<u>Interference and Diffraction Laboratory Exercises</u>

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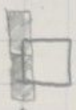
22 October 2017

1) $\lambda_0 = 589\,nm$

Screen to virtual: $S = 2m$, $R = 1m$
$\Delta y = 0.5\,mm$

The needed equation is given by: $\sin\theta = \frac{S\lambda}{2\Delta y R} = \frac{(2m)(589\times10^{-9}m)}{2(1m)(0.5\times10^{-3}m)}$

$$\theta = \sin^{-1}\left(\frac{(2m)(589\times10^{-9}m)}{2(1m)(0.5\times10^{-3}m)}\right) = (0.06749)^\circ \Rightarrow \boxed{\theta = 0.0675^\circ}$$

2) 

$d = 76.18\,\mu m$

Fringes for this setup:

$$n = \frac{2\cdot d}{\lambda} \quad \text{So for } \lambda = 589nm,$$

$$n = \frac{2(76.18\times10^{-6}m)}{589\times10^{-9}m} = 258.7 \quad \text{or simply } \boxed{258 \text{ fringes}}$$

3) $\lambda = 632.8\,nm$ $\quad w = 0.04\,mm$ $\quad D = 2m$ $\quad m = 1$ (first minima)

Single-slit equation for minima: $x = \frac{m\cdot\lambda\cdot D}{w} = \frac{1(632.8\times10^{-9}m)2m}{(0.04\times10^{-3}m)}$

$$x = 0.032m \Rightarrow \boxed{x = 3.2cm}$$

4) $w = 0.2cm$ $\quad D = 1m$ $\quad x = 1cm$

We can find the angular position of the second maxima:

$$\tan\theta = \frac{x}{D} = \frac{0.01m}{1m} = 0.01m \quad \text{thus} \quad \theta = 0.573^\circ$$

Irradiance: $\beta = \frac{\pi w}{\lambda}\sin\theta = \pm 2.46\pi$ ← numerical approximation

$$\lambda = \frac{w}{2.46}\sin(0.573^\circ) = \frac{0.2\times10^{-2}m}{2.46}\sin(0.573^\circ) = 8.13\times10^{-6}m$$

$$\boxed{\lambda = 8130\,nm}$$

5) Double-slit maxima: $x = \frac{m\lambda D}{d}$ $D = 1.5\,m$ $d = 0.05\,cm$ $\nu = 384\times10^{12}\,\frac{1}{s}$

$m = 4$ $\lambda = \frac{3\times10^{8}\,\frac{m}{s}}{384\times10^{12}\,\frac{1}{s}}$

$$x = \frac{4\left(\frac{3\times10^{8}\,\frac{m}{s}}{384\times10^{12}\,1/s}\right)1.5\,m}{0.05\times10^{-2}\,m} = 0.0094\,m$$

$$x = 9.4\times10^{-3}\,m \qquad \boxed{x = 9.4\,mm}$$

6) $\nu = 384\times10^{12}\,1/s$ $\lambda = \frac{3\times10^{8}\,m/s}{384\times10^{12}\,1/s}$ $D = 1.5\,m$ $d = 0.05\,cm$

$$I = I_0\,\frac{\sin^2\beta}{\beta^2}\cos^2\alpha \qquad \beta = \frac{\pi b}{\lambda}\sin\theta \qquad \alpha = \frac{\pi a}{\lambda}\sin\theta$$

$$\lim_{\beta\to0}\frac{\sin^2\beta}{\beta^2} = \frac{\cancel{2}\sin\beta\cos\beta}{\cancel{2}\beta} = \frac{\sin\beta\cos\beta}{\beta} = \cos^2\beta - \sin^2\beta = 1$$

$$a\sin\theta = m\lambda$$

$$\beta = \frac{\pi b}{a\lambda}m\lambda, \quad \alpha = \frac{\pi}{\lambda}m\lambda \qquad I_{in} = I_0\cos^2(\pi m) = I_0$$

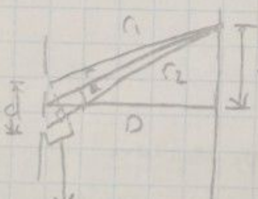
$$\beta = \frac{\pi b}{a}m, \quad \alpha = \pi m \qquad I(1cm) = I_0\,\frac{\sin^2\beta}{\beta^2}\cos^2\alpha$$

$$I_1 = I_0\,\frac{\sin^2\left(\frac{\pi b}{a}m\right)}{\frac{\pi^2 b^2}{a^2}m^2}\cos^2(\pi m)$$

$$I_{ratio} = \frac{I_1}{I_0} = \frac{\sin^2\left(\frac{\pi(0.05\times10^{-2})m}{1\times10^{-2}m}\right)}{\frac{\pi^2(0.05\times10^{-2}m)^2}{(1\times10^{-2}m)^2}} = \boxed{0.0056 = I_1/I_0}$$

7) The constructive interference lines are observed as a periodic function. Path distance is an integer multiple of λ ($a\sin\theta = m\lambda$)

Shifting a sine by a whole number doesn't matter, since it is periodic. So this constructive interference shows up.

8) 

$$\tan\theta = \frac{x}{D}$$

$\delta = r_2 - r_1$

from law of cosines: $r_1^2 = r^2 + \left(\frac{d}{2}\right)^2 - dr\cos\left(\frac{\pi}{2}-\theta\right)$

$$r_1^2 = r^2 + \left(\frac{d}{2}\right)^2 - dr\sin\theta$$

$$r_2^2 = r^2 + \left(\frac{d}{2}\right)^2 + dr\sin\theta$$

$$r_2^2 - r_1^2 = dr\sin\theta + dr\sin\theta$$

$(r_2 - r_1)(r_2 + r_1) = 2dr\sin\theta$ we require that $r_1 + r_2 \approx 2r$, since we take $D \gg d$. $(r_2 - r_1)2r = 2dr\sin\theta$

$$\delta = d\sin\theta$$

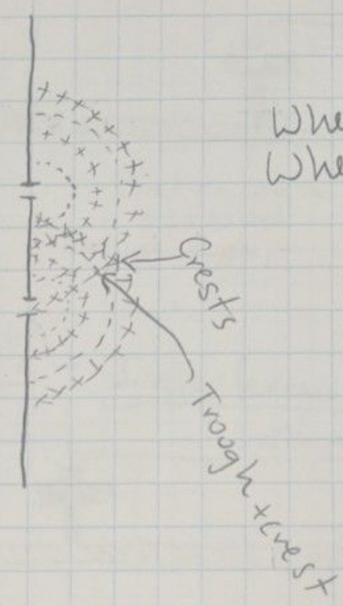
For constructive, $\delta = m\lambda$, so $\boxed{d\sin\theta = m\lambda}$

9) This is very similar to number 7, but in this case, full destructive interference occurs exactly when light meets out of phase, meaning the difference in their wavelengths in 1/2.

Thus:

$$d\sin\theta = (m+1/2)\lambda$$

10)



Wherever '+' meets '+': Constructive
Wherever '-' meets '+': Destructive