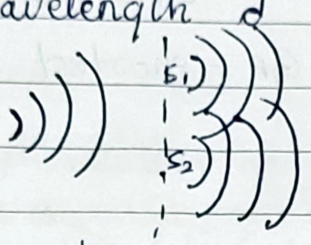
fluctuates phase relation b/w waves emitted by 2 conventional light source rapidly and therefore cannot be co-herent though identical in all respect. Two coherent source are derived from a single source of technique which are divided into 2 types

Techniques of obtaining Interference

conventional light → emit light in all direction

(1) Wavelength division technique

→ Wavelength



Ex: Young's double slits experiment:

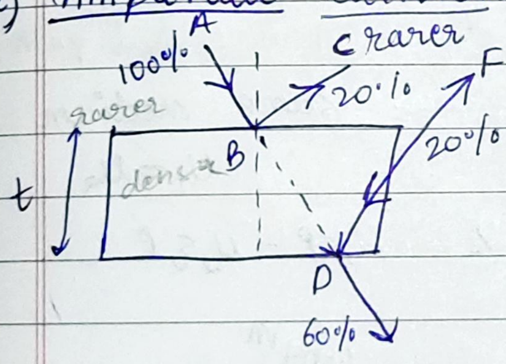
It consists of narrow slit as source and the wave front is divided.

other example Fresnels biprism.

The wave front emerging from slit S is divided into 2 parts by double slit S_1 S_2.

(2) Amplitude division technique.

amplitude of light is divided into 2 or more beams.



20% → reflected

80%, 60% → transmitted

C, F are coherent waves

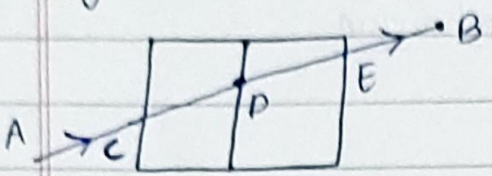
Obtained from same source having same amplitude, wave-length & freq

GPL same for vacuum or any medium

Reflection

light travel along a st. line path from pt $A \to B$ it is known as <u>path of light</u>. The shortest path

1] **Geometrical path:** between any two point A & B is GPL



$GP = AB$

$GP =$ shortest distance

Light travel μ times slower in medium, therefore it take μ time more time to cover the distance AB than in vacuum.

2] **Optical path:** $OPL = \mu \times GPL$

$\Delta = \mu L$

$\mu_1 =$ air $\qquad \mu_2 =$ glass $\qquad \mu_3 = H_2O$

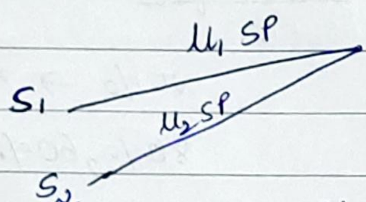
$\Delta \to$ signifies no. of wavelength that at accomodated in a given medium over corresponding geometrical path length

$OP = \mu_1 AC + \mu_2 CD + \mu_3 DE + \mu_1 EB$

3] **Path difference:**

Same as OP (consider)

diff between optical path of two rays travelling in diff direction is optical path diff



same medium

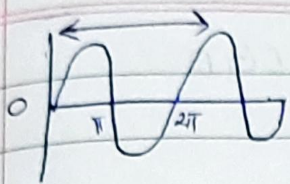
$\mu_1 = \mu_2$

$Pd = \Delta = \mu_1 S_1 P - \mu_2 S_2 P$

4] **Phase difference:**

geo. length

$\lambda : 2\pi :: L : \Delta$

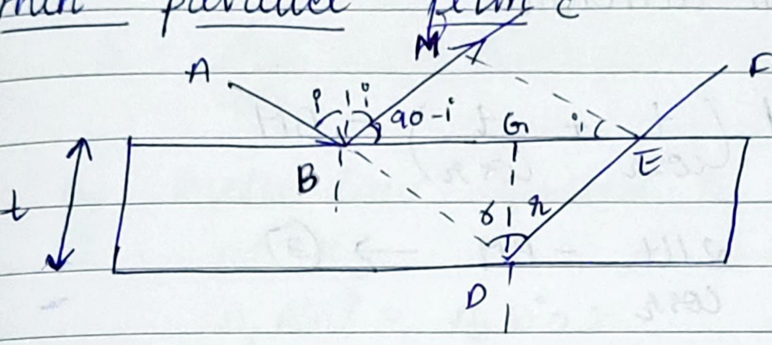


$$\lambda \Delta = 2\pi L$$

$$\Delta = \frac{2\pi L}{\lambda} = \frac{2\pi \mu L}{\lambda}$$

<u>Interference</u> <u>due</u> <u>to</u> <u>reflected</u> <u>light</u> <u>from</u> <u>a</u> <u>thin</u> <u>parallel</u> <u>film</u>

V-Imp
8-10 marks



Two waves BC & BDEF

Geo. Path diff = BD + DE − BM
but for calc calculate OP

From the right angled ΔBGD

$$\cos r = \frac{DG}{BD}$$

$$BD = \frac{DG}{\cos r}$$

But $DG = t$ thickness of the film

$$BD = \frac{t}{\cos r} \rightarrow (1)$$

from right angled ΔEGD

$$\cos r = \frac{DG}{DE} = \frac{t}{DE}$$

$$DE = \frac{t}{\cos r} \rightarrow (2)$$

Path difference

$$\delta = \mu\left(\frac{t}{\cos r} + \frac{t}{\cos r}\right) - BM$$

$$= \frac{2\mu t}{\cos r} - BM \rightarrow (3)$$

from Δ^{le} BME

$$\sin i = \frac{BM}{BE}$$

$$BM = BE \sin i$$

which can be written as

$$BM = (BG + GE)\sin i$$

But $BG = GE$

$$BM = 2BG \sin i \rightarrow (4)$$

sub (4) in (3) we get

$$\delta = \frac{2\mu t}{\cos r} - 2BG \sin i \rightarrow (5)$$

from Δle ΔBGD $\tan r = \frac{BG}{GD} = \frac{BG}{t}$

$$BG = t \tan r \rightarrow (6)$$

putting the value of BG from eq^n (6) in (5) we get

$$\delta = \frac{2\mu t}{\cos r} - 2t \tan r \sin i \rightarrow (7)$$

By snells law applied to the refraction at B,

$$n_1 \sin i = n_2 \sin r$$

But here $n_1 = 1$ & $n_2 = \mu$

$$\sin i = \mu \sin r \rightarrow (8)$$

sub eq (8) in (7) we get

$\tan r = \frac{\sin r}{\cos r}$ $\sin r$

$$\delta = \frac{2\mu t}{\cos r} - 2\mu t \frac{\sin^2 r}{\cos r}$$

$$= \frac{2\mu t}{\cos r} [1 - \sin^2 r]$$

$$= \frac{2\mu t}{\cos r} \cos^2 r$$

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

$$\delta = 2\mu t \cos r \rightarrow (9)$$

But when a ray of light propagating from rarer to denser medium suffers reflection at the boundary between the two medium it undergoes additional path change of "$\frac{\lambda}{2}$".

The resultant path diff

$$\delta = 2\mu t \cos r - \frac{\lambda}{2} \rightarrow (10)$$

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

$$= \cancel{\lambda\left(\frac{2n+1}{2}\right)}$$

$$= \cancel{\frac{\lambda}{2}(2n+1)}$$

~~(ii) Condition for destructive~~

which is the exp for path diff between two reflected waves in case of a parallel thin film

Path difference

$$\delta = 2\mu t \cos r - \frac{\lambda}{2}$$

Condition for constructive & distructive Interference when 2 interfering wave pulse have a displacement in same direction the resultant displacement is greater than displacement of either wave

(i) Condition for constructive interference.

seen when crests meet a crests & trough meets trough

WKt PD ⇒ $\delta = n\lambda$ where $n = 0, 1, 2 \ldots$ → (11)

equaling eq^{n}s (10) & (11)

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

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

$$= \lambda\left(\frac{2n+1}{2}\right)$$

$$= (2n+1)\frac{\lambda}{2} \rightarrow (12)$$

(ii) Condition for destructive interference.

when 2 interfering waves have displacement in oppo direction the resultant displacement is smaller than either wave

equaling eq^{n}s (12) & (10)

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

$$\frac{2n\lambda}{2} + \frac{\lambda}{2} = 2\mu t \cos r - \frac{\lambda}{2}$$

The destruction is not permanent condition. Destructive interference is only a momentary condition in which the displacement of medium is 0.
At total des. Int. .. net wave shape of P.E are zero. The wave energy is stored in medium completely in form of K.E

2-common

$$\frac{\cancel{2}n\lambda}{2} + \frac{\cancel{2}\lambda}{\cancel{2}} = \cancel{2}\mu t\cos r.$$

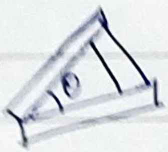
$$2\mu t\cos r = n\lambda + \lambda$$

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

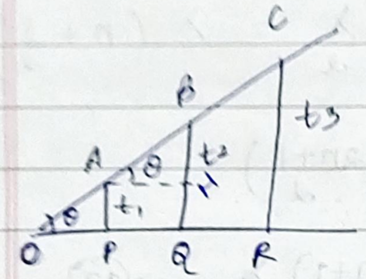
$$2\mu t\cos r = n\lambda \quad \text{when } n=0.$$

Wedge shaped film

wedge → 0 thickness at one end and progressively ↑ to particular thickness at other end



fringe width → distance between 2 successive dark or bright fringes.



consider wedge of the wedge "θ"
dark fringe lies at A next at B, next at C

Also

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

WKT condⁿ for distractive interference is

$$2\mu t\cos r = n\lambda \rightarrow (2)$$

for normal incidence $i = r = 0$

eqⁿ (2) takes the form

$2\mu t = n\lambda$

$2t\mu = n\lambda \rightarrow (4)$

for n^{th} dark fringe occuring at A, the equation (4) may be written as

$\mu 2t_1 = n\lambda \rightarrow (5)$

for $(n+1)^{th}$ dark fringe lying at point B we can write

$2\mu t_2 = (n+1)\lambda$

$\mu 2t_2 = (n+1)\lambda$

Sub (5) from (6)

$2t_2 - 2t_1 = (n+1)\lambda - n\lambda$

$2(t_2 - t_1) = \cancel{2}\left(\frac{(n+1)\lambda}{\cancel{2}\mu} - \frac{n\lambda}{\cancel{2}\mu}\right)$

$2\mu(t_2 - t_1) = \lambda \rightarrow (7)$

But from Δ right angle triangle AMB

$\tan\theta = \frac{MB}{AM}$

$MB = AM\tan\theta \rightarrow (8)$

But $MB = QB - PA$

$= t_2 - t_1 \rightarrow (9)$

~~wrt condition~~

where t_1 is the thickness of film at the point A where A is the n^{th} dark fringe is lying & t_2 is the thickness of film at the point B where B is the $(n+1)$th dark fringe is lying.

from eq^n 8 & 9

$$AM \tan\theta = t_2 - t_1$$

But $AM = \beta$ = the fringe width which is the distance between successive dark (or bright) fringes is

$$t_2 - t_1 = \beta \tan\theta \rightarrow 10$$

Sub eq^n 10 in 7

we get $2\mu\beta \tan\theta = \lambda$

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

Since angle θ is very small we can take $\tan\theta \approx \theta$ only.

$$\beta = \frac{\lambda}{2\mu\theta} \rightarrow (11)$$

which is expression for fringe width.

V.V.Imp

Newtons Rings

They another example of fringes of equal thickness, formed when plano-convex lens of length L of large radius of curvature placed on a sheet glass

Path diff between the two inter fringe wave is given by

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

Bright rings the condn

$$\delta = n\lambda$$

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

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

which is the condition for bright ring

Dark rings

$$\delta = (2n+1)\frac{\lambda}{2}$$

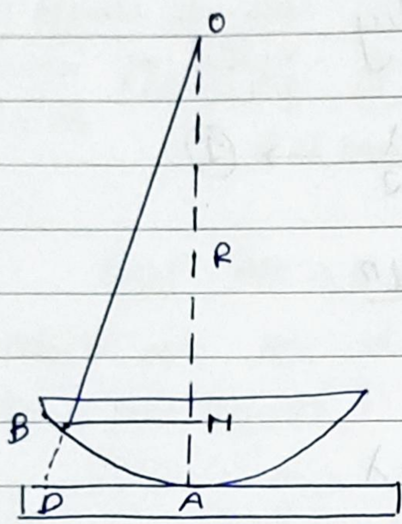
$$2\mu t \cos r - \frac{\lambda}{2} = (2n+1)\frac{\lambda}{2}$$

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

In general

$$2\mu t \cos r = n\lambda \rightarrow (3)$$

<u>Expression for radius of n^{th} dark ring</u>



Condition for n^{th} dark ring

$$2\mu t \cos r = n\lambda \rightarrow (3)$$

For normal incidence eq (3) can be written as

$$2\mu t = n\lambda \rightarrow (4) \quad (\because i = r = 0)$$

From geometry of the fig from right angle Δ^{le} OMB

$$OB^2 = OM^2 + MB^2$$

$$OB^2 = (OA - AM)^2 + MB^2$$

$OB = OA = R \rightarrow$ radius of curvature of plano convex lens

$$OB^2 = (R - AM)^2 + MB^2$$

$R^2 = (R - AM)^2 + MB^2$

But $AM = BD = t \rightarrow$ thickness of the film at n^{th} dark ring

Also $MB = r_n = AD$

$r_n \rightarrow$ radius of dark ring.

$\therefore$ The above equation becomes

$$R^2 = (R - t)^2 + r_n^2$$

$$r_n^2 = 2Rt - t^2$$

Since, t^2 is $<<< 2Rt$ we can neglect t^2 in the above exp.

$$r_n^2 = 2RT \rightarrow (5)$$

equating eq^{n}s (5) & (4)

$$2t = \frac{r_n^2}{R} \qquad 2t = \frac{n\lambda}{\mu}$$

$$\frac{r_n^2}{R} = \frac{n\lambda}{\mu}$$

$$r_n^2 = \frac{Rn\lambda}{\mu}$$

$$r_n = \sqrt{\frac{Rn\lambda}{\mu}} \rightarrow (6)$$

for air film between the glass plate & plano convex lens, the eq^n (7) may be written as

$$r_n = \sqrt{n\lambda R}$$

$$r_n = \sqrt{n\lambda R} \rightarrow \sqrt{n}\sqrt{\lambda R}$$

$$r_n \propto \sqrt{n}$$

for $n=1$ $\quad r_1 = 1$

$n=2$ $\quad r_2 = 1.144$

$n=3$ $\quad r_3 = 1.732$

$n=4$ $\quad r_4 = 2$

$n=5$ $\quad r_5 = 2.236$

$\left.\begin{matrix} r_1 \\ r_2 \end{matrix}\right\} 0.4$ $\quad \left.\begin{matrix} r_2 \\ r_3 \end{matrix}\right\} 0.3$ $\quad \left.\begin{matrix} r_3 \\ r_4 \end{matrix}\right\} 0.2$

Numericals

1] Fringes of equal thickness are observed in a thin glass wedge of $\mu = 1.52$. The fringe spacing is 0.1 um, wavelength of ligth is 589.3nm. Calculate wedge angle)

$\mu = 1.52$

$\lambda = 589.3 \times 10^{-9}$

$\beta = 0.1 \times 10^{-6}$

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

$$\theta = \frac{\lambda}{2\mu\beta} = \frac{589.3 \times 10^{-9}}{2 \times 1.52 \times 0.1 \times 10^{-6}}$$

$$\theta = 1938.48 \times 10^{-3}$$

$$\theta = \frac{1.93 \times 180}{\pi}$$