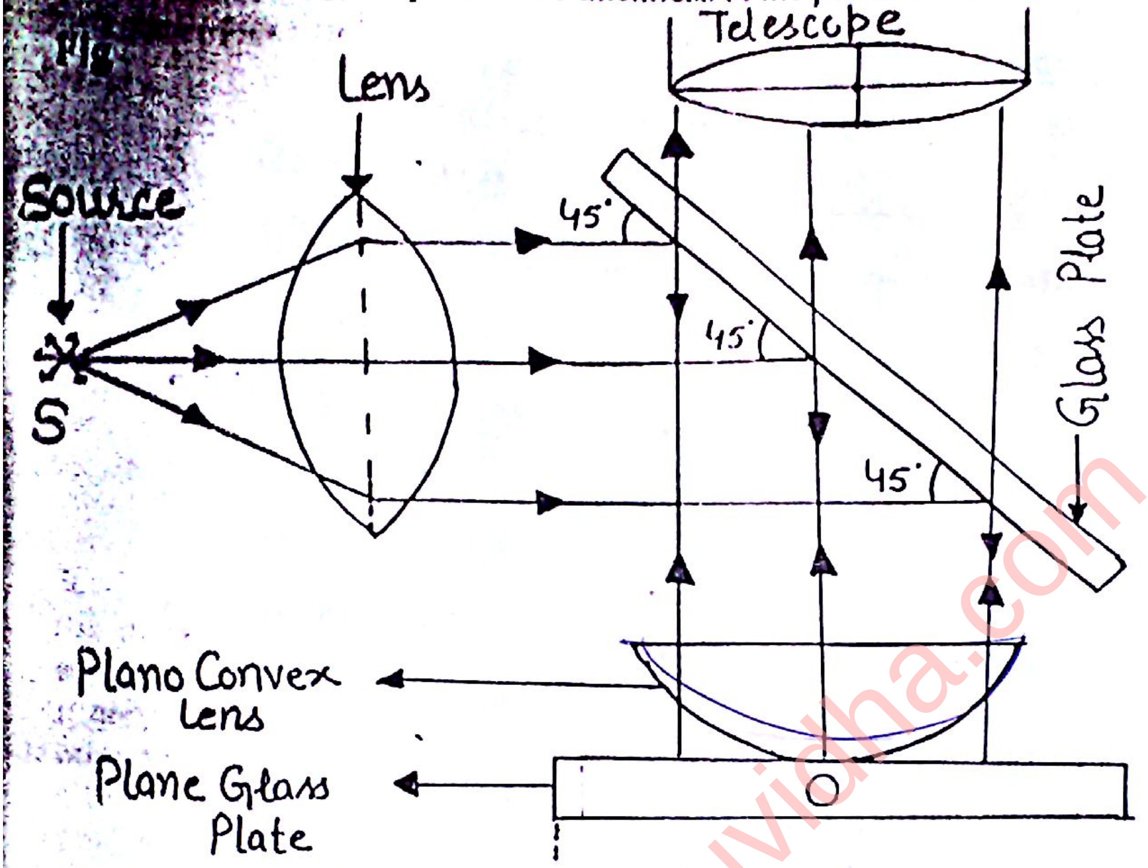
2.2 Newton's Ring

[illegible] When a Plano convex lens with its convex surface placed on a glass plate an air film of increasing thickness is formed between the Plano convex lens and glass plate. The thickness at the point of contact is zero.

Fig



If S be the source of monochromatic light. When light from the sources is allowed to fall on a convex lens. Then it render's a parallel beam of light .This parallel beam of light is allowed to fall on plane glass plate. That is placed at an angle 45^0 to the direction of incident beam of light. Then the glass plate reflects the incident beam of light normally towards the air film enclosed between the Plano convex lens and the glass plate. First of all this light is allowed to fall on a plane surface of Plano convex lens. Then a part of this light is reflected and a part of light is transmitted, then this transmitted light is allowed to fall on a curve surface of Plano convex lens. Then a part of this transmitted light is reflected and comes out in the form of ray no. 1 and a part of light is transmitted, after that this transmitted light is allowed to fall on a plane glass plate then a part of light is reflected and comes out in the form of ray no. 2 and a part of light is transmitted and comes out in the form of ray no. 4.

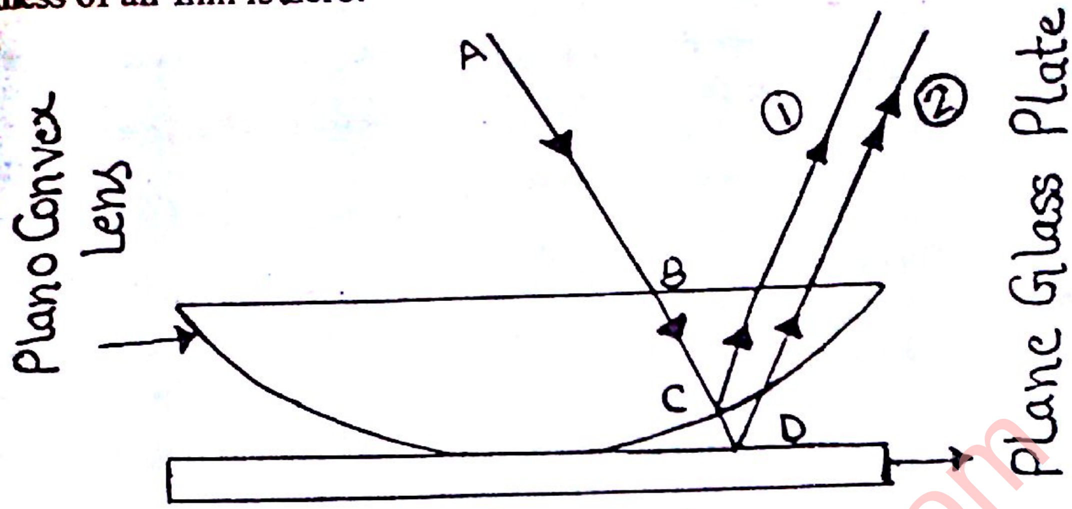
Thus at a particular constant thickness interference take place due to the reflected ray no. 1 and 2.

Due to convexity of Plano convex lens and at the particular constant thickness the radii are constant so that the interference patterns are take place in the form of concentric ring.

Diameter of Ring in Case Of Reflected Light:-

When a Plano convex lens placed on a glass plate then air film of increasing thickness is formed between both of them. But at the point of contact thickness of air film is zero.

Fig:



Let us suppose that a beam of monochromatic light (AB) is allowed to fall in the plane surface of a Plano convex lens then a part of this light is refracted along BC, when this refracted beam is allowed to fall on the curve surface of a Plano convex lens at a point C. Then a part of this BC ray will be reflected and comes out in form of ray no.1 and a part of this BC ray will be transmitted along CD. Then transmitted light is allowed to fall on the plane glass plate. Then a part of CD will be reflected and comes out in the form of ray no.2 and a part of ray will transmitted and comes out in the form of ray no.3

When these two reflected ray no. 1 and 2 are superimpose on each other then interference take place in the form of concentric ring. Thus interference pattern is either dark or bright depend upon path difference between the two reflected rays. Thus the path difference between two reflected ray will be:- $2\mu t\cos(r+\alpha)+\lambda/2$ .... (1)

But in our experiment rays are incident normally thus for normal incidence.

Angle of refraction (r) =0

For air film (μ) = 1

And if angle α = small then the $(r+\alpha)$ value almost zero if $(r+\alpha)=0$ then

$\cos(r+\alpha)=1$

Putting value of $\cos(r+\alpha)=1$, $\mu=1$ then the path difference between both of the reflected ray will be:-

$$2t+\lambda/2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

But at the point of contact thickness of air film is zero so that when t=0 then path difference between the two reflected ray is $\lambda/2$ which is condition of the minima so that at the point of contact in case of reflected ray interference pattern will be dark.

Diameter of Dark Or Bright Ring

A Plano convex lens that is a part of sphere whose radius of curvature (R) placed on a glass plate then air film of increasing thickness is formed between both of them. So at particular constant thickness (t) interference take place in the form of concentric ring. And suppose that is nth ring whose radius is r_n. And the ring will appear dark or bright depend upon path difference between the two reflected rays that is

$$2t + \lambda/2 \quad \ldots\ldots\ldots\ldots (1)$$

Now consider right triangle OAB in this triangle

OC = R, OA = (R- t) because AC =t, AB = r_n

Applying Pythagoras Theorm in this triangle

$$OB^2 = OA^2 + AB^2$$

$$R^2 = (R-t)^2 + r_n^2 \Rightarrow R^2 = R^2 + t^2 - 2Rt + r_n^2$$

$$0 = t^2 - 2Rt + r_n^2 \ldots\ldots\ldots\ldots (2)$$

In the Fig (AC = t) which is very small as compared to (OC =R) or (AB = r_n) So that t^2 in eq. (2) can be neglected then we get.

$$0 = -2Rt + r_n^2 \Rightarrow r_n^2 = 2Rt$$

$$\Rightarrow t = \frac{r_n^2}{2R} \ldots\ldots\ldots\ldots (3)$$

Putting value of (t) in Eq. (1) we get

$$\frac{2r_n^2}{2R} + \lambda/2 \ldots\ldots\ldots\ldots (4)$$

This is path difference between the reflected ray (1) and (2)

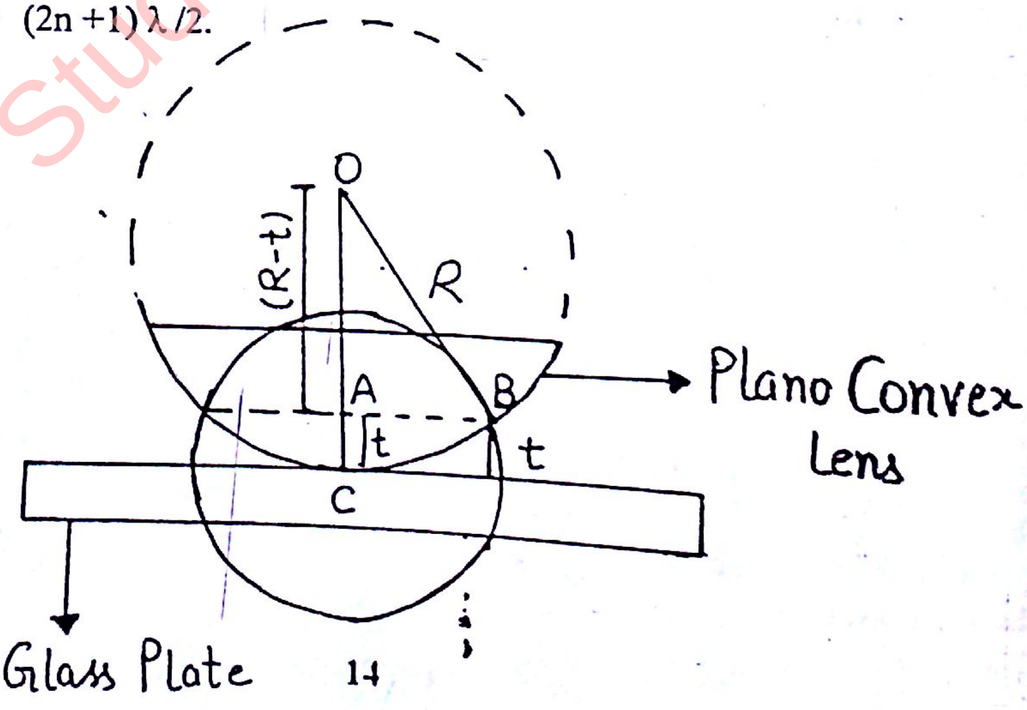
So that nth ring will appear bright only when path difference = $n\lambda$.

$$\Rightarrow \frac{r_n^2}{R} + \lambda/2 = n\lambda \ldots\ldots\ldots\ldots (5)$$

And nth ring will appear dark only when path difference

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

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

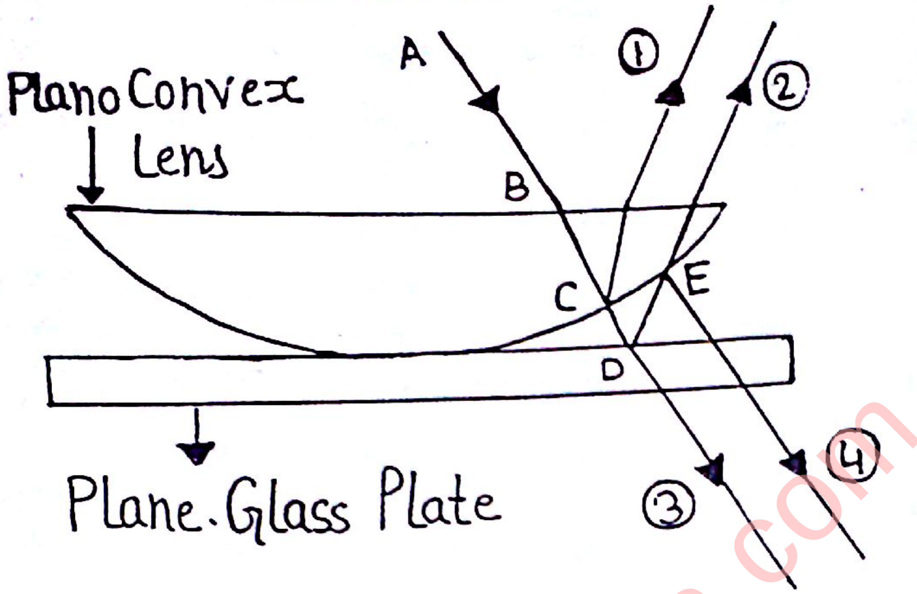


Calculation of diameter of dark and bright ring

Now n^{th} ring will appear bright only when $\frac{r_n^2}{R} + \lambda/2 = n\lambda$ $\Rightarrow \cancel{\frac{r_n^2}{R} + \lambda/2 = (2n-1)\lambda/2}$. $\Rightarrow \frac{r_n^2}{R} = (2n-1)\frac{\lambda R}{2}$ ......(6) Where r_n is the radius of n^{th} ring. So diameter of n^{th} ring bright ring will be. $D_n = 2r_n \Rightarrow r_n = D_n/2$ Putting value of r_n in Eq (6) $\frac{D_n^2}{4} = \frac{(2n-1)\lambda R}{2}$ $D_n^2 = \frac{4\lambda R}{2}(2n-1)$ $D_n = \sqrt{2\lambda R}\ \sqrt{2n-1}$ Thus the ring will appear bright whose diameter comes out to be $D_n = \sqrt{2\lambda R}\ \sqrt{2n-1}$	Now n^{th} ring will appear dark only when $\frac{r_n^2}{R} + \lambda/2 = (2n+1)\lambda/2$. Or $\frac{r_n^2}{R} = (2n+1)\lambda/2 - \lambda/2$ Or $\frac{r_n^2}{R} = n\lambda$ Or $r_n^2 = n\lambda R$ ....(7) Where r_n is the radius of n^{th} ring. So diameter of n^{th} ring dark ring will be. $D_n = 2r_n$ or $r_n = D_n/2$ Putting value of r_n in Eq (7) $\frac{D_n^2}{4} = n\lambda R$ $D_n^2 = 4n\lambda R$ $D_n = \sqrt{4n\lambda R}$ Thus the ring will appear dark whose diameter comes out to be $D_n = \sqrt{4n\lambda R}$

...er of dark and bright ring in case of transmitted Light:

... Plano convex lens placed on a glass plate than air film of increasing ...ness is formed between the Plano convex lens and glass plate.



Suppose that a beam of monochromatic light AB allowed to fall on a plane surface of a Plano convex lens then a part of this light will be refracted along BC then this light will allowed to fall on curve surface of a Plano convex lens. Then a part of light wills reflected and comes out in the form of ray No 1 & a part of light will be transmitted along CD. This light will be allowed to fall on a glass plate then a part of this light reflected along DE and a part of light will be transmitted and comes out in the form of ray No 3

Now our aim is to study interference between the transmitted rays no. (3) & (4). Now interference pattern between these rays depend upon path difference between transmitted rays. Then path difference between transmitted rays will be: $-2\mu t \cos(r+\alpha)$

(According *to principle of reversibility when a wave transmitted from an optically denser medium than no phase change occur. So in that case no additional path introduced in that case*)

For normal incidence $r = 0$

Angle of inclination α = small

So that $r + \alpha = 0 +$ small $= 0$

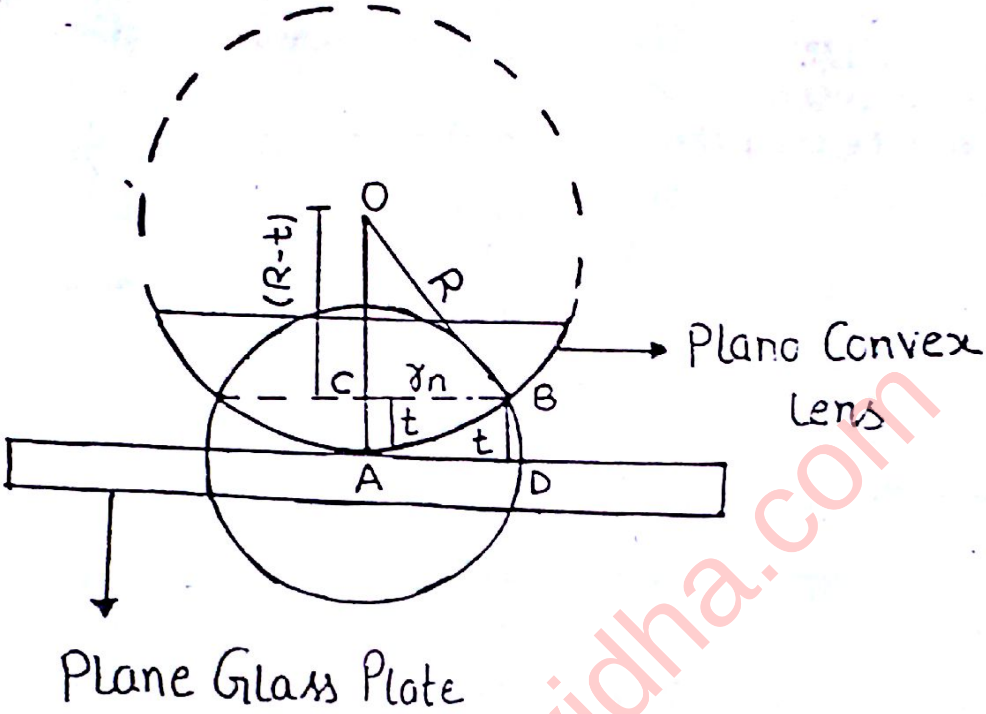
When $r + \alpha = 0$ then $\cos(r+\alpha) = 1$

For air film $\mu = 1$ then the path difference between two transmitted ray will be:

$2t$ .... (1)

At the point of contact $t = 0$ Thus the path difference between the two transmitted ray would be zero. That is the condition of maxima so that in that case central fringe is to be bright.

When a Plano convex lens that is a part of sphere of radius of (R) placed on a glass plate than air film of increasing thickness is between both of them



Then at a particular constant thickness interference is take place in the form of concentric ring. Let us suppose that n^{th} ring having radius r_n then
$AD = r_n$.
Now taking OCB right angle triangle in this triangle OA = R. AC= t. OC = R-t.
OB =R.
Applying Pythagoras Theorm in this triangle
$OB^2 = OC^2 + CB^2 \Rightarrow R^2 = (R-t)^2 + r_n^2$
or $R^2 = R^2 + t^2 - 2Rt + r_n^2$
or $0 = t^2 - 2Rt + r_n^2$
But t is very small in compersion of R so that t^2 can be neglected. then we get:-
$-2Rt + r_n^2 = 0$ or $2Rt = r_n^2$ or $t = \frac{r_n^2}{2R}$

Putting the value of t in eq. (1) we get then the path difference between two transmitted ray will be:-

$$\text{Path diff.} = 2.\frac{r_n^2}{2R} = \frac{r_n^2}{R}$$

Now n^{th} ring will appear bright only when path difference is equal to $n\lambda$.
Thus for bright ring :-

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

or $r_n^2 = n\lambda R$ ....(2)

As $D_n = 2r_n \Rightarrow r_n = D_n/2$

Putting Value of r_n in Eq. (2)

$$\frac{D_n^2}{4} = n\lambda R \text{ or}$$

$$D_n^2 = 4n\lambda R$$

or $D_n = \sqrt{4n\lambda R}$

Thus conditions are reversed

Now n^{th} ring will appear dark only when path difference is equal to $(2n-1)\lambda/2$ Thus for dark ring :-

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

or $r_n^2 = \frac{\lambda R}{2}(2n+1)$ ....(3)

or $D_n = 2r_n \Rightarrow r_n = D_n/2$

Putting Value of r_n in Eq. (3)

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

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

or $D_n = \sqrt{2\lambda R}\sqrt{2n+1}$

Application of Newton's Ring:-

First of all the experiment is performed and diameter of dark ring is comes out to be: -

$$D_n^2 = 4n\lambda R\text{................ (1)}$$

Similarly we can calculate the diameter of $(n+p)^{th}$ ring that comes out to be:-

$$D_{n+p}^2 = 4(n+p)\lambda R\text{ .... (2)}$$

Subtracting Eq. (2) and (1) we get.

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

Or $\lambda = D_{n+p}^2 - D_n^2/4pR$.

Where R is radius of curvature of Plano convex lens.

2 Determination of refractive Index of a liquid:-

First of all the experiment is performed and diameter of dark ring is comes out to be: -

$$D_n^2 = 4n\lambda R\text{................ (1)}$$

After that take a box in that box whole of apparatus is placed in that box. Now that liquid whose refractive index (μ)we can find out placed in that box. So in that case liquid film is made instead of air film again calculate diameter of dark ring that comes out to be:-

$$D_n'^2 = 4n\lambda R/\mu\text{..................(2)}$$

Dividing Eq. (1) And (2) we get.

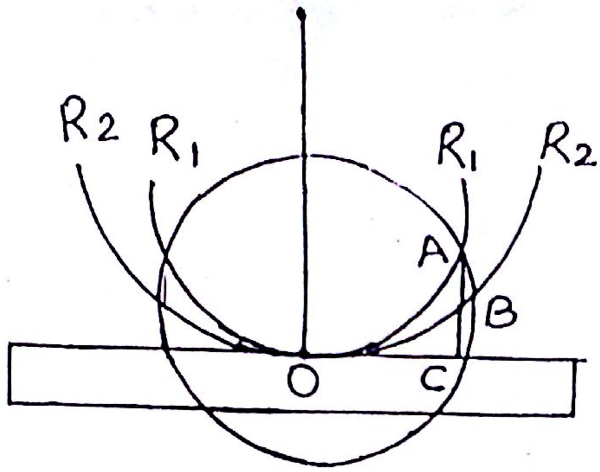
$$\frac{D_n^2}{D_n'^2} = \frac{4n\lambda R \times \mu}{4n\lambda R} = \mu.$$

Thus $\mu = \frac{D_n^2}{D_n'^2}$ in such a way we can calculate refractive index of a liquid.

...ton's Ring formed by two curved Surface:-

Consider two curved surface of radius of curvature R_1 and R_2 placed in ... a way that they are contact at a point O Then air film of increasing thickness is formed between the two surface.

Fig:



Then at particular constant thickness AB interference take place in the form of concentric ring. Suppose that n^{th} ring and radius of that n^{th} ring is r_n. That n^{th} ring will appear dark and bright depend upon path difference between the two reflected ray that comes out to be:-

$2\mu t \cos(r+\alpha) + \lambda/2$ .... (1)

For air film $\mu = 1$. For normal incidence $r = 0$

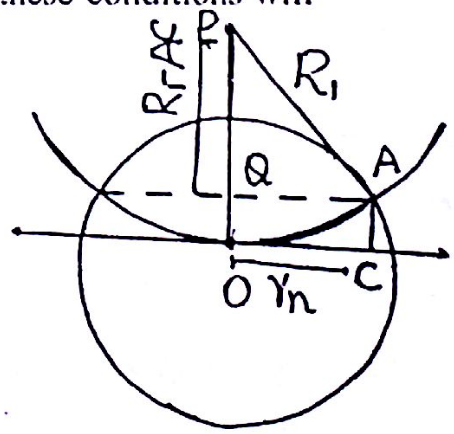
Angle of inclination α = small then path difference under these conditions will be: $2t + \lambda/2$ .... (A)

Here $AB = t = AC - BC$

Now calculate value of AC and BC

In this fig. taking right angle triangle PQA in this triangle

$OP = R_1$, $OQ = AC$, $PQ = R_1 - AC$, $AP = R_1$, $AQ = r_n$.



Applying Pythagoras Theorm we get

$AP^2 = PQ^2 + QA^2$

$R_1^2 = (R_1 - AC)^2 + r_n^2$

$R_1^2 = R_1^2 + AC^2 - 2R_1 AC + r_n^2$

$0 = AC^2 - 2R_1 AC + r_n^2$

Now AC is very small as compared to R_1 and r_n So in that case AC^2 can be neglected then we get

$0 = 2R_1 AC + r_n^2$ or $r_n^2 = 2R_1 AC$

or $AC = r_n^2/2R_1$ .... (1)

Similarly we can calculate value of BC

Now taking right angle triangle OQB in this right angle triangle:

$OP = R_2$, $OQ = R_2 - BC$, $QB = r_n$, $OQ = R_2 - BC$, $OB = R_2$

Applying Pythagoras Theorm we get

$OB^2 = OQ^2 + QB^2$

$R_2^2 = (R_2 - BC)^2 + r_n^2$

$R_2^2 = R_2^2 + BC^2 - 2 R_2 BC + r_n^2$

or $0 = BC^2 - 2 R_2 BC + r_n^2$

Now BC is very small as compared to R_2 and r_n So in that case BC^2 can be neglected then we get

$0 = -2 R_2 BC + r_n^2$ or $r_n^2 = 2 R_2 BC$

or $BC = r_n^2/2 R_2$ .... (2)

Putting value of AC and BC in AB we get

$t = AB = AC - BC = \frac{r_n^2}{2R_1} - \frac{r_n^2}{2R_2} = r_n^2/2 \,[1/R_1 - 1/R_2]$

Putting value of t = AB in Eq. (A).

$r_n^2 [1/R_1 - 1/R_2] + \lambda/2$ .... (3)

Thus the ring will appear bright only when path diff. = n λ. thus

$r_n^2 [1/R_1 - 1/R_2] + \lambda/2 = n\lambda$

or $r_n^2 [1/R_1 - 1/R_2] = n\lambda - \lambda/2 = (2n-1)\lambda/2$

or $r_n^2 \left[\frac{R_2 - R_1}{R_1 R_2}\right] = (2n-1)\lambda/2$

$r_n^2 = \frac{\lambda R_1 R_2 (2n-1)}{2(R_2 - R_1)}$

But $D_n = 2r_n \Rightarrow r_n = D_n/2$

Putting value of r_n and get diameter of bright ring:-

$\frac{D_n^2}{4} = \frac{\lambda R_1 R_2 (2n-1)}{2(R_2 - R_1)}$ or $D_n^2 = \frac{4\lambda R_1 R_2 (2n-1)}{2(R_2 - R_1)}$

or $D_n^2 = 2\lambda R_1 R_2 (2n-1)/(R_2 - R_1)$

And the ring will appear dark only when

Path diff. $= r_n^2 \left[\frac{1}{R_1} - \frac{1}{R_2}\right] + \lambda/2 = (2n+1)\lambda/2$

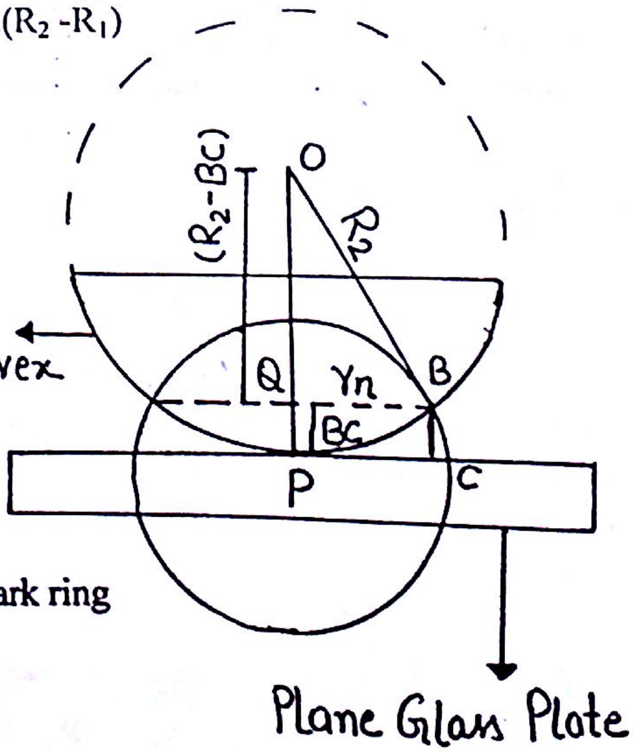
or $r_n^2 \left[\frac{R_2 - R_1}{R_1 R_2}\right] = n\lambda + \lambda/2 - \lambda/2$

or $r_n^2 \left[\frac{R_1 - R_2}{R_1 R_2}\right] = n\lambda$

$r_n^2 = n\lambda \frac{R_2 R_1}{R_2 - R_1}$ But $D_n = 2r_n$

Putting value of r_n and we get diameter of dark ring

$\frac{D_n^2}{4} = \frac{n\lambda R_2 R_1}{R_2 - R_1}$



or $D_n^2 = \dfrac{4n\lambda R_2 R_1}{R_2 - R_1}$

Case II

When both curved surface are placed in such a way that whose convex surface are contact at a point. Then air film of increasing thickness is formed between the two curved surfaces. Then at particular constant thickness AB interference take place in form of concentric ring. Suppose that is nth ring whose radius is r_n that nth ring will appear dark or bright depend upon path difference between the two reflected rays that is

$$2t+\lambda/2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Here $t = AB = AC + BC$

Now value of AC and BC are

$AC = \dfrac{r_n^2}{2R_1}$ and $BC = \dfrac{r_n^2}{2R_2}$

Putting value of AC and BC we get

$t = AB = \dfrac{r_n^2}{2}\left[\dfrac{1}{R_1}+\dfrac{1}{R_2}\right] = \dfrac{r_n^2\,[R_1 + R_2]}{2\,R_1R_2}$

Putting value of $t = AB$ in Eq. (1) we get path difference

Path diff. $= r_n^2 \dfrac{[R_1 + R_2]}{R_1 R_2} + \lambda/2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$