Unit 31 - Homework Solution

36-1

a) $\lambda = \frac{c}{f} \Rightarrow f = \frac{c}{\lambda} = \frac{3\times10^{8}}{589\times10^{-9}} = 5.1\times10^{14}$ Hz

b) $n = \frac{\lambda_{air}}{\lambda_{glass}} \Rightarrow 1.52 = \frac{589}{\lambda_g} \Rightarrow \lambda_g = 387$ nm

c) $v = \lambda f = (387\times10^{-9})(5.1\times10^{14}) = 1.97\times10^{8}$ m/s

36-9 a) Wavelength of light inside each piece of plastic is different than λ in air.

$$\lambda_1 = \frac{\lambda}{n_1} \qquad \lambda_2 = \frac{\lambda}{n_2}$$

When they both have emerged from the layers, the top ray has traveled L_2 inside the plastic and $(L_1 - L_2)$ inside the air. The bottom one has traveled L_1 inside the plastic.

$$N_2 - N_1 = \frac{L_2}{\lambda_2} + \frac{L_1 - L_2}{\lambda} - \frac{L_1}{\lambda_1} = \frac{L_2}{\lambda/n_2} - \frac{L_1}{\lambda/n_1} + \frac{L_1 - L_2}{\lambda}$$

$$= \frac{L_2 n_2 - L_1 n_1 + L_1 - L_2}{\lambda} = \frac{(3.5\times10^{3})(1.6) - (4\times10^{3}\times1.4) + 0.5\times}{600}$$

$$= 0.833$$

b) An intermediate one which is closer to a constructive interference. (0.833 is closer to 1 than to 0.5)

36 – 19 $d = 5.0 \text{ nm}$, $L = 1.0 \text{ m}$

$\lambda_1 = 480 \text{ nm}$, $\lambda_2 = 600 \text{ nm}$

for λ_1 : $d \sin\theta_1 = m\lambda_1$ $\sin\theta_1 = \dfrac{3 \times 480 \times 10^{-9}}{5 \times 10^{-3}} \Rightarrow \theta_1 = 0.000288$ rad

$$\frac{x_1}{L} = \tan\theta_1 \approx \theta_1 \Rightarrow x_1 = 0.000288 \text{ m} = 0.288 \text{ mm}$$

for λ_2 : $d \sin\theta_2 = m\lambda_2 \Rightarrow \sin\theta_2 = \dfrac{3 \times 600 \times 10^{-9}}{5 \times 10^{-3}} = 0.00036$ rad

$$x_2 = L \tan\theta_2 = 0.00036 \text{ m} \Rightarrow x_2 = 0.36 \text{ mm}$$

$$\Delta x = 0.360 - 0.288 = 0.072 \text{ mm}$$

37 – 7

$$a \sin\theta_1 = m\lambda \Rightarrow \sin\theta_1 = \frac{m\lambda}{a} = \frac{1 \times 589 \times 10^{-9}}{1 \times 10^{-3}} = 0.000589$$

$$\tan\theta_1 \sim \sin\theta_1 = \frac{x_1}{L} \Rightarrow x_1 = (3 \text{ m})(0.000589) = 1.767 \text{ mm}$$

[redacted]

$$x_2 = L \sin\theta_2 = \frac{L m \lambda}{a} = \frac{3 \times 2 \times 589 \times 10^{-9}}{1 \times 10^{-3}} = 3.534$$

$$\boxed{\Delta x = 1.77 \text{ mm}}$$

37-10

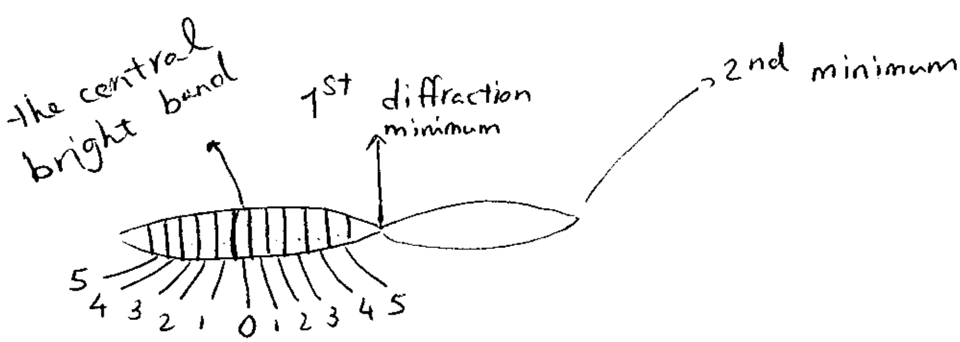
a) $\tan\theta = \frac{x}{L} = \frac{1.1}{3.5\times10^{2}} \Rightarrow \theta = 0.0031$ rad

b) $\alpha = \frac{\pi a}{\lambda}\sin\theta = \frac{\pi \times 0.025\times10^{-3}\times0.0031}{538\times10^{-9}} = 0.452$ rad

c) $I_\theta = I^{max}\left(\frac{\sin\alpha}{\alpha}\right)^2$

$$\frac{I_\theta}{I^{max}} = \left(\frac{\sin\alpha}{\alpha}\right)^2 = 0.934$$

37-27



We know that the angular spacing of the interference and the diffraction patterns are uniform. If there are five bright band between the central and the first minimum we should have five bands between the 1st and the 2nd minima. (Considering that the diffraction minima eliminate the bright bands.)

a) $d\sin\theta_1 = m_1\lambda \quad , \quad d\sin\theta_2 = (m_1+1)\lambda$

$$d = \frac{m_1\lambda}{\sin 0.2} \qquad d = \frac{m_1\lambda + \lambda}{\sin 0.3} = \frac{d\sin 0.2 + \lambda}{\sin 0.3}$$

$$\Rightarrow d\sin(0.3) = d\sin(0.2) + \lambda$$

$$d = \frac{\lambda}{\sin 0.3 - \sin 0.2} = \frac{600\text{ nm}}{\sin 0.3 - \sin 0.2} = 6195\text{ nm}$$

$$= 6.19\ \mu m$$

b) If the forth order is missing, that means it appears at the same angle as the diffraction minimum.

$a\sin\theta = m\lambda$ for smallest a: $m=1$

$$\left.\begin{array}{l} a\sin\theta = \lambda \Rightarrow \sin\theta = \dfrac{\lambda}{a} \\ \text{and} \quad d\sin\theta = n\lambda = 4\lambda \Rightarrow \sin\theta = \dfrac{4\lambda}{d} \end{array}\right\} \frac{1}{a} = \frac{4}{d}$$

$$a = \frac{d}{4} = \frac{6.19}{4}\mu m$$

$$\boxed{a = 1.54\ \mu m}$$

$$a \geq 1.54 = \frac{d}{4}$$

c) $\cancel{d/4} \Rightarrow$ for maxima: $d\sin\theta = m\lambda$

$$\Rightarrow \sin\theta = m\frac{\lambda}{d} = m\frac{600}{6000} = \frac{m}{10} \qquad \sin\theta \leq 1 \Rightarrow \frac{m}{10} \leq 1$$

4th orders are missing, So existing maxima are:

1, 2, 3, 5, 6, 7, 9

$m=10$ is at $\theta = 90°$ which won't appear on the scree