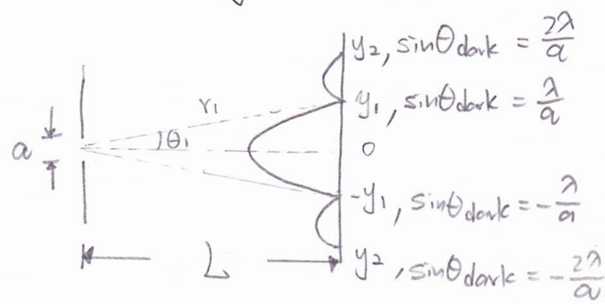
Ch 27 Assigned Questions

2014 Spring
PHYS 1Cb

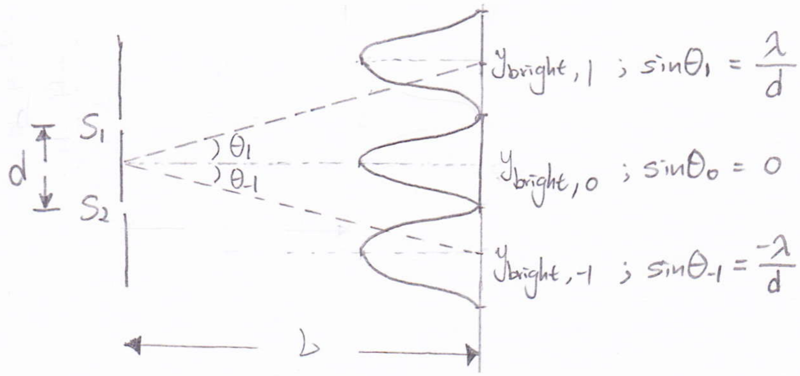
1. 

The width of the central maximum $= 2y_1$ (see the graph)

Since $\sin\theta_{dark,1} = \frac{\lambda}{a}$ for the 1st dark fringe,

$\Rightarrow y_1 = L\tan\theta_1 \approx L\sin\theta_1 = L\sin\theta_{dark,1} = L\cdot\frac{\lambda}{a}$

$\therefore W_{central\ maximum} = 2y_1 = 2\cdot L\cdot\frac{\lambda}{a}$. If a is halfed $\Rightarrow W \propto \frac{1}{a}$ $\therefore$ width is doubled (d) //

2. 

(a) blue light, $d = 400\,\mu m$, $L = 4\,m$

(b) red light, $d = 400\,\mu m$, $L = 4\,m$

(c) red light, $d = 800\,\mu m$, $L = 4\,m$

(d) red light, $d = 800\,\mu m$, $L = 8\,m$

(i) the angle between the central maximum & 1st order side maximum $\equiv \theta_1$

$\theta_1 \approx \sin\theta_1 = \frac{\lambda}{d}$ * you should know that $\lambda_{red\ light}$ ($\approx 700\,nm$) $> \lambda_{blue\ light}$ ($\approx 470\,nm$)

$\therefore \theta_b > \theta_a > \theta_c = \theta_d$ (b) > (a) > (c) = (d) //

(ii) the distance between the central maximum and 1st order side maximum $\equiv y_1$

$y_1 = L\tan\theta_1 \approx L\sin\theta_1 = L\cdot\frac{\lambda}{d}$ $\therefore y_{1,b} = y_{1,d} > y_{1,a} > y_{1,c}$

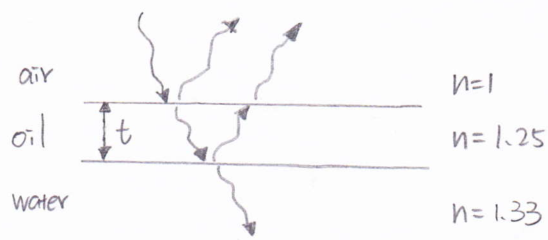
(b) = (d) > (a) > (c) //

3. From air to water $\Rightarrow$ speed of light decreases $\Rightarrow$ λ of light decreases ($\because f$ is the same)

$\because$ Distance between successive bright fringes $= L\cdot\frac{\lambda}{d}$

$\therefore$ Bright fringes are closer together (c) //

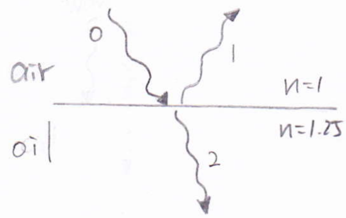
6.



the wavelength of the green light in air = $\lambda_{air} = 530$ nm

$\Rightarrow$ the wavelength of it in the oil = $\lambda_{oil} = \dfrac{530}{1.25} = 424$ nm

Step 1 : light enters oil from air :



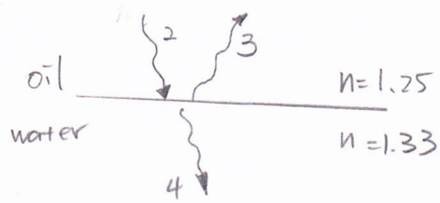
$\because n_{oil} > n_{air}$

$\Rightarrow$ ① Wave 1 has 180° phase change with respect to wave 0.

② Wave 2 has no phase change with respect to wave 0

Step 2 : light enters water from oil :

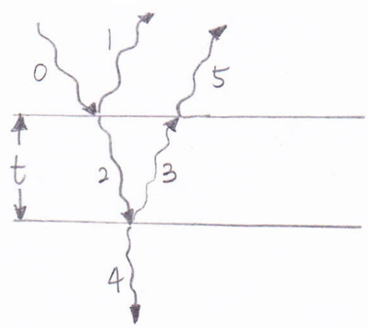
$\because n_{water} > n_{oil}$



$\therefore$ ③ Wave 3 has 180° phase change with respect to wave 2

④ Wave 4 has no phase change with respect to wave 2

Step 3 : full view :



⑤ Wave 5 has no phase change w.r.t. wave 3 (transmission)

$\Rightarrow$ Wave 5 has 180° phase change w.r.t. wave 2. (from ③)

$\Rightarrow$ Wave 5 has 180° phase change w.r.t. wave 0 (from ②)

$\Rightarrow$ Wave 5 has no phase change w.r.t. wave 1 ! (from ①)

When green light is "strongly" reflected $\Rightarrow$ constructive interference

$\Rightarrow \quad 2t = m\lambda_{oil} \Rightarrow 2t = m \cdot 424$ (nm) , where $m = 0, 1, 2, \ldots$

$\therefore$ $m=1$ yields minimum non-zero t $\Rightarrow$ $t_{min} = \frac{1}{2} \times 424 = 212$ nm

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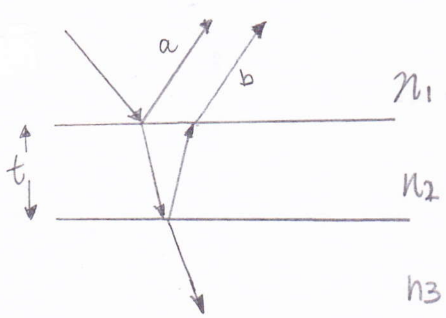
To summarize :



① $n_2 > n_1$ and $n_2 > n_3$

a and b will have constructive interference if $2t = (m+\frac{1}{2})\lambda_2$

destructive interference if $2t = m \cdot \lambda_2$

② $n_2 > n_1$ and $n_2 < n_3$

a and b will have constructive interference if $2t = m \cdot \lambda_2$

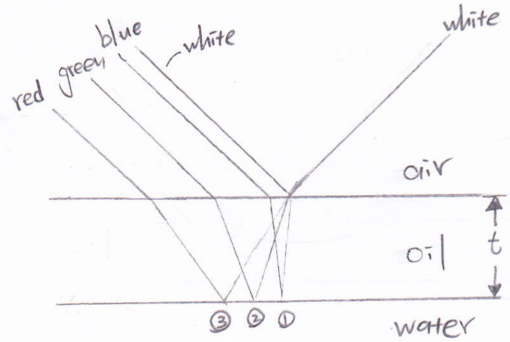
destructive interference if $2t = (m+\frac{1}{2})\lambda_2$

where λ_2 means the wavelength in n_2 ; and $m = 0, 1, 2, 3, \ldots$

7. Refer to Figure 27.5, $\sin\theta_2 = \frac{2\lambda}{d}$

$$\therefore \theta_2 \approx \sin\theta_2 = \frac{2\lambda}{d} = \frac{2\times 500\times10^{-9}}{2\times10^{-5}} = 5\times10^{-2} = 0.05 \text{ (rad)}$$ #

8.



From Question 6, constructive interference occurs when $2t = m\lambda_{oil}$. A variety of bright light is seen means that, the thickness of the oil is on the same order of λ of visible light (that is $t = 400\,nm \sim 700\,nm$), thus a slight change in the angle of reflection will make the optical path be any wavelength of visible light. (ex. in the graph, paths ①, ②, and ③ give constructive interference in blue, green and red light respectively.

10. (Please look at the figure I drew on the 1st page, in Question 1)

$L = 1\,m$, $\lambda = 5\times10^{-7}\,m$, $y_1 = 5\times10^{-3}\,m$

$$\because y_1 = L\cdot\frac{\lambda}{a} \Rightarrow 5\times10^{-3} = 1\times\frac{5\times10^{-7}}{a} \Rightarrow \therefore a = 10^{-4}\,m = 0.1\,mm$$ #

12. $\lambda_{x\text{-}ray} \approx 0.1\,nm = 10^{-10}\,m$ In diffraction grating, $d\sin\theta_{bright} = m\lambda$

$\Rightarrow \sin\theta_{bright} = m\cdot\frac{\lambda}{d}$, where $m = 0, 1, 2, \dots$ and d = spacing between 2 ribs

let's say $d \approx 1\,cm = 10^{-2}\,m$ $\therefore \sin\theta_{bright} = m\cdot10^{-8} = 0.00000001\times m$ (so small!)

Ribs don't act as a diffraction grating because d is so large comparing to λ ($d >> \lambda$) $\therefore$ (b) #

13. (e) $\because \theta_{min} = 1.22\frac{\lambda}{D}$ $\therefore$ Increasing D yields smaller θ_{min} (improving the resolution).