Government Degree College, Nandikotkur

1.1.1: The Institution ensures effective curriculum planning and delivery through a well-planned and documented process including Academic calendar and conduct of continuous internal Assessment

TEACHING SYNOPSIS 2019-20

TEACHING NOTES ACADEMIC YEAR

Academic Year : 2019-20

Name Of The Topic: Interference of ‖le thin film / colours of thin film
Course : physics

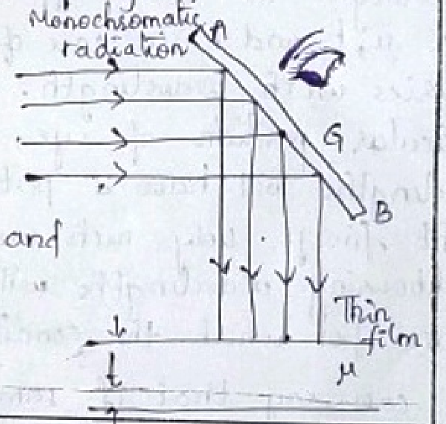
Hours Required	2
Learing Objectives	1. To enable the students to learn colours of thin film.
	2. To make them understand interference
	3. To apply previous knowledge
Previous Knowledge To Be Reminded	Interference

Topic Synopsis : Interference :- The phenomenon of multiple light waves interfering with one another under certain circumstances causing combined amplitudes of the waves to either increase or decrease.

Interference by a plane parallel film illuminated by a plane wave :-

Let a plane wavefront be allowed to incident normally on thin film of uniform thickness t. The plane wavefront is obtained with help of partially reflecting glass plate G inclined at an angle 45° with parallel monochromatic beam of light.

The plane wavefront is partly reflected at upper surface of film and partly transmitted into the film. It is then emerges from upper surface. The wavefront reflected from upper surface and the lower surface interfere with each other.



Teaching Aids Used	black board
Additional Inputs taught	charts, videos..
References cited	S.L Gupta and Sanjeev Gupta
Student Activity Planned After The Teaching	Seminars.

Signatur of the Lecturer /Reader

Signatur of the Lecturer I/C of the Dept

Signature of the Principal

Here we consider the following two points:

(i) The wave reflected from lower surface of film traverses an additional path $2\mu t$ [μt from upper to lower surface & μt from lower to upper surface] where μ is the refractive index of film.

(ii) when film is placed in air, the wavefront from upper surface undergoes an additional phase change of π. There is no phase change takes place at lower surface because reflection takes place at surface of rarer medium. Thus, conditions of maxima & minima are changed.

$2\mu t = n\lambda$ Conditions of destructive interference

$2\mu t = (2n+1)\frac{\lambda}{2}$ conditions of constructive interference

where $n = 0, 1, 2, 3 \ldots$

Thus, film appears bright when path difference $2\mu t$ is equal to $(2n+1)\frac{\lambda}{2}$ and dark when path difference $2\mu t$ is equal to $n\lambda$.

Colours of thin films

It is an experimental fact that when a thin film is exposed to a white light source beautiful colours are observed. Suppose incident light is white and falls on a parallel sided film. The incident light will split up by reflection at the top and bottom of the film. The splitted rays are in a position to interfere and the interference of these rays is responsible for colours.

The bright or dark appearance of the reflected light depends upon μ, t and r. In case of white light even t and r made constant, μ varies with wavelength. At a particular point of film and for a particular position of eye, the interfering rays of only certain wavelengths will have a path difference satisfying the conditions of bright fringe. Only such wavelengths will be present there. Other neighbouring wavelengths will be present with diminished intensity. The colours for which the conditions of minima is satisfied are absent.

We can say that if same point of film is observed with eye in different positions or different points of film are observed with eye in same position, a different set of colours is observed each time.

We have shown that the conditions for maxima and minima in transmitted light are reversed that of reflected light. Hence, the colours suppressed or absent in reflected light appears as intense colours in transmitted light or colours of reflected and transmitted light are complementary.

[redacted]

TEACHING NOTES ACADEMIC YEAR

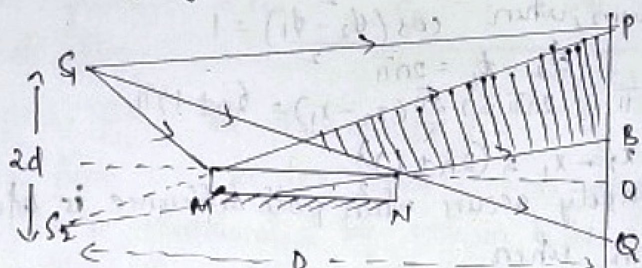
Academic Year : 2019-20

Name Of The Topic Lioyd's single mirror **Course :** PHYSICS.

Hours Required	1
Learing Objectives	1. To enable the students to learn Lioyd's single mirror 2. To make them understand Lioyd's mirror 3. To apply previous knowledge
Previous Knowledge To Be Reminded	Interference.

Topic Synopsis : Lioyd's Single Mirror:- In 1834, Lioyd devised a convenient method to obtain two coherent sources of light to produce sustained interference. The importance of ~~ligh~~ Lioyd's method is that it proves that a phase change of π occurs when the reflection takes place at the surface of an optically denser medium.

The experimental arrangement of Lioyd's mirror is shown in figure.



It consists of a plane mirror MN polished on front surface and blackened at the back to avoid multiple reflections. The light ray is incident on mirror & reflected beam appears to diverge from S_2. Thus S_1 & S_2 act as two coherent sources.

Zero order fringe :- The central fringe is not visible as the point 'O'.

Teaching Aids Used	black board
Additional Inputs taught	Pictures.
References cited	Sanjeev Gupta and SL Gupta
Student Activity Planned After The Teaching	Assignment

Signatur of the Lecturer /Reader — Signatur of the Lecturer I/C of the Dept — Signature of the Principal is outside the region of interference. It is made visible by moving screen towards mirror MN such that point O coincides with end N of mirror.

Theory of the experiment :- Here S_1 is real source while S_2 is reflected virtual image of source S_1. S_1 & S_2 act as coherent sources producing interference. Here an additional phase difference is introduced due to reflection. So, we have

$$y_1 = ae^{i(\omega t - \phi_1)}; \quad \text{and} \quad y_2 = ae^{i(\omega t - \phi_2)};$$

where $\phi_1 = \frac{2\pi}{\lambda} x_1$ and $\phi_2 = \frac{2\pi}{\lambda} x_2 \pm \pi$

The resultant displacement is given by.

$$y = y_1 + y_2$$
$$= ae^{i(\omega t - \phi_1)}; + ae^{i(\omega t - \phi_2)};$$
$$= a e^{i\omega t}[e^{-i\phi_1} + e^{-i\phi_2}];$$
$$= e^{i\omega t}[a(\cos\phi_1 - i\sin\phi_1 + \cos\phi_2 - i\sin\phi_2)];$$
$$= e^{i\omega t}[a(\cos\phi_1 + \cos\phi_2) - ia(\sin\phi_1 + \sin\phi_2)];$$
$$= e^{i\omega t}[R\cos\theta - iR\sin\theta];$$
$$= R\, e^{i(\omega t - \theta)};$$

Here $R\cos\theta = a(\cos\phi_1 + \cos\phi_2)$

$R\sin\theta = a(\sin\phi_1 + \sin\phi_2)$

$$I = R^2 = a^2 [\cos^2\phi_1 + \cos^2\phi_2 + 2\cos\phi_1\cos\phi_2 + \sin^2\phi_1 + \sin^2\phi_2 + 2\sin\phi_1\sin\phi_2]$$

$$I = 2a^2[1 + \cos(\phi_2 - \phi_1)] = 4a^2\cos^2\left(\frac{\phi_2 - \phi_1}{2}\right)$$

(1) Intensity is maximum, when $\cos\left(\frac{\phi_2 - \phi_1}{2}\right) = 1$

$$\frac{\phi_2 - \phi_1}{2} = n\pi$$

$$\frac{2\pi}{\lambda}x_2 - \frac{2\pi}{\lambda}x_1 \pm \pi = 2n\pi \Rightarrow \frac{2\pi}{\lambda}(x_2 - x_1) = (2n \pm 1)\pi$$

$$x_2 - x_1 = (2n \pm 1)\frac{\lambda}{2}$$

So the maximum intensity occurs when path difference is odd multiple of $\lambda/2$

(2) Intensity is minimum when

$$\cos\left(\frac{\phi_2 - \phi_1}{2}\right) = 0$$

$$\frac{\phi_2 - \phi_1}{2} = (2n+1)\frac{\pi}{2} \Rightarrow \frac{2\pi}{\lambda}(x_2 - x_1) = (2n+1)\pi \pm \pi = (2n+2)\pi$$

$$x_2 - x_1 = (2n+2)\frac{\lambda}{2} \text{ (or) } \frac{2n\lambda}{2}$$

when path difference is an even multiple of $\lambda/2$, the intensity becomes zero. when $x_1 = x_2$ we get central fringe.

Determination of wavelength:- for determination of wavelength Lloyd mirror is mounted vertically on an upright of an optical bench and placed along length of bench. On another upright, a narrow vertical slit is mounted which is illuminated by a monochromatic source of light. Now the mirror is rotating about an axis parallel to length of bench until distinct fringes are observed in a micrometer eyepiece.

In case of biprism experiment, the fringe width β is measured by micrometer eyepiece. The distance $2d$ is measured by displacement method, the distance D between screen and slit is measured by meter scale. The wavelength of monochromatic source of light can be calculated by using following formula.

$$\beta = \frac{\lambda D}{2d} \Rightarrow \lambda = \frac{\beta \cdot 2d}{D}.$$

TEACHING NOTES ACADEMIC YEAR

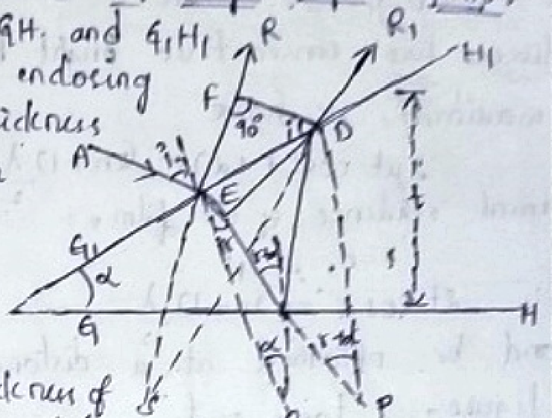
Academic Year : 2019-20.

Name Of The Topic Wedge shaped film **Course :** physics

Hours Required	1
Learing Objectives	1. To enable students to learn wedge method 2. To make them understand wedge method 3. To apply previous knowledge.
Previous Knowledge To Be Reminded	Interference

Topic Synopsis : Interference due to a wedge shaped film :-

Consider two plane surfaces GH and G_1H_1 inclined at an angle α and enclosing a wedge shape film. The thickness of a air film increasing from G to H as shown in figure. Let μ be the refractive index of material of film.



Wedge shaped film :- The thickness of film increases from zero as the distance from edge increases.

⇒ When the film is illuminated by sodium light, then interference between two systems of rays, one reflected from front surface & consequent transmission at the back surface takes place. The interfering waves BR and DR_1 are not parallel but appear to diverge from a point S. First we will calculate the path difference between the two waves.

Teaching Aids Used	charts.
Additional Inputs taught	blackboard
References cited	Sanjeev Gupta
Student Activity Planned After The Teaching	Assignment.

Signatur of the Lecturer /Reader

Signatur of the Lecturer I/C of the Dept

Signature of the Principal

Clearly optical path difference Δ is given by.

$$\Delta = \mu(BC+CD) - Bf$$
$$\Delta = \mu(BE+EC+CD) - \mu BE$$
$$\Delta = \mu(EC+CD) = \mu EP$$
$$\Delta = 2\mu t\cos(r+\alpha) \quad \text{------} \; (1)$$

Due to reflection, additional phase change of $\lambda/2$ is introduced.

$$\Delta = 2\mu t\cos(r+\alpha) \pm \lambda/2$$

for constructive interference $\Delta = n\lambda$ ... (2)

$$\therefore 2\mu t\cos(r+\alpha) \pm \lambda/2 = n\lambda$$
$$2\mu t\cos(r+\alpha) = (2n \pm 1)\frac{\lambda}{2} \quad \text{(For Maxima)} \; \text{---} \; (3)$$

for destructive interference.

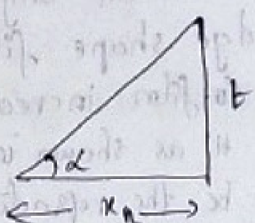
$$\Delta = (2n \pm 1)\frac{\lambda}{2}$$
$$2\mu t\cos(r+\alpha) \pm \lambda/2 = (2n \pm 1)\frac{\lambda}{2}$$
$$2\mu t\cos(r+\alpha) = n\lambda \quad \text{(for minima)} \; (4)$$

where $n = 0, 1, 2, 3 \ldots$ etc.

<u>Space between two consecutive bright bands:</u>

for nth maxima, we have

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



for Normal incidence & air film,

$$r = 0, \; \mu = 1$$
$$2t\cos\alpha = (2n+1)\frac{\lambda}{2} \quad \text{-----} \; (1)$$

let this band be obtained at a distance x_n from thin edge of film.

from figure, $\tan\alpha = \frac{t}{x_n}$

$$t = x_n \tan\alpha \quad \text{---} \; (2)$$

from eq (1) & eq (2)

$$2x_n\tan\alpha\cos\alpha = (2n+1)\frac{\lambda}{2}$$
$$2x_n\sin\alpha = (2n+1)\frac{\lambda}{2} \quad \text{---} \; (3)$$

If $(n+1)^{th}$ maximum is obtained at a distance x_{n+1} from thin edge,

$$2x_{n+1}\sin\alpha = [2(n+1)+1]\lambda/2$$
$$2x_{n+1}\sin\alpha = (2n+3)\frac{\lambda}{2} \quad \text{------} \; (4)$$

~~from~~ Substracting ~~from~~ (4) from (3) we get

$$2(x_{n+1} - x_n)\sin\alpha = \lambda$$

Spacing $\beta = x_{n+1} - x_n$

$$\beta = \frac{\lambda}{2\sin\alpha} = \frac{\lambda}{2\alpha} \quad \text{-------} \; (5)$$

where α is small and measured in radians.

As the fringe width is independent of n, all bright fringes are equally spaced.

TEACHING NOTES ACADEMIC YEAR

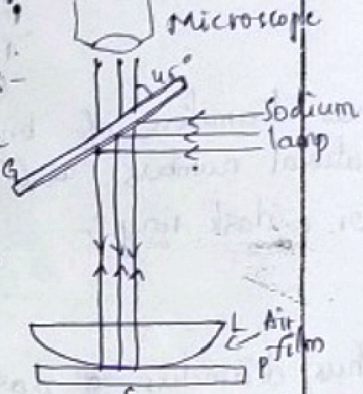
Academic Year : 2019-20

Name Of The Topic Newton's Rings **Course** : Physics

Hours Required	2
Learning Objectives	1. To enable students to learn Newton's Ring 2. To make them understand Newton's Ring 3. To apply the previous knowledge
Previous Knowledge To Be Reminded	Interference.

Topic Synopsis : Experimental Arrangement of Newton's Rings :-

L be a plano-convex lens with its convex surface placed on plane glass P. The lens makes contact with plate at C.

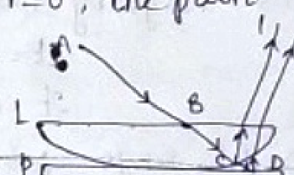


Explanation of formation of Newton's Rings :-

When a monochromatic ray of light falls on the system. A part is reflected at curved surface which goes out in the form of ray 1 without any phase reversal. The other part is refracted which is again reflected and goes out in the form of ray 2 with a phase reversal of π. The reflected rays 1 and 2 interfere with each other and form the interference pattern in the form of rings. The path difference between them is $2\mu t \cos r + \lambda/2$. for air film $\mu = 1$ and for normal incidence $r = 0$, the path difference is $2t + \lambda/2$

for n'th maximum, we have

$$2t + \lambda/2 = n\lambda$$



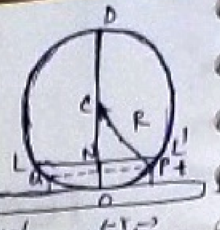
Teaching Aids Used	blackboard
Additional Inputs taught	charts.
References cited	Sanjeev Gupta
Student Activity Planned After The Teaching	Seminars.

Signatur of the Lecturer Reader

Signatur of the Lecturer I/C of the Dept

Signature of the Principal

(1) Newton's ring by reflected light: Now calculate the diameter of bright & dark rings. let LOL' be lens placed on glass plate AB. The curved surface LOL' be part of spherical surface with centre at C. Let R be radius of curvature & r n be the radius of Newton's ring corresponding to a constant film thickness t.



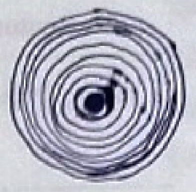
$$2t + \lambda/2 = n\lambda$$

$$2t = (2n-1)\frac{\lambda}{2} \quad \text{for bright ring}$$

where $n = 1, 2, 3, \ldots$ etc.

$$2t = n\lambda \quad \text{for dark ring}$$

where $n = 0, 1, 2, 3, \ldots$ etc.



from property of circle $NP \times NQ = NO \times ND$

$$r^2 = t(2R - t)$$

$$r^2 = 2Rt - t^2 \approx 2Rt$$

$$r^2 = 2Rt \text{ (or) } t = r^2/2R.$$

for bright rings:- $r^2 = \underline{(2n-1)\lambda R}$

Replace r by D/2, we get diameter of nth bright ring as

$$\frac{D^2}{4} = \frac{(2n-1)\lambda R}{2} \Rightarrow D = \sqrt{2\lambda R}\,\sqrt{2n-1}.$$

$$D \propto \sqrt{(2n-1)}$$

Thus diameters of bright rings are proportional to square roots of odd natural numbers as $(2n-1)$ is an odd number.

for a dark ring:-

$$r^2 = n\lambda R$$

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

$$D = 2\sqrt{n\lambda R} \propto \sqrt{n}$$

Thus, diameters of dark rings are proportional to square roots of natural numbers. The fringe width decreases with the order of the fringe and fringes get closer with the increase in their order.

$D_{16} = 8\sqrt{\lambda R} \Rightarrow D_9 = 6\sqrt{\lambda R} \Rightarrow D_{16} - D_9 = 8\sqrt{\lambda R} - 6\sqrt{\lambda R} = 2\sqrt{\lambda R}.$

(2) Newton's rings by transmitted light:-

$$2t = n\lambda \text{ for } \cancel{\text{bright}} \text{ bright rings}$$

$$2t = (2n-1)\lambda/2 \text{ for dark rings}$$

for bright rings $D = \sqrt{n\lambda R} \propto \sqrt{n}$

for dark ring $D = \sqrt{2\lambda R}\,\sqrt{2n-1} \propto \sqrt{2n-1}$

In transmitted light central ring is bright. The rings are opposite to the rings in reflected light.

Determination of wavelength:- let R be the radius of curvature of surface in contact with plate, λ is the wavelength of light & D_n & D_{n+p} the diameters of nth & $(n+p)^{th}$ dark rings, then $(D_n)^2 = 4n\lambda R$

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

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

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

Using this formula, 'λ' can be determined.

TEACHING NOTES ACADEMIC YEAR

Academic Year : 2019 - 20

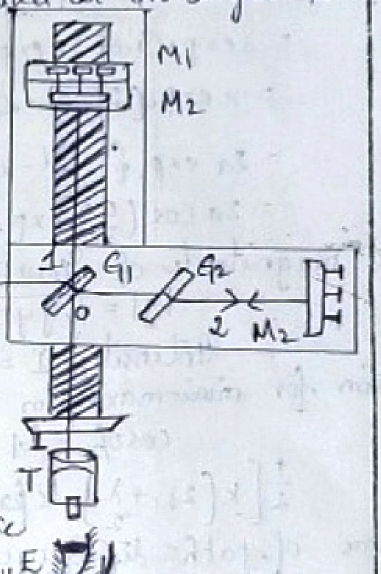
Name Of The Topic Michelson's morley Interferometer Experiment **Course :** physics.

Hours Required	2
Learing Objectives	1. To enable students to learn Michelson morley 2. to make them understand Michelson Morley Ex[n]t. 3. To apply the previous knowledge
Previous Knowledge To Be Reminded	Interference.

Topic Synopsis :

Michelson Interferometer :- Construction

It consists of two mirrors M_1 & M_2 which are at right angles to each other. There are two glass plates G_1 & G_2 inclined at an angle 45° with the mirrors. The face of G_1 towards G_2 is semi silvered. Mirrors M_1 & M_2 are provided with three leveling screws at their backs.



Working :- Light from monochromatic source S falls on semi-silvered glass plate G. It is divided into two parts (1) which travels towards M_1 & other towards M_2. The reflected rays again meet at semi-silvered surface at G_1 & enter the telescope T. A desired path difference can be introduced b/w two reflected rays by moving the mirror M_1.

Thus, the two interfering beams come by reflection from mirror M_1 & other which is reflected from M_2. If the distance $OM_1 = x_1$ and $OM_2' = x_2$ then the path difference between interfering

Teaching Aids Used	blackboard
Additional Inputs taught	charts, videos.
References cited	Sanjeev Gupta & S.L.Gupta.
Student Activity Planned After The Teaching	Seminars.

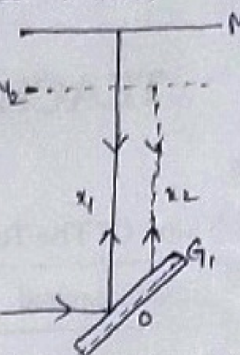
Signatur of the Lecturer Reader

Signatur of the Lecturer I/C of the Dept

Signature of the Principal

rays is given by $\Delta = 2(x_1 \sim x_2)$ (when glass plate is heavily silvered)

& $\Delta = 2(x_1 \sim x_2) \pm \frac{\lambda}{2}$ (when silvering of glass plate is thin)



Mathematical Analysis :- The respective displacements of a particle at O due to component waves are expressed as.

$$y_1 = a\exp.\left[i\left\{\omega t - k\left[2x_1 + \frac{\lambda}{2}\right]\right\}\right]$$

$$y_2 = a\exp.\left[i\left\{\omega t - k\left[2x_2 + \frac{\lambda}{2}\right]\right\}\right]$$

Resultant displacement is given by

$$y = y_1 + y_2$$

$$= a\exp\left[i\left\{\omega t - k\left[2x_1+\frac{\lambda}{2}\right]\right\}\right] + a\exp\left[i\left\{\omega t - k\left[2x_2+\frac{\lambda}{2}\right]\right\}\right]$$

$$y = a\exp.(i\omega t)\cdot\left[\exp\left\{-ik\left[2x_1+\frac{\lambda}{2}\right]\right\} + \exp\left\{-ik\left[2x_2+\frac{\lambda}{2}\right]\right\}\right] \quad \text{---- (3)}$$

$$k\left[2x_1+\frac{\lambda}{2}\right] = \alpha_1 \text{ and } k\left[2x_2+\frac{\lambda}{2}\right] = (\alpha_1 - \theta)$$

$$\theta = k\left[2x_1+\frac{\lambda}{2}\right] - k\left[2x_2+\frac{\lambda}{2}\right] = 2k(x_1-x_2) \quad (4)$$

Substituting these values in above equation

$$y = a\exp.(i\omega t)\left[\exp.(-i\alpha_1) + \exp.\{-i(\alpha_1-\theta)\}\right]$$

$$= a\exp.(i\omega t)\cdot\exp.(-i\alpha_1)\left[1+\exp.(i\theta)\right]$$

$$= a\exp\{i(\omega t-\alpha_1)\}\left[\exp.\left[\frac{-i\theta}{2}\right] + \exp.\left[\frac{i\theta}{2}\right]\right]\exp.\left[\frac{i\theta}{2}\right]$$

$$= 2a\exp.\{i(\omega t-\alpha_1)\}\cos\frac{\theta}{2}\exp.\left(\frac{i\theta}{2}\right)$$

$$= 2a\cos\left(\frac{\theta}{2}\right)\exp.\left\{i\left(\omega t-\alpha_1+\frac{\theta}{2}\right)\right\} \quad \text{---- (5)}$$

The magnitude of resultant displacement y is given by

$$|y| = \sqrt{(yy^*)} = 2a\cos(\theta/2)$$

$$\text{Intensity } I = |y|^2 = 4a^2\cos^2(\theta/2) \quad (6)$$

Condition for ~~mini~~ maximum intensity :-

$$\cos\theta/2 = \pm 1 \Rightarrow \theta/2 = n\pi$$

$$\frac{1}{2}\left[k\left(2x_1+\frac{\lambda}{2}\right) - k\left[2x_2+\frac{\lambda}{2}\right]\right] = n\pi$$

In terms of path difference, $\frac{2\pi}{\lambda}(2x_1 - 2x_2) = 2n\pi$ (7)

$2(x_2 - x_1) = n\lambda$ (when plate is heavily polished)

$2(x_2 - x_1) = n\lambda \pm \frac{\lambda}{2}$ (when plate is lightly polished)

Condition for minimum intensity :- $\cos\theta/2 = 0$ (or) $\frac{\theta}{2} = (2n+1)\frac{\pi}{2}$

$$\frac{1}{2}\left\{k\left[2x_1+\frac{\lambda}{2}\right] - k\left[2x_2+\frac{\lambda}{2}\right]\right\} = (2n+1)\frac{\pi}{2}$$

In terms of path difference, $\frac{2\pi}{\lambda}(2x_1 - 2x_2) = (2n+1)\pi$

$2(x_1 - x_2) = (2n+1)\frac{\lambda}{2}$ (when glass plate is heavily polished)

$2(x_1 - x_2) = (2n+1)\frac{\lambda}{2} \pm \frac{\lambda}{2}$ (when glass plate is lightly polished)

Determination of Wavelength :- If t be the thickness of air film enclosed between two mirrors & n the order of spot obtained, then as for normal incidence $\cos r = 1$, we have $2t + \frac{\lambda}{2} = n\lambda$.

$$N\frac{\lambda}{2} = x_2 - x_1$$

$$\lambda = \frac{2(x_2 - x_1)}{N}$$

The difference $(x_2 - x_1)$ is measured with micrometer screw and N is actually counted.

The experiment is repeated & mean value of λ is obtained.