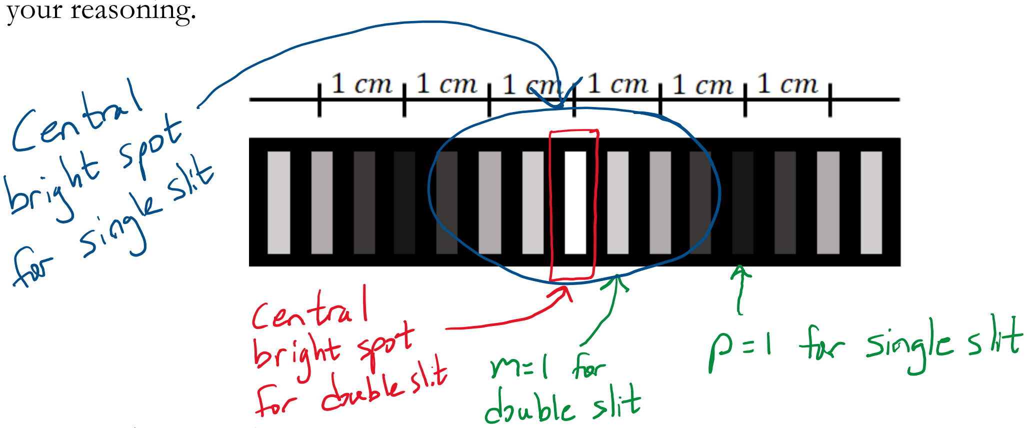
Week 2 Challenge Homework Solutions

Question 1

Below is an image of the fringe pattern produced by two identical slits and light of wavelength, $\lambda = 600$ nm. The pattern is produced on a screen 1.0 meters (L) from the slits. Using the provided scale, determine the separation between the slits and the width of one individual slit. Explain your reasoning.



a) Separation between the two slits:

d

⇓

double slit pattern

$$y_1 = 0.5\text{ cm}, \quad L = 1.0\text{ m} \quad \Big\} \quad L \gg y_m \Rightarrow \text{small } \theta \text{ approx. is good!}$$

$$\text{Small } \theta \Rightarrow \quad m\lambda = d\sin\theta = d\tan\theta = d\,\frac{y_m}{L}$$

$$\Rightarrow d = m\,\frac{\lambda L}{y_m} = 1\,\frac{(6\times10^{-7}\text{ m})(1.0\text{ m})}{(0.005\text{ m})} = \boxed{120\ \mu\text{m}}$$

b) Width of one individual slit:

a

⇓

aside: since $a < d$, θ for double slit ($m=1$) will be smaller than θ for single slit ($p=1$)

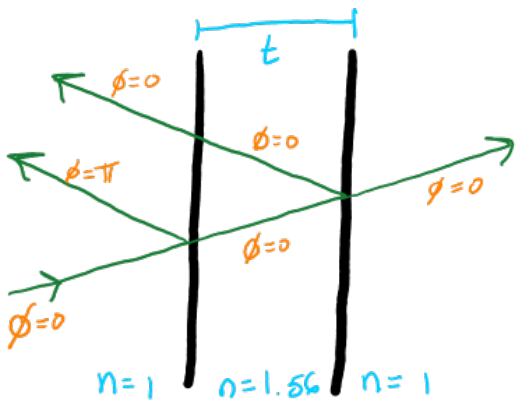
$$p\lambda = a\sin\theta$$

$$\text{small } \theta \Rightarrow \quad p\lambda = a\tan\theta = a\,\frac{y_p}{L}$$

$$\Rightarrow a = p\,\frac{\lambda L}{y_p} = 1\,\frac{(6\times10^{-7}\text{ m})(1.0\text{ m})}{(0.02\text{ m})} = \boxed{30\ \mu\text{m}}$$

Question 2

Muscovite (n = 1.56), or better known as mica, is a phyllosilicate mineral of aluminum and potassium. New industrial uses include being an insulator, usually for small electrical components. Fabrication of devices with mica often require high precision in the determination of the mica thickness. If a mica sheet is suspended in air and reflected light shows gaps in the visible spectrum at 450, 525, and 630 nm, what is the thickness of the mica sheet?



destructive interference

$\Rightarrow$ PLD $= m\lambda$

b/c of π phase diff.

$$2t = m\lambda_{1.56}$$

λ_{air}	λ_{Musc}	m=1	m=2	m=3	m=4	m=5	m=6	m=7	…
$\lambda = 630$ nm $\Rightarrow$	$\lambda_{1.56} = 403.8$ nm	403.8	808	1211	1615	2019	2423	2827	
$\lambda = 525$ nm $\Rightarrow$	$\lambda_{1.56} = 336.5$ nm	336.5	673	1010	1346	1683	2019	2356	
$\lambda = 450$ nm $\Rightarrow$	$\lambda_{1.56} - 288.5$ nm	288.5	577	866	1154	1443	1731	2019	

values of $m\lambda$ (in nm)

if we let the PLD be 2019 nm, then 5 wavelengths of 403.8 nm will fit, 6 wavelengths of 336.5 nm will fit, and 7 wavelengths of 288.5 nm will fit.

$$\Rightarrow 2t = 2019\text{ nm} \Rightarrow t = 1.0\ \mu m$$

↑ sig. figs.