Applied Physics (UPH004)
Tut : 05 :: Interference

(1) Two beams are forming an interference fringe pattern.
(a) If their amplitudes are in the ratio of 3/1, what is visibility?
(b) what ratio of amplitudes produces a visibility of 0.5?

Solution:-

(a)
$$\boxed{V = \frac{2a_1a_2}{a_1^2+a_2^2}}$$
$$= \frac{2(a_1/a_2)}{\left(\frac{a_1}{a_2}\right)^2+1} = \frac{2\times3}{(3)^2+1} = 0.6$$

$$\frac{a_1}{a_2} = \frac{3}{1}$$

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

$$\left(\frac{a_1}{a_2}\right)^2 - 4\left(\frac{a_1}{a_2}\right) + 1 = 0$$

$$b^2 - 4ac = 0$$
$$16 - 4\times1\times1 = 12$$

$$\frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{-(-4)\pm\sqrt{12}}{2\times1} = \frac{4\pm\sqrt{12}}{2} = \frac{4\pm3.464}{2}$$

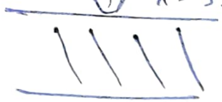
if $\frac{4+3.464}{2} = 3.732$ & if $\frac{4-3.464}{2} = 0.268$

Ques 2: what is the min. thickness of parallel ~~beam~~ film ($\mu = 1.4$) (refractive index) in which interference of Green component (wavelength 530 nm) of the normally incident light can take place by Reflection?

Sol^n: normal so angle $= 0$
Reflection angle $= 0$

normal = 0 , Reflection angle = 0

$\lambda = 530\ nm$



$\mu = 1.4$

$r = 0$ (refl. angle)

for ∥ thin films, we have interference due to reflected light there are two conditions :-

① minima →

$$2\mu t \cos r = n\lambda \quad (n = 1, 2, \ldots)$$

② max. →

$$2\mu t \cos r = (2m+1)\lambda/2 \; ; \; m = 0, 1, 2$$

minima = $\boxed{2\mu t \cos r = n\lambda}$

$n = 1, 2, 3, \ldots$

maxima = $2\mu t \cos r = (2m+1)\frac{\lambda}{2}$.

from (i) condition

$$2\mu t_{min} \underbrace{\cos r}_{0} = \underbrace{n}_{1}\lambda$$

$$2\mu t_{min} = \lambda \quad \text{or} \quad t_{min} = \frac{\lambda}{2\mu}$$

from (2nd) condition.

$$2\mu t_{min} = \frac{\lambda}{2} \Rightarrow \boxed{t_{min} = \frac{\lambda}{4\mu}}$$

($m_{min} = 0$ & $r = 0$)

(*) t_{min} comes ~~at~~ for max. ~~of~~ of the interference pattern

$$t_{min} = \frac{530 \times 10^{-9}\ m}{4 \times 1.4} = 94.6 \times 10^{-9}\ m$$

2γ

$\boxed{\text{Tut - 5}}$

Que 3

Ans : Order no of destructive interference

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

$$n_1 = \frac{2\mu t \cos r}{\lambda_1}$$

$$= \frac{2 \times 1 \times 0.001 \times 0.01 \times 1 \times 0.7071}{400 \times 10^{-9} m}$$

$$= 35.35$$

& for

$\lambda = 700 nm$

$$n_2 = \frac{2\mu t \cos r}{\lambda_2}$$

$$= \frac{2 \times 1 \times 0.001 \times 0.01 \times 1 \times 0.7071}{700 \times 10^{-9} m}$$

$$= 20.02$$

Mean Dark line

$$n_1 - n_2 = 35 - 20$$
$$= 15$$

4th ques

Ques:-

Ans :-

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

$$\beta = \frac{1}{15}\ Cm$$

$$\theta = \frac{632.8\ nm}{2.66 \times 0.00066\ m} = \frac{632.8 \times 10^{-9} m}{2.66 \times 0.00066}$$

$$= 360446.0 \times 10^{-9}$$

$$= 3.60 \times 10^{-4}\ rad.$$

5 th

Ans :- Destructive fringes (Dark)

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

$$n = 0, 1, 2 \ldots$$

at $n = 0$, $r = 0$

$$t = \frac{\lambda}{2} \cdot \frac{1}{2\mu \cos r}$$

$$= \frac{580\ nm}{4 \times 1.38 \times 1} = 105\ nm$$

(*) Using Snell's law

$$\mu = \frac{\sin i}{\sin r} \Rightarrow \sin r = \frac{\sin i}{\mu} = \frac{\sin 45°}{1.38\ nm} = 0.5123$$

$$r = \sin^{-1}(0.5123)$$

$$= 30.8171°$$

$$4\mu t \cos r = \lambda$$

$$= 4 \times 1.38 \times 105 \times 10^{-9} \times \cos(30.8171)$$

$$= 579.6 \times 10^{-9} \times 0.8588$$

$$= 497.76\ nm.$$

Ques 6 :- If the dia. of 10^{th} & 15^{th} dark rings of newtons rings patters are found to be 6.0mm & 8.0mm respectively, find the dia. of 5^{th} dark ring. plano glass plate & plano convex lens combination is used to produce interference pattern due to reflected beam.

Solⁿ :-
$$\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR}$$

D_n → is the dia. of n-th dark ring

$D_{10} = 6\,mm$

$D_{15} = 8\,mm$; $D_5 = ?$

$$\frac{D_{15}^2 - D_{10}^2}{4 \times 5 \times R} = \cancel{D_{10}^2 \times +}\ \frac{D_{10}^2 - D_5^2}{4 \times 5 \times R}$$

$$(D_{15}^2 - D_{10}^2) \times \cancel{20}R = \cancel{20R}\,(D_{10}^2 - D_5^2)$$

$$D_{15}^2 - D_{10}^2 - D_{10}^2 + D_5^2 = 0$$

$$64 - 36 - 36 + D_5^2 = 0$$

$$64 - 72 + D_5^2 = 0$$

$$D_5^2 = 8$$

$$D_5 = \sqrt{8} = 2.83\,mm$$

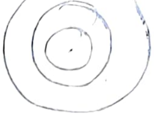
Qu
7. Newton rings are formed in the air film enclosed b/w pl
Convex lens ~~for~~ (of R = 50 cm) & a plane glass plate by
reflection. Dia. of 4th & 20th bright rings are respectively
0.203 cm & 0.484 cm. So that the lens & plate are not
exactly in contact. Also find wavelength of light used.

Solⁿ:

$R = 50 \text{ cm}$

$D_4 = 0.203 \text{ cm}$

$D_{20} = 0.484 \text{ cm}$



$D_n^2 = 4R(2n+1)\frac{\lambda}{2}$, $n = 0, 1, 2, 3$

for bright fringe → 4th ring has $n = 3$
& 20th $= n = 19$

$$\lambda_4 = \frac{D_4^2}{4R(2n+1)\frac{1}{2}} = \frac{(0.203)^2}{4 \times 50 \times \frac{7}{2}} = 589 \text{nm}$$

$$\lambda_{20} = \frac{D_{20}^2}{4R(2n+1)\frac{1}{2}} = \frac{(0.484)^2}{4 \times 50 \times \frac{39}{2}} = 601 \text{nm}$$

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

$$\boxed{\lambda = 603 \text{nm}}$$

Qu 8: The Dia. of mth dark ring in Newton's Ring exp. changes from 3 mm to 2.5 mm when air film is replaced by liquid. find refractive index of liquid.

Solⁿ

plano convex lens

$D_m = 3 \text{mm}$ → air
$D_m = 2.5 \text{ mm}$ → liquid.

we have dark ring Dia. $D_m = 4mR\lambda$ → Air film
$D_m = \frac{4mR\lambda}{\mu}$ → liquid.

$$\mu = \frac{D_m^2}{D_m^2} = \frac{(3.0)^2}{(2.5)} = 1.44 \quad \frac{9}{6.25}$$