Tutorial # 5; Interference (Hints)

1 (a) $\frac{a_2}{a_1} = \frac{3}{1}$; visibility = ?

$$\text{visibility} = \frac{2a_1a_2}{a_1^2+a_2^2} = \frac{2\left(a_2/a_1\right)}{1+\left(\frac{a_2}{a_1}\right)^2}$$

$$= \frac{2\left(\frac{3}{1}\right)}{1+\left(\frac{3}{1}\right)^2} = 0.6$$

(b) $\frac{a_2}{a_1} = ?$; visibility = 0.5

$$V = \frac{2\left(a_2/a_1\right)}{1+\left(\frac{a_2}{a_1}\right)^2} \Rightarrow 0.5 = \frac{2\left(\frac{a_2}{a_1}\right)}{1+\left(\frac{a_2}{a_1}\right)^2}$$

Let $\frac{a_2}{a_1} = A$; $1+A^2-4A=0$

Solving $A = \frac{a_2}{a_1} = 3.73$ or 0.27

2 For maximum intensity; we have

$$2\mu t\cos r = (2n+1)\frac{\lambda}{2} \quad -(1)$$

For normal incidence, we have

$i=0 \Rightarrow r=0$ and $\cos r = 1$

$\therefore$ from eq (1) $\quad t_{min} = \frac{\lambda}{4\mu} \quad -(2)$

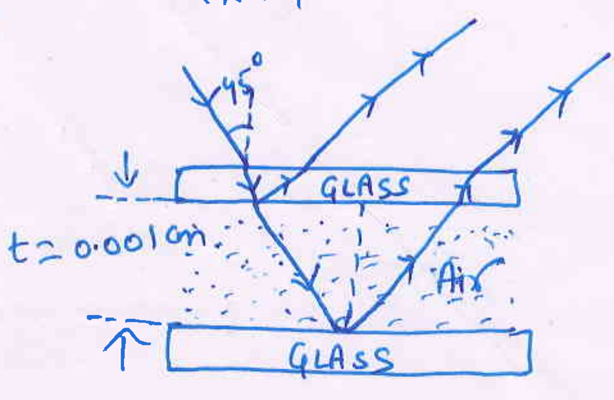
For minimum intensity; we use

$2\mu t = n\lambda \Rightarrow t_{min} = \frac{\lambda}{2\mu} \quad -(3)$

Since we get minimum thickness for maximum intensity, therefore we use eq (2) $t_{min} = \frac{\lambda}{4\mu}$

$$t_{min} = \frac{530}{4\times 1.4} = 94.6\,nm$$

3



3 continued $400nm \le \lambda \le 700nm$

For minima; we have

$$2\mu t\cos r = n_1\lambda_1 = n_2\lambda_2$$

μ for air = 1

$\Rightarrow 2\times1\times0.001\times\cos45^\circ$

$= n_1\times400\times10^{-7} = n_2\times700\times10^{-7}$

$\Rightarrow n_1 = 35$ and $n_2 = 20$

There are 15 orders in the visible with n ranging from 20 to 35.

4 Soap film become wedge shaped under gravity.

Angle of wedge is

$$\theta = \frac{\lambda}{2\mu\beta}$$

Side view of the wedge film

where β is fringe width

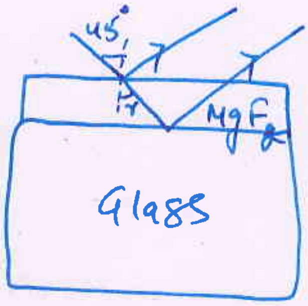
$$\theta = \frac{632.8\times10^{-7}}{2\times1.33\times\frac{1}{15}}$$

Solving ;

$\theta = 3.56\times10^{-4}$ radians

$\theta = 1'14''$

(5)



Since both rays got reflected from the surface of denser medium, therefore we have

$$2\mu t\cos r - \frac{\lambda}{2} - \frac{\lambda}{2} = (2n-1)\frac{\lambda}{2}$$

$$\Rightarrow 2\mu t\cos r = (2n+1)\frac{\lambda}{2} \quad \text{—(1)}$$

Given $\mu = 1.38$ and $\lambda = 580nm$

At normal incidence ($\cos r = 1$) and for t_{min}; $n=0$

$\therefore$ from eq (1)

$$2\times 1.38\times t_{min}\times (1) = (0+1)\frac{\lambda}{2}$$

$$\Rightarrow t_{min} = 105nm$$

At $i = 45°$; $2\mu t\cos r = (2n+1)\frac{\lambda'}{2}$ —(2)

From snell's law; $\frac{\sin 45°}{\sin r} = 1.38$

$\Rightarrow \sin r = \frac{0.707}{1.38} \Rightarrow \cos r = 0.86$

from eq (2) $2\times 1.38\times 105\times 0.86 = (0+1)\frac{\lambda'}{2}$

$$\Rightarrow \lambda' = 498nm$$

(6) $D_{10} = 6.0\,mm$ and $D_{15} = 8\,mm$

$D_5 = ?$

$$\frac{D_{15}^2 - D_{10}^2}{\cancel{4pR}} = \frac{D_{10}^2 - D_5^2}{\cancel{4pR}}$$

$$\Rightarrow D_5 = 2.83\,mm$$

(7) $R = 50cm$, $D_4 = 0.203cm$, $D_{20} = 0.484\,cm$

$$D_n^2 = 4R(2n+1)\frac{\lambda}{2}$$

$$D_{n+1}^2 = 4R(2(n+1)+1)\frac{\lambda}{2}$$

For 4th bright ring; $n = 3$

and for 20th " " ; $n = 19$.

Hence $\lambda = \frac{D_4^2}{4R\frac{(2n+1)}{2}} = \frac{(0.203)^2}{4\times 50\times\left(\frac{2\times 3+1}{2}\right)}$

$$\lambda = 589nm$$

and $\lambda = \frac{D_{20}^2}{4R(2n+1)\frac{\lambda}{2}} = 601nm$

$\Rightarrow \lambda$ values are not consistent. Thus either the rings number are wrong or lens and plate are not in exact contact. In this case, correct relation is :-

$$\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR} = \frac{(0.484)^2 - (0.203)^2}{4\times 16\times 50}$$

$$\lambda = 6.03\times 10^{-5}\,cm = 603nm$$

(8) $D_m = 3mm = 3\times 10^{-3} m$

$D_m' = 2.5mm = 2.5\times 10^{-3} m$

$\mu = ?$

Diameter of mth ring in presence of liquid

$$(D_m')^2 = \frac{4mR\lambda}{\mu} \quad \text{—(1)}$$

Diameter of mth ring in air is

$$D_m^2 = 4mR\lambda \quad \text{—(2)}$$

Dividing (2) by (1)

$$\mu = \frac{D_m^2}{D_m'^2} = \frac{(3.0)^2}{(2.5)^2} = 1.44$$