Conceptual questions

22.5 Angular posns of the p^{th} order dark fringes are given by $\sin\theta_p = p\lambda/a$

Now definitely there is at least first order dark fringe here corresponding to which $\sin\theta_1 = \lambda/a$. But sine of any angle is less than 1 meaning that $\sin\theta_1 < 1$ or, $\lambda/a < 1$ or $\lambda < a$.

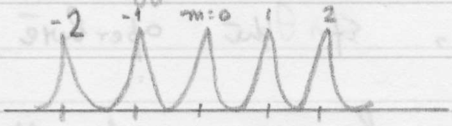
22.6 (c) Just as above, if the aperture size becomes smaller than the wavelength λ/a becomes greater than 1 and we can find no angle to satisfy $\sin\theta_1 = 1.22\,\lambda/D$. Hence no dark fringes.

22.10 (c) As we half the wavelength relative phase difference for the two rays become twice as before (e.g. $2n\pi$ becoming $4n\pi$, $(2n+1)\pi$ becoming $2(2n+1)\pi$ etc). Then even where we had dark lines before we'll be see bright ones. Effectively the pattern shrinks by a factor of 2.

Excercises

22·2 At the centre ($y=0$) path difference is zero and we always have a bright spot there. As we move away either side exact phase matching happens only after the path difference between two rays has been λ or 2λ or. $m\lambda$ for m^{th} order fringe.

For $m=2$ the path difference should be $2\lambda = 1000$ nm $= 1\mu$.

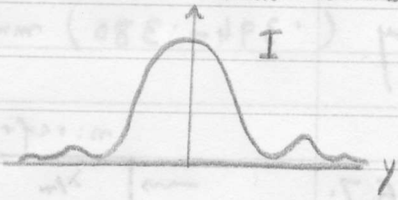


22·3 Just by applying the above concept we see that path difference for the 4th order max. of unknown λ should be equal to the path difference for 3^{rd} order max. for orange light with wavelength 600 nm. Hence $4\lambda = 3 \times 600$ nm or, $\lambda = 450$ nm (Which colour is it?)

22·4 Let's try doing it by proportion. We know from $\Delta y = \lambda L/d$ that the separation varies proportionally with λ. As because we have decreased λ by a factor of $\frac{2}{3}$ so does the separation Δy and we get $\Delta y_{new} = \frac{2}{3} \Delta y_{old} = \frac{2}{3} \times 1.8$ m $= 1.2$ mm.

22.15 Should check that small angle appx. is valid here.

22.21 If you look at the intensity pattern for single slit diffraction we see that it decays generally fast compared to the central peak. That's why the width of the central maximum is taken to be the width of the diffracted wave.



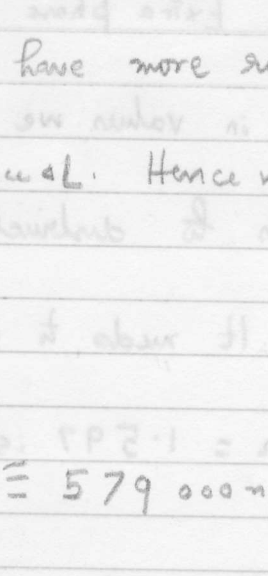
29. If the path difference for two rays is ΔL we have $(\Delta L/\lambda + 1)$ maximums / bright rings possible. Smaller wavelength, as we see from the formula would tend to have more rings than for larger wavelength for same path difference ΔL. Hence we expect

$$(\Delta L/\lambda_{small} + 1) - (\Delta L/\lambda_{large} + 1) = 1$$

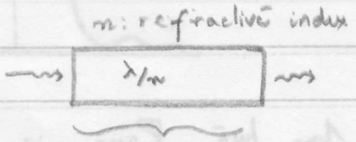
or, $\Delta L \left(1/\lambda_{small} - 1/\lambda_{large}\right) = 1$

or, $\Delta L = \lambda_{small} * \lambda_{large} / \lambda_{large} - \lambda_{small} \cong 579\,000\ nm = \cdot 579\ mm.$

Now remembering that ΔL is twice the displacement we get it to be $\frac{1}{2} \cdot \cdot 579\ mm \approx \cdot 289\ mm.$



63. According to the idea of problem 29, a displacement Δx causes $2\Delta x/\lambda$ fringes to appear / disappear. Hence, for the first displacement $\Delta x_1 = 1200\,\lambda_{He-Ne}/2 \approx .380$ mm. Similary $\Delta x_2 = 1200 \times 656.5/2 = .394$ mm. Hence it has been moved closer by $(.394 - .380)$ mm $\approx .014$ mm.

67. 

$$\Delta\phi_n = \frac{L}{\lambda/n}\cdot 2\pi = \frac{nL}{\lambda}\, 2\pi$$

(a) → Extra phase due to this $\Delta\phi = \phi_n - \phi_{air} = \frac{nL}{\lambda}2\pi - \frac{L}{\lambda}2\pi = \frac{(n-1)L}{\lambda}$

Plugging in values we get $\Delta\phi = .522 \times 6.70\ 2\pi \approx 7\pi$ which cossepondes to distructive interference. Hence Off.

(b) It needs to be $8\pi = (n-1)\frac{L}{\lambda}\,2\pi$ or, $(n-1) = \frac{4}{6.7} = .597$

or, $n = 1.597$ is reqd to switch it on.