1. Physics of optics

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* Interference of Light

The phenomenon in which two cohrent light waves surpose to form a resultant wave of greater or lower amplitude.

Types

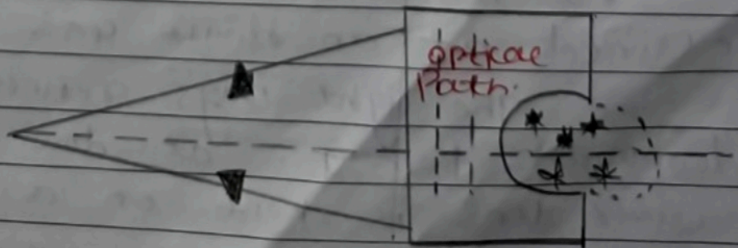
a] Constructive interference : If a crest of one wave.

Introduction :

Optics is one of the special branch in Physics which deals with the study of Behaviour & Properties of light.
There are two types of optics light as a collection of rays that travel in a straight line.
In Physical optics light travel as a wave.

Optical Path :

Optical Path is a optical medium path where light can travel.



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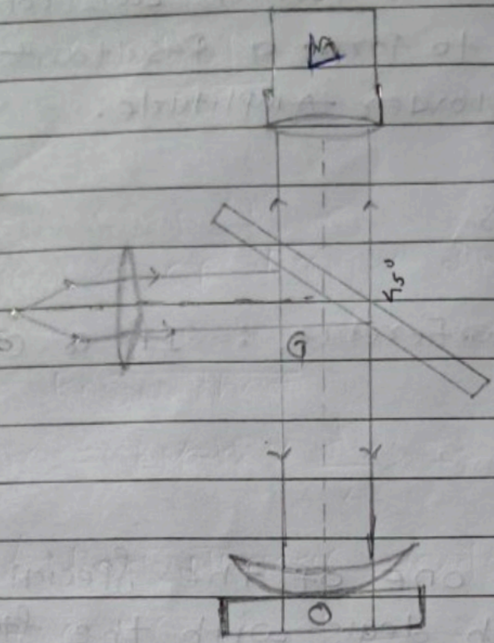
* Newtons Ring :



M - Microscope

In above diagram experimental arrangment of newtons Ring is shown. in diagram

- S is source of monochromatic light.
- L is conversing lens / convex
- G is Glass plate
- O is centre of plano-convex lens

are arranged neatly.

A Parallel beam of monochromatic light is incident on lens L, the light ray travelling as a wave ~~light~~ guide.

It fall on glass Plate (G) which is inclined at an angle 45°.

The light rays reflected toords downwords from G. at downword plano-convex lens is kept on a glass plate.

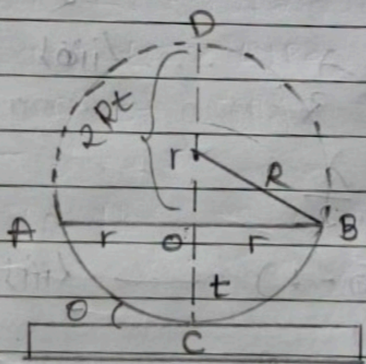
bright – constructive Interference
dark – destuctive interference.

After falling light rays on plano-convex lens, it a get back reflected to upward direction. where microscope is arranged.
~~the~~ .

the two light rays produced upper & lower constructtive and destructive interference. due to plano-convex lens.

It is observed that the dark & bright concentric rings. ~~at~~ point of contact O this is called as newtons ring.

Diameter of Newtons Ring:-



AB – length of planoconvex lens

OC – Thickness of planoconvex lens.

from property of circle

$AO \times OB = OC \times OD$

$r \times r = t \times 2R - t$

$r^2 = t \times 2R \; \{ O >> t \}$ so t is neglected.

$$\boxed{t = \frac{r^2}{2R}} \quad \text{—— (i)}$$

Eqn (I) is thicness of Diameter.

$$\boxed{D = 2R = \frac{r^2}{t}}$$

Eqn (I) is thickness of Planoconvex lens of Newtons Ring.

* Diameter of Bright Ring :- {constructive Interference}

We know that,

$$\Delta x = \text{Even} \times \frac{\lambda}{2} \quad \text{-----} \quad \left\{ \begin{array}{c} \text{for} \\ \text{maxima} \end{array} \right\}$$

(For Normal incidence $\theta <<< 0$)

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

$\theta << 0$

$$2\mu t + \frac{\lambda}{2} = 2n\frac{\lambda}{2} \quad \ldots \langle ii \rangle$$

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

$$2\mu t = \frac{\lambda}{2}(2n-1) \quad \text{——} \quad \langle iii \rangle$$

put the value of t in Eqn (iii)

$$2\mu\left(\frac{r^2}{2R}\right) = \frac{\lambda}{2}(2n-1)$$

$r^2 = D^2/2$

$D^2/2$

$$r^2 = \frac{(2n-1)\lambda R}{2\mu}$$

$$r^2 = \frac{(2n-1)\lambda R}{2} \quad \left\{ \because \mu = 1 \text{ due to air arrived} \right\}$$

D - Diameter

Radius (r) = $\frac{Dn}{2}$

$$\left(\frac{Dn}{2}\right)^2 = \frac{(2n-1)\lambda R}{2}$$

$$(Dn)^2 = \frac{\cancel{4}^2 (2n-1)\lambda R}{\cancel{2}}$$

$$\boxed{Dn = \sqrt{2(2n-1)\lambda R}} \text{ —— (iv)}$$

$$Dn \propto (2n-1)$$

* Diameter of Newton Dark Ring :- {distructive inter.}

We know that

{Minima}

$$\Delta x = \text{odd} \times \frac{\lambda}{2}$$

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

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

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

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

$$2\mu t = n\lambda \text{ —— (3)}$$

Put the value of t in eq^n (3)

$$\cancel{2}\mu\left(\frac{r^2}{\cancel{2}R}\right) = n\lambda$$

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

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

$$\left(\frac{Dn}{2}\right)^2 = \frac{n\lambda R}{\mu}$$

$$\left(\frac{Dn^2}{2}\right) = \frac{n\lambda R}{\mu}$$

$$Dn^2 = \frac{4n\lambda R}{\mu}$$

$$Dn^2 = 4n\lambda R \quad \{\mu = 1\}$$

$$Dn = \sqrt{4n\lambda R} \quad \text{—— (4)}$$

$$\underline{Dn = 2\sqrt{n\lambda R}}$$

Applications of Newton's Ring :-

There are many applications of newton's Ring following are few applications of Newtons Rin

1) Deremination of wavelength of monochromatic Light.

ii) Determination of Refractive index of medium

iii) Newton's Ring in AntiReflective coatings.

Determination of wavelength of monochromatic light.

The diameter of OF Newton's Dark ring is

$$D_n = \sqrt{4n\lambda R} \quad \text{——— (I)}$$

Simillarly, The Diameter of (n+P) upcoming Ring is $D_{n+P} = \sqrt{4(n+P)\lambda R}$ ——— (II)

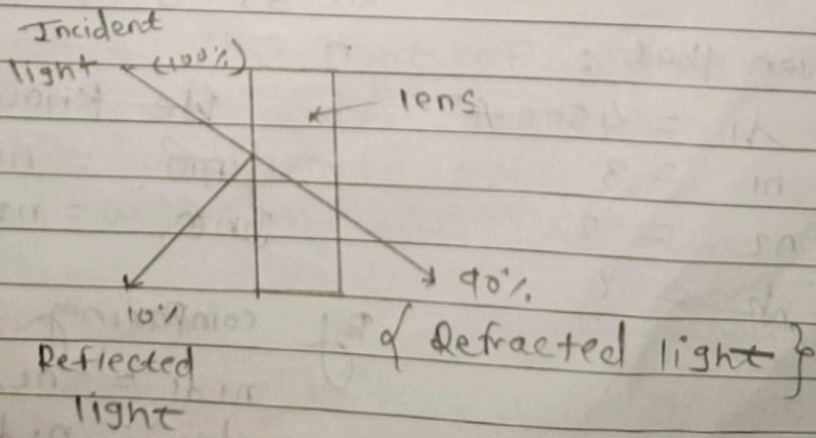
from (I) & (II)

$$\lambda = D(n^2$$

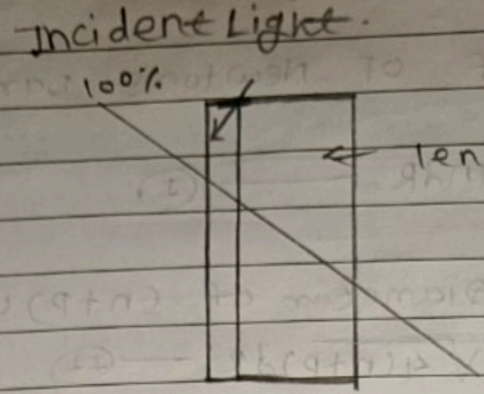
- Application of Newton's Ring in Antirelactive coating.

~~Antirelactive~~ coating minimize the reflection of one & many wavelength and are typically used or Surface lenses So that minimum light is lost.

- Lens without Anti-Reflection coating.



- Lens with Anti-reflection coating :



following are some examples where ARC coatings are done.

For Ex. : (i) Spectacles (ii) camera lenses (iii) Laptop screen (iv) LED & LED screen etc.

* Numericals :

problem 1 : In case of plane diffraction Grating in ~~III~~rd order maxima having wavelength 45000 A° coincide with IInd order maxima of unknown wavelength. Calculate unknown wavelength.

$n_1 = 3, \lambda_1 = 45000$

Soln : Given that :

$\lambda_1 = 4500 A°$

$n_1 = 3$

$n_2 = 2$

$\lambda_2 = ?$

We know that

$\sin\theta = n_1 \lambda_1$

$\sin\theta = n_2 \lambda_2$

By comparing.....

$n_1\lambda_1 = n_2\lambda_2$

$\lambda_2 = \frac{n_1\lambda_1}{n_2} = \frac{4500 \times 3}{2}$

$$\frac{6750 + 13500}{2} = 6750 A^\circ$$

problem 2 : If sodium light of wavelength 5893 A° has doublet of 6 A°. calculate total no. of lines present on Grafting to Rueone the doublet of 3^{rd} order.

Soln → Given That,

$\lambda = 5893\ A^\circ$

$d\lambda = 6 A^\circ$

$n/m = 3$

$N = ?$

We know that....

$$R.P.\ \frac{\lambda}{d\lambda} = m/n \cdot N$$

$$N = \frac{\lambda}{n \times d\lambda} = \frac{5893}{3 \times 6}$$

$$= 327.38$$

$N = 327.$

Problem 3 : The light of wavelength 5890 A° in the 4th order overlaps with unknown wavelength in a 5th order. Find unknown wavelength.

→ Given that

$\lambda_1 = 5890 A^\circ$

$n_1 = 4$

$n_2 = 5$ $\lambda = ?$

we know that

$$\cancel{\sin\theta} = n_1 \cancel{\lambda} \lambda_1$$
$$\cancel{\sin\theta} = n_2 \cancel{\lambda} \lambda_2$$

$$\therefore \underline{n_1\lambda_1} = n_2\lambda_2$$

$$\lambda_2 = \frac{n_1\lambda_1}{n_2}$$

$$= \frac{4 \times 5890}{5} = \cancel{4712\,A^\circ} \; 4712\,A^\circ$$

$$\therefore \lambda_2 = 4712\,A^\circ$$