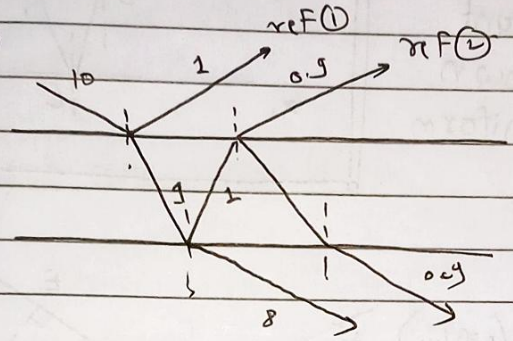
Types of interforance : ① Due to division of wavefront → 12 y n → Doubl Sli & str

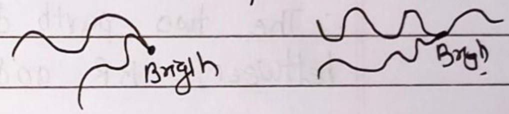
② Due to division of amplitude → <u>Now</u>

Division by Amplitude (General not accurate diagram)

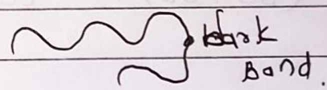


	max	min
Reflected	1 + 0.9 → 1.9 disting	1 − 0.9 = 0.1 disable
Transmis	8 + 0.09 → 8.09 non distinguiable	8 − 0.09 → 7.97

Note ① Constructive interference ⇒ crust + crust / trough + trough



② Destructive interference ⇒ crust + trough



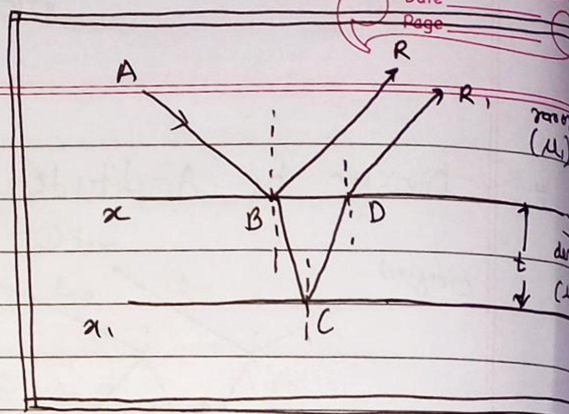
Derivations :

1] ⇒ Obtain condition of maxima and minima in thin unifor film due to reflected light [7 marks]

P.T.O

Derivation

$\Delta \equiv$ Path difference

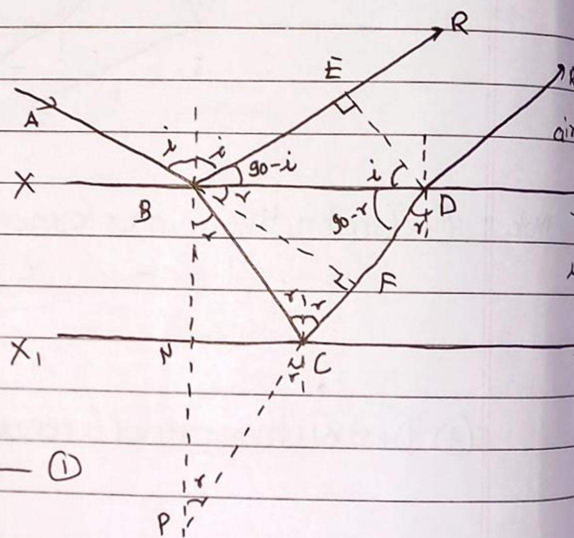


* 1]. ⇒ When BR and DR_1 interfer each other a resultant pattern is form known as interference in uniform thin film

We know,

For maxima $\Delta = n\lambda$ — $(n = 0, 1 \ldots)$

For minima $\Delta = (2+1)\frac{\lambda}{2}$



∴ The two path difference bettween BR and DR_1

$$\Delta = (BC + CD)\mu - (BE)\mu_4$$
$$= (BC + CD)\mu - (BE)1 \quad \text{—— (1)}$$

In triangle BED & BFD

According to Snell's law

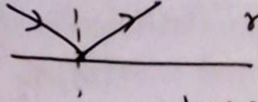
$${}_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{\sin i}{\sin r} = \frac{BE/BD}{FD/BD} = \frac{BE}{FD}$$

$$\therefore \quad \mu = \frac{BE}{FD} \quad - \quad (\mu_1 = 1)$$

$$\therefore \quad BE = \mu FD \quad \text{———— (2)}$$

From equation (1) and (2)

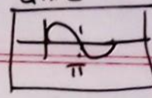
Note ⇒



Path diff in incident and reflect

$\Delta = \lambda/2$

Phase diff = π



$$\Delta = (BC + CD - FD)\mu$$
$$= (BC + CF)\mu \quad — (3)$$

In ΔNBC and ΔNPC

$\angle NBC = \angle NPC = r^\circ$

$\angle BNC = \angle PNC = 90^\circ$

$NC \cong NC$ — (common)

$\therefore \Delta NBC \cong \Delta NPC$

$\therefore BC = PC \quad — (4)$

$BN = PN = t$

$\therefore$ From (3) and (4)

$$\Delta = (PC + CF)\mu$$
$$= (PF)\mu \quad — (5)$$

In ΔBPF

$$\cos r = \frac{PF}{BP} = \frac{PF}{BN + NP} = \frac{PF}{2t}$$

$\therefore \quad PF = 2t\cos r \quad — (6)$

$\therefore$ from (5) and (6)

$$\Delta = (2t\cos r)\mu \quad — (7)$$

Condition for maxima.

$$\Delta = n\lambda$$

$\therefore 2\mu t \cos r \pm \lambda/2 = n\lambda$

① $2\mu t \cos r - \lambda/2 = n\lambda$

$\therefore \boxed{2\mu t \cos r = (2n+1)\frac{\lambda}{2} \quad - n=(0,1,2..)}$

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

$\therefore \boxed{2\mu t \cos r = (2n-1)\frac{\lambda}{2}} \quad — \quad n = (1,2,3)$

Conditions for minima.

$$\Delta = (2n+1)\lambda/2$$

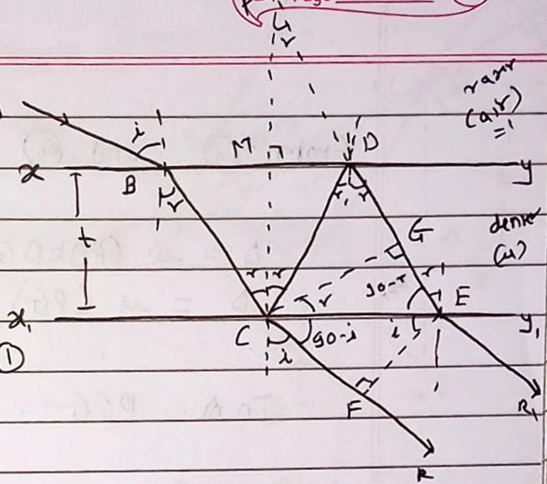
$\therefore 2\mu t \cos r \pm \lambda/2 = (2n+1)\lambda/2$

① $2\mu t \cos r - \lambda/2 = (2n+1)\lambda/2 \quad - \quad n = (0,1,2)$

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

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

Obtain Condition for maxima & minima in thin uniform film due to transmitted light



$\Rightarrow$ To Find the path difference between CR and ER,

$$\Delta = \mu (CD + DE) - \mu_r (CF)$$
$$= \mu (CD + DE) - CF \quad \text{---} (1)$$

In ΔCGE and ΔCFE

According to snell's law

$$\mu = \frac{\sin i}{\sin r} = \frac{CF/CE}{GE/CE} = \frac{CF}{GE}$$

$$\therefore \boxed{CF = \mu GE} \quad \text{———} (2)$$

$\therefore$ from (1) and (2)

$$\Delta = \mu (CD + DE - GE)$$
$$= \mu (CD + DG) \quad \text{---} (3)$$

In ΔMPD and ΔMCD

$$\angle PMD = \angle CMD = 90$$
$$MD \cong MD - (\text{common})$$
$$\angle MPD \cong \angle MCD = r$$
$$\therefore \Delta MPD \cong \Delta MCD$$

$$\therefore \left.\begin{aligned} PD &= CD \\ PM &= CM = t \end{aligned}\right\} \text{---} (4)$$

From (3) and (4)

$\therefore \Delta = \mu (PD + DG)$

$\Delta = \mu (PG)$ — (5)

In $\triangle$ PCG

$\angle LPG = r$ $\angle PGC = 90°$

$\therefore \cos r = \frac{PG}{PC} = \frac{PG}{PM + CM} = \frac{PG}{2t}$ — (from (2))

$\therefore PG = 2t \cos r$ — (6)

$\therefore$ From (5) and (6)

$$\boxed{\Delta = 2\mu t \cos r}$$

<u>Condition for maxima</u>

$\Delta = n\lambda$

$\therefore \boxed{2\mu t \cos r = n\lambda}$ — $(n = 0, 1, 2 ..)$

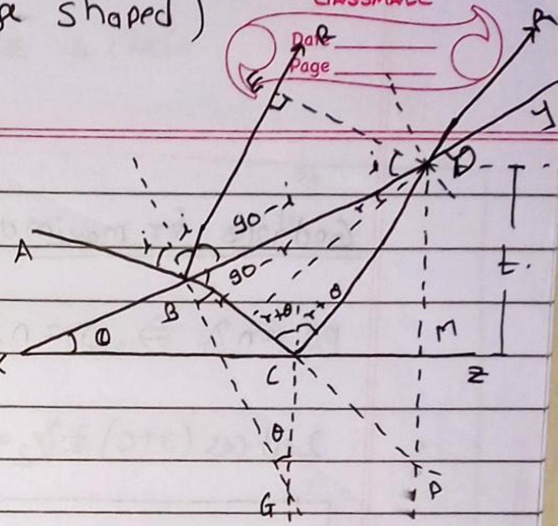
<u>Condition for minima</u>

$\Delta = (2n \pm 1)\frac{\lambda}{2}$ —

$\therefore \boxed{2\mu t \cos r = (2n + \frac{1}{2})\frac{\lambda}{2}}$ — $(n = 0, 1, 2 ..)$

$\boxed{2\mu t \cos r = (2n - 1)\frac{\lambda}{2}}$ — $(n = 1, 2, 3 ...)$

Obtain the condition for maxima and mina due to non-unifor thin film (wedge shaped) due to rflected ligh.



⇒ To find path diff betwen BR & DR_1

$$\Delta = \mu(BC + CD) - \mu_1(BE)$$

$$\boxed{\Delta = \mu(BC+CD) - BE} \quad \text{--- (1)}$$

In ΔBED & ΔBFD.

According to snell's law

$$\mu = \frac{\sin i}{\sin r} = \frac{BE/BD}{BF/BD} = \frac{BE}{BF}$$

$$\therefore \boxed{BE = \mu BF} \quad \text{--- (2)}$$

$\therefore$ from (1) and (2)

$$\Delta = \mu(BC + CD - BF)$$

$$\therefore \boxed{\Delta = \mu_0 (CD + CF)} \quad \text{--- (3)}$$

In ΔDCM & ΔPCM

$\angle CDM = \angle CPM = r + \theta$.

$\angle CMD = \angle CMP = 90$

$CM = CM$ — (common)

$\therefore \Delta DCM \cong \Delta PCM$

$$\boxed{\begin{array}{l} CD = CP \\ DM = PM = t \end{array}} \quad \text{--- (4)}$$

From (3) & (4)

$$\Delta = \mu(CP + CF)$$

$$\therefore \boxed{\Delta = \mu(PF)} \quad \text{--- (5)}$$

In ΔPFD

$\angle PFD = 90$, $\angle DPF = r + \theta$.

$$\therefore \cos(r+\theta) = \frac{PF}{DP} = \frac{PF}{DM + MP} = \frac{PF}{2t}.$$

$$\therefore \boxed{PF = 2t\cos(r+\theta)} \quad \text{--- (6)}$$

$\therefore$ from (5) and (6)

$$\boxed{\Delta = \mu 2t \cos(r+\theta)}$$

Additional path diff is $\lambda/2$

$\therefore$ Effective path diff. will be

$$\boxed{\Delta = 2\mu t\cos(r+\theta) \pm \lambda/2}$$

Conditions for maxima

$PD = n\lambda \Rightarrow \Delta = n\lambda$

$\therefore 2\mu t\cos(r+\theta) \pm \lambda/2 = n\lambda$

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

$-(n = 0, 1, 2 \ldots)$

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

$-n(= 1, 2, 3 \ldots)$

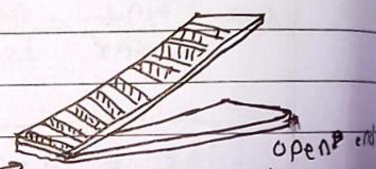
Condition for minima

$\Delta = (2n \pm 1)\lambda/2$

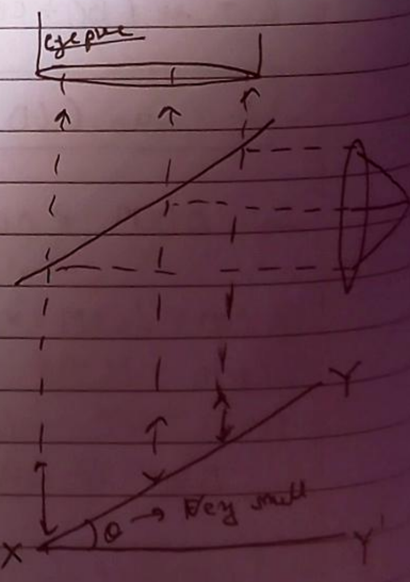
$\therefore 2\mu t\cos(r+\theta) \pm \lambda/2 = 2n \pm 1\,\lambda/2$

$\therefore \boxed{2\mu t\cos(r+\theta) = n\lambda}$ → integer

Note : wedge film



Experimental arrangement of wedged film



At point of contact
$t = 0 \qquad n = 0$

For maxima
$2\mu t\cos(r+\theta) = (2n+1)\lambda/2$
$\therefore \quad 0 \neq \lambda/2.$

For minima
$2\mu t\cos(r+\theta) = n\lambda$
$0 = 0$

$\therefore$ At point of contact there is 'Dark band'

Note : ① locus of all the point at equal thickness is straight line in wedge shaped film.
② locus of all the point of equal thickness is circle in newton rings

For Bright band.

$$2\mu t \cos(r+\theta) = (2n+1)\lambda/2 \quad - (n=0,1,2\ldots)$$

∴ if wedge medium is air $\mu = 1$
For normal incidence
$\theta = 0 \qquad i = 0 \quad r = 0$

$$\therefore \; 2t = (2n+1)\lambda/2$$

$$\therefore \boxed{t = (2n+1)\lambda/4}$$

$$\therefore t = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4} \ldots$$

For dark band.
$2\mu t \cos(r+\theta) = n\lambda$. — $(n=0,1,2)\ldots$
for normal incidence.

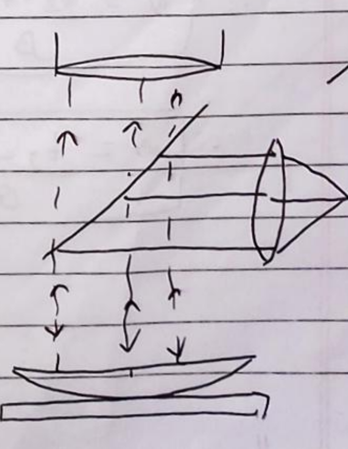
$$2t = n\lambda$$

$$\boxed{t = \frac{n\lambda}{2}}$$

$$\therefore t = 0, \frac{\lambda}{2}, \lambda, \frac{3\lambda}{2} \ldots$$

also applicable

Newton rings



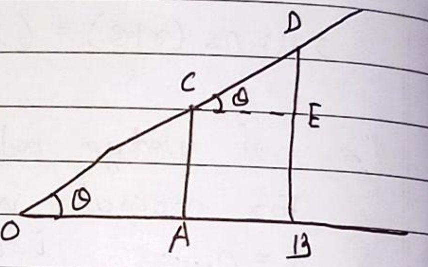
∴ For maxima : $t = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4} \ldots$

For minima : $t = 0, \lambda/2, \lambda, \frac{3\lambda}{2} \ldots$

Fringe width.

⇒ The distance between two conserutive Bright or Dark band is known as fringe width.

→ From figure.



0th dark is at the contact

'O' is point of ontact.

→ 'AC' is thickness of wedge shaped film at 1st dark band (t)

→ 'DB' is thickness of wedge shape film at 2nd dark band (t_2)

∴ AB is distance between consecutive dark band (β)

$\angle DOB = \angle BCE. = \theta$

$AB = CE = \beta$, $AC = BE = t_1$ ∴ $DE = t_2 - t_1$

$BD = t_2$

In ΔDCE

$$\tan\theta = \frac{DE}{CE} = \frac{t_2 - t_1}{\beta}$$

θ is very small ∴ $\tan\theta = \theta$

$$\therefore \boxed{\theta = \frac{t_2 - t_1}{\beta}}$$

$$\therefore \boxed{\beta = \frac{t_2 - t_1}{\theta}} \quad \text{— (1)}$$

Due to reflected rays

$2\mu t \cos(r+\theta) = n\lambda$ — (Dark band) - ($n=0,1,..$)

For normal incidence.

$$t = \frac{n\lambda}{2}$$

∴ At point A.

$t = t_1 = \frac{1\lambda}{2}$ — ($n=1$)

∴ $\boxed{t_1 = \frac{\lambda}{2}}$ — ②

At point B

$t = t_2 = \frac{2\lambda}{2}$

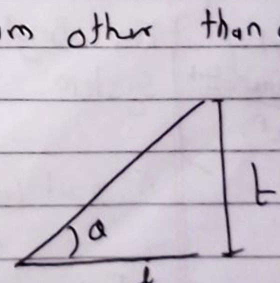
∴ $\boxed{t_2 = \lambda}$ — ③

∴ From ①, ② and ②

$$\therefore \beta = \frac{\lambda/2}{\theta}$$

$\boxed{\beta = \frac{\lambda}{2\theta}}$ — (for wedge medium is air)

$\boxed{\beta = \frac{\lambda}{2\mu\theta}}$ — (for wedge medium other than air



from fig $\tan\theta = t/l$.

θ is very small

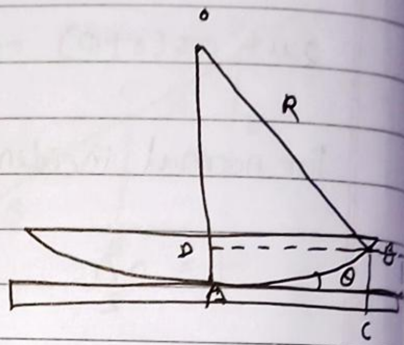
∴ $\theta = t/l$. — Ⓐ

$\beta = \frac{\lambda}{2\mu\theta}$ ∴ $\theta = \frac{\lambda}{2\mu B}$ — B

∴ $\frac{t}{l} = \frac{\lambda}{2\mu B}$ ∴ $\boxed{t = \frac{\lambda l}{2\mu B}}$

Diameter of Newton's ring:

⇒ From Geometry of figure



$OA = OB = R$

$BC = t \qquad AC = r_n = \text{radius}$

$\theta = \text{Wedge Angle}$

$AD = BC = t.$

$\therefore \boxed{OD = R - t}$

In ΔODB

$\angle ODB = 90^\circ$

$\therefore OB^2 = OD^2 + DB^2$

$R^2 = (R-t)^2 + (r_n)^2 \quad - (DB = AC = r_n)$

$\cancel{R^2} = \cancel{R^2} - 2Rt + t^2 + r_n^2$

$R >>>> t \;\therefore t^2$ can be neglected

$\therefore \quad r_n^2 = 2Rt.$

$$\therefore \boxed{t = \frac{(r_n)^2}{2R}} \quad -(1).$$

Dark in transmitted system.

For Bright ring in reflected System.

$\therefore 2\mu t \cos(r+\theta) = (2n+1)\lambda/2 \quad - (n = 0, 1 \ldots)$

$\therefore$ For normal incidence.

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

$$\boxed{t = (2n+1)\frac{\lambda}{4\mu}} \quad -(2)$$

$\therefore$ from (1) and (2)

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

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

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

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

$$\therefore \boxed{D_n = \sqrt{2(2n+1)\frac{\lambda R}{\mu}}}$$

for air $\boxed{\mu = 1}$

$$\therefore \boxed{D_n \propto \sqrt{2n+1}}$$

Bright in transmitted system

For Dark ring in reflected system
$\therefore$ $2\mu t \cos(r+\theta) = n\lambda$.
$\therefore$ for normal incidence.

$$2\mu t = n\lambda$$

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

$\therefore$ from (1) and (2)

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

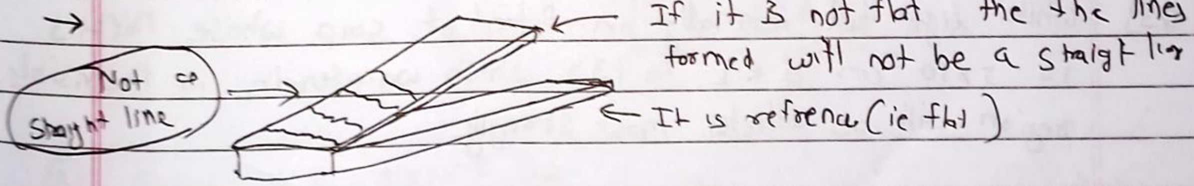
$$\therefore (D_n)^2 = \frac{4n\lambda R}{\mu}$$

$$\boxed{D_n = 2\sqrt{n\lambda R/\mu}}$$

$$\therefore D_n \propto \sqrt{n}$$

⇒ Applications

1] To Find optical flatness of any glass plate.

→ 

2] To Find radius of curvature of any Plano-convex lens

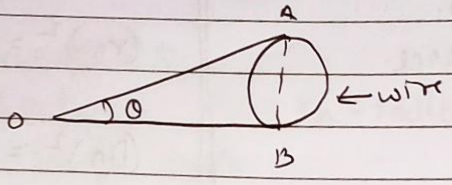
⇒ Using dark ring

$$(D_n)^2 = \frac{4n\lambda R}{\mu} \qquad (D_{n+p})^2 = \frac{4(n+p)\lambda R}{\mu}$$

$$\therefore (D_{n+p})^2 - (D_n)^2 = \frac{4p\lambda R}{\mu}$$

$$\therefore R = \frac{\left[(D_{n+p})^2 - (D_n)^2\right]\mu}{4p\lambda}$$

③ Diameter of Thin wire / Thikness of paper



$\boxed{t = d}$ $\boxed{t = \frac{\lambda}{2\mu\beta}}$

Q1] A beam of light with wavelength 5890 Å is incident on glass film with R.I 1.5 and angle of refraction 60°. Calculate the thikness of glass film whic will appear dark by 1st reflection

Q2) Find the thickness of soap film which will appear yellow with wavelength 5896° in 1st reflection when it is exposed by white light at an angle 45° R.I of film is 1.33

Q3] White light fall normally on film of soap whose thickness is 5×10^{-5} cm & R.I is 1.33 which wavelength in the visible region will be reflected most strongly

Answers ① Given: $\lambda = 5890$ Å   dark : $n = 1$

$\mu = 1.5$

$r = 60°$

⇒ We know.

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

$t = \frac{n\lambda}{2\mu \cos r} = \frac{5890 \times \cancel{10^{-10}} \text{ Å}}{\cancel{2} \times 1.5 \times 1/2} = 3926.6667$ Å