow s'=0.0869m.$

$y'=\frac{s'}{s}y=-\frac{0.0869}{3.90}$ 1750 mm = 39.0 mm, so it will not fit on the

24-mm x 36-mm film.

34-46: $\frac{n_a}{s}+\frac{n_b}{s'}=\frac{n_b-n_a}{R}\Rightarrow\frac{1}{40.0\,cm}+\frac{1.40}{2.60\,cm}=\frac{0.40}{R}\Rightarrow$ R = 0.710 cm.

34-48: a) Angular magnification M = $\frac{25.0\,cm}{f}=\frac{25.0\,cm}{6.00\,cm}$ = 4.17.

b) $\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}\Rightarrow\frac{1}{s}+\frac{1}{-25.0\,cm}=\frac{1}{6.00\,cm}\Rightarrow$ s = 4.84 cm.

34.58: $|y'|=y\frac{s'}{s}=y\frac{f}{s}=\theta f=(0.014°)\left(\frac{\pi}{180°}\right)(18\text{ m})=4.40\times10^{-3}$ m.

34-106: $\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}\Rightarrow\frac{1}{1300\,mm}+\frac{1}{s'}=\frac{1}{90\,mm}\Rightarrow$ s′ = 96.7 mm.

$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}\Rightarrow\frac{1}{6500\,mm}+\frac{1}{s'}=\frac{1}{90\,mm}\Rightarrow$ s′ = 91.3 mm.

$\Rightarrow$ Δs′ = 96.7 mm – 91.3 mm = 5.4 mm toward the film.

35-4: a) The path difference is 120 m, so for destructive interference:

$\frac{\lambda}{2}$ = 120 m ⇒ λ = 240 m.

b) The longest wavelength for constructive interference is λ = 120 m.

35-8: a) For the number of antinodes we have:

$\sin\theta = \dfrac{m\lambda}{d} = \dfrac{mc}{df} = \dfrac{m(3.00x10^8\, m/s)}{(12.0m)(1.079x10^8\, Hz)} = 0.2317\ m$, so, setting $\theta = 90°$, the maximum integer value is four. The angles are ±13.4º, ±27.6º, ±44.0º, and ±67.9º for m = 0, ±1, ±2, ±3,±4.

b) The nodes are given by $\sin\theta = \dfrac{(m+1/2)\lambda}{d} = 0.2317(m + ½)$. So the angles are ±6.65º, ±20.3º, ±35.4º, ±54.2º for m = 0, ±1, ±2, ±3.

35-32: a) The number of wavelengths inside the film is given by the total extra distance traveled (2t), divided by the wavelength (adjusted for index of refraction), so the number is

$$\frac{x}{\lambda} = \frac{2tn}{\lambda_0} = \frac{2(8.76\times10^{-6}\ \text{m})\,(1.35)}{6.48\times10^{-7}\text{m}} = 36.5.$$

b) The phase difference for the two parts of the light is zero because the path difference is a half-integer multiple of the wavelength and the top surface reflection has a half-cycle phase shift, while the bottom surface does not.

35-36: a) Since there is a half-cycle phase shift at just one of the interfaces, the minimum thickness for constructive interference is:

$$2t = \frac{\lambda}{2}, \text{ or}$$

$$t = \frac{\lambda}{4} = \frac{\lambda_0}{4n} = \frac{550nm}{4(1.85)} = 74.3 \text{ nm.}$$

b) The next smallest thickness for constructive interference is with another half wave-length thickness added: $t = \dfrac{3\lambda}{4} = \dfrac{3\lambda_0}{4n} = \dfrac{3(550nm)}{4(1.85)} = 223$ nm.

35.42: To find destructive interference, $d = r_2 - r_1 = \sqrt{(200\ m)^2 + x^2} - x = \left(m + \frac{1}{2}\right)\lambda$

$$\Rightarrow (200\ \text{m})^2 + x^2 = x^2 + \left[\left(m + \frac{1}{2}\right)\lambda\right]^2 + 2x\left(m + \frac{1}{2}\right)\lambda$$

$$\Rightarrow x = \frac{20{,}000\ \text{m}^2}{\left(m + \frac{1}{2}\right)\lambda} - \frac{1}{2}\left(m + \frac{1}{2}\right)\lambda.$$

The wavelength is calculated by $\lambda = \dfrac{c}{f} = \dfrac{3.00\times10^8\ \text{m/s}}{5.80\times10^6\,\text{Hz}} = 51.7$ m.

$\Rightarrow m = 0: x = 761$ m, and $m = 1: x = 219$ m, and $m = 2: x = 90.1$ m, and $m = 3$; $x = 20.0$ m.

36-2: $y_1 = \dfrac{x\lambda}{a} \Rightarrow a = \dfrac{x\lambda}{y_1} = \dfrac{(0.600\,\text{m})(5.46\text{x}10^{-7}\,\text{m})}{10.2\text{x}10^{-3}\,\text{m}} = 3.21 \text{ x } 10^{-5}$ m.

36-12: $\beta = \dfrac{2\pi a}{\lambda}\sin\theta \approx \dfrac{2\pi a}{\lambda}\cdot\dfrac{y}{x} = \dfrac{2\pi(4.50\text{x}10^{-4}\,\text{m})y}{(6.20\text{x}10^{-7}\,\text{m})(3.00\text{m})} = (1520 \text{ m}^{-1})y.$

a) $y = 1.00 \text{ x } 10^{-3}$ m: $\dfrac{\beta}{2} = \dfrac{(1520m^{-1})(1.00x10^{-3}\,m)}{2} = 0.760.$

$$\Rightarrow I = I_0\left(\frac{\sin(\beta/2)}{\beta/2}\right)^2 = I_0\left(\frac{\sin(0.760)}{0.760}\right)^2 = 0.822I_0$$

b) $y = 3.00 \text{ x } 10^{-3}$ m: $\dfrac{\beta}{2} = \dfrac{(1520m^{-1})(3.00x10^{-3}\,m)}{2} = 2.28.$

$$\Rightarrow I = I_0 = \left(\frac{\sin(\beta/2)}{\beta/2}\right)^2 = I_0\left(\frac{\sin(2.28)}{2.28}\right)^2 0.111I_0$$

c) $y = 5.00 \text{ x } 10^{-3}$ m: $\dfrac{\beta}{2} = \dfrac{(1520m^{-1})(5.00x10^{-3}\,m)}{2} = 3.80.$

$$\Rightarrow I = I_0 = \left(\frac{\sin(\beta/2)}{\beta/2}\right)^2 = I_0\left(\frac{\sin(3.80)}{3.80}\right)^2 0.259I_0$$

36-24: Diffraction dark fringes occur for $\sin\theta = \dfrac{m_d\lambda}{a}$, and interference maxima occur for $\sin\theta = \dfrac{m_i\lambda}{d}$. Setting them equal to each other yields a missing bright spot whenever the destructive interference matches the bright spots. That is: $\dfrac{m_i\lambda}{d} = \dfrac{m_d\lambda}{a} \Rightarrow m_1 = \dfrac{d}{a}m_d = 3m_d$. That is, the missing parts of the pattern occur for $m_1 = 3, 6, 9\ldots = 3m$, for m = integers.

36-36: $\dfrac{\lambda}{\Delta\lambda} = \text{Nm} \Rightarrow \text{N} = \dfrac{\lambda}{m\Delta\lambda} = \dfrac{587.8002nm}{(587.9782nm - 587.8002nm)} = \dfrac{587.8002}{0.178}$

$\Rightarrow$ N = 3302 slits.

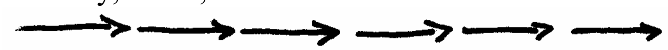
$$\frac{N}{1.20\,cm} = \frac{3302}{1.20} = 2752\frac{slits}{cm}.$$

36-44: The image is 25.0 cm form the lens, and from the diagram and Rayleigh's criteria, the diameter of the circles is twice the "height" as given by:

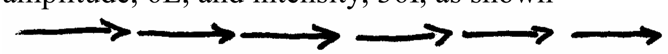
$$D = 2|y'| = \frac{2s'}{s}y = \frac{2fy}{s} = \frac{2(0.180m)(8.00x10^{-3}m)}{25.0m} = 1.15 \text{ x } 10^{-4} \text{ m} = 0.115 \text{ mm}.$$

36-60: For six slits, the phasor diagrams must have six vectors.

a) Zero phase difference between adjacent slits means that the total amplitude is 6E, and the intensity, is 36I, as shown.



b) If the phase difference is 2π, then we have the same phasor diagram as above, and equal amplitude, 6E, and intensity, 36I, as shown



c) The is an interference minimum whenever the phasor diagrams close on themselves, such as in the five cases below.