AKTU

B. Tech I-Year

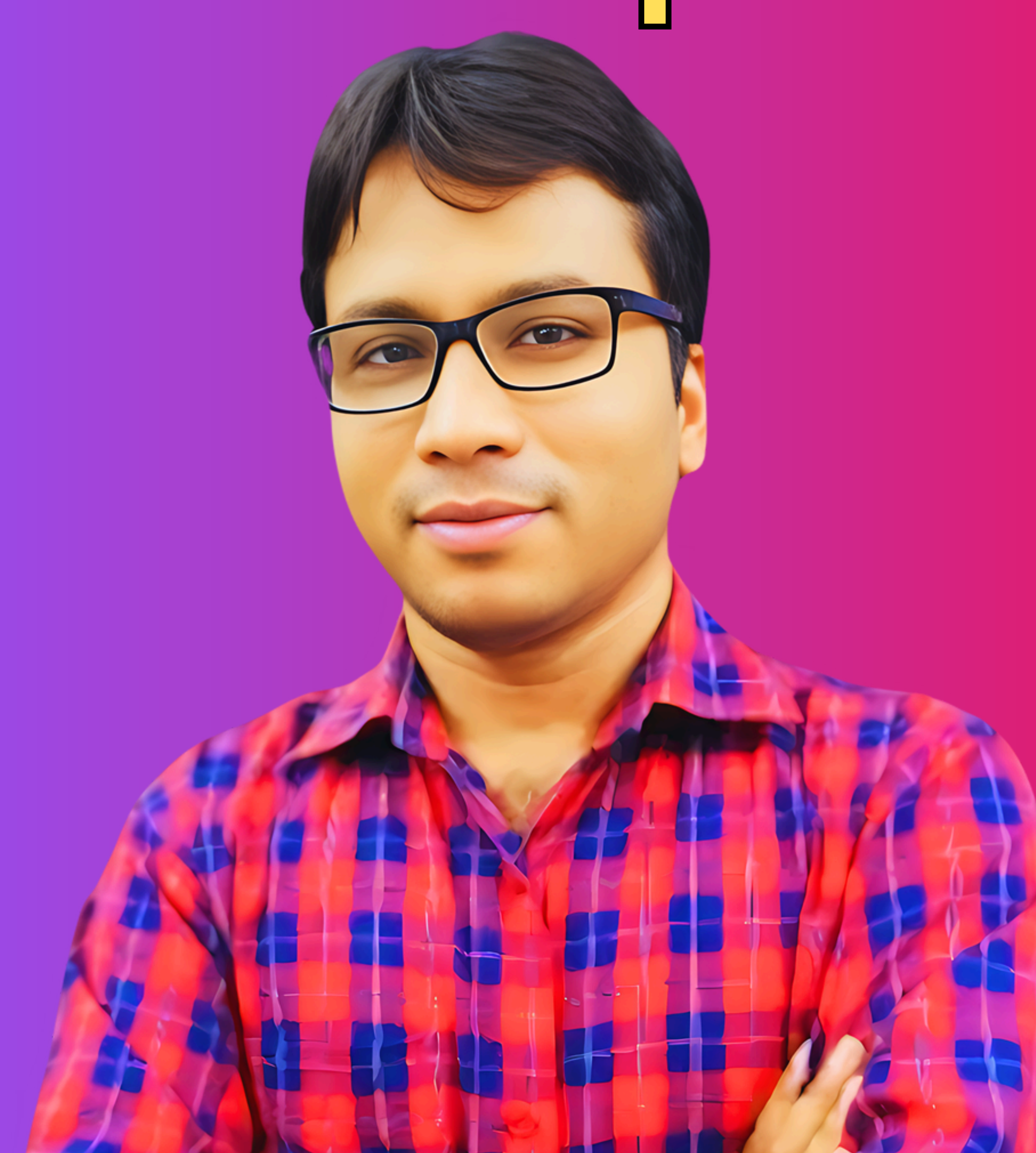
Gateway Classes

Semester -I & II

Common to All Branches

BAS101 / BAS201: ENGINEERING PHYSICS

UNIT-3 (P-1) ONE SHOT : Wave Optics



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BAS101 / BAS201: ENGINEERING PHYSICS

Unit-3

Introduction to : Wave Optics

Syallbus

Coherent sources, Interference in uniform and wedge shaped thin films, Necessity of extended sources, Newton's Rings and its applications, Introduction to diffraction, Fraunhoffer diffraction at single slit and double slit, Absent spectra, Diffraction grating, Spectra with grating, Dispersive power, Resolving power, Rayleigh's criterion of resolution, Resolving power of grating.


AKTU
GATEWAY CLASSES
Engg. Physics
ONE SHOT
Unit-3 : Wave Optics
Interference
By Gulshan Sir

One Shot PDF Notes Available On

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AKTU : B.Tech (II-Sem & IV-Sem)

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1	B.Tech II-SEM COMBO
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3	B.Tech IV-SEM : EC & EC Allied
4	B.Tech IV-SEM : ME & ME Allied
5	B.Tech IV-SEM : EE & EE Allied

Validity till semester exam

AKTU : B.Tech (IV-Sem)

Engg. Maths-4 All Branches (Except CE/ENV)

Validity till semester exam

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AKTU : B.Tech

- Video Lectures
- Pdf Notes
- DPP
- PYQs
- Unit wise One Shot

UNIT : Wave Optics

Interference

- Coherent sources
- Interference in uniform and wedge shaped thin films
- Necessity of extended sources
- Newton's Rings and its applications

Diffraction

- Introduction to diffraction
- Fraunhoffer diffraction at single slit and double slit
- Absent spectra, Diffraction grating, Spectra with grating
- Dispersive power, Resolving power, Rayleigh's criterion of resolution, Resolving power of grating

I Semester Theory Examination – 2023 – 24 (Unit-III)

Section – A

c. *What happens if the slit is smaller than wavelength in diffraction pattern?*

Section – B

c. *Newton's rings are observed normally in reflected light of wavelength 6000Å. The diameter of the* 10^{th} *dark ring is 0.50cm. Find the radius of curvature of lens and thickness of the film.*

Section – C

5. *Attempt any one part of the following:*

(a) *Discuss the phenomenon of interference of light due to parallel thin films and find the condition of maxima and minima. Show that the interference patterns of reflected and transmitted source of light are complementary.*

(b) *Discuss single slit Fraunhofer diffraction and show that the relative intensities of successive maximum are nearly* $1: 1/22 : 1/62 : 1/121$.

I Semester Theory Examination – 2022 – 23 (Unit-III)

Section – A

d. *What do you understand by coherent sources ?*

Section – B

c. *What do you understand by the phenomenon of Fraunhofer differaction. Find out the ratio of intensities of successive secondary maxima compared to the intensity of the principle maximum.*

Section – C

5. *Attempt any one part of the following:*

(a) (i) *Describe the phenomenon of interference in thin film (uniform thickness) due to reflected light and write down the conditions for constructive and destructive interference.*

(ii) *A light source of wavelength 6000Åis used along with plano – convex lens With radius of curvature equal to100cm in a Newton's ring arrangement. Find out the diameter of the 15th dark ring.*

(b) *Explain briefly the Rayleigh criterion of resolution. Discuss the resolving power of plane transmission grating and find the relation between resolving and dispersive power of the grating.*

II Semester Theory Examination – 2022 – 23 (Unit–III)

Section – A

d. *Why two independent light sources cannot produce interference pattern?*

e. *What are the changes that are caused in the diffraction pattern if the number of slits are made large?*

Section – B

c. *Describe how Newton's ring experiment can be used to determine the refractive index of a liquid.*

Section – C

5. *Attempt any one part of the following:*

(a) (i) *Obtain an expression for the fringe width in a wedge – shaped thin film and explain nature of fringe pattern.*

(ii) *A light of wavelength 6000Å falls normally on a slit of width 0.10 mm. Calculate the total angular width of the central maximum.*

(b) (i) *What particular spectra would be absent if width of the transparencies and opacities of the grating are equal.*

(ii) *A plane transmission grating has 16,000 lines to an inch over a length of 5 inches. Find in wavelength region of 6000Å, in the second order, the smallest wavelength difference that can be resolved.*

I Semester Theory Examination – 2021 – 22 (Unit-III)

Section – A

g. *The light rays from two independent bulbs do not show interference. Give the reason.*

h. *State the Rayleigh criteria of resolution.*

Section – B

d. *White light is incident on a soap film at an angle Sin- 1 (4/5) and the reflected light is observed with a spectroscope. It is found that two consecutive dark bands correspond to wavelengths* 6.1×10^{-5} *cm and* 6.0×10^{-5} *cm. If the refractive index of the film is 4/3, calculate the thickness.*

Section – C

6. *Attempt any one part of the following:*

(a) *What do you mean by a wedge-shaped film? Discuss the interference due to it and obtain the expression for the fringe width.*

(b) *Discuss the formation of Newton's rings. Show that the diameters of the bright rings are proportional to the square root of odd natural numbers.*

Section – A

g. Why the center of Newton's ring in reflected system is dark?

h. Explain Rayleigh's criterion of resolution.

Section – B

d. Newton's rings are observed in reflected light of wavelength 5900Å. The diameter of 10th dark ring is 0.50cm. Find the radius of curvature of the lens.

6. Attempt any one part of the following:

(a) What is Rayleigh criterion of resolution how one can increase the resolving power of a diffraction grating? Using Rayleigh criterion for just resolution show that the resolving power of grating is equal to nN, where n is the order of the spectrum, and N is total no of lines on the grating.

(b) Discuss the phenomena of Fraunhofer diffraction at a single slit and show that the relative intensities of the successive maximum are nearly $1 : 4/9\pi^2 : 4/(25\pi^2) : 4/49\pi^2 : \ldots$

I Semester Theory Examination – 2020 – 21(Unit-III)

Section – A

g. Two independent sources of light cannot produce interference, why?

h. State Rayleigh criterion of Resolution. Also define resolving power.

Section – B

d. Calculate the thickness of a soap bubble thin film that will result in constructive interference in reflected light. The film is illuminated with light of wavelength 5000 Å and the refractive index of the film is 1.45.

Section – C

6. Attempt any one part of the following:

(a) Describe the formation of Newton's rings in monochromatic light. Show that in reflected light, the diameters of dark rings are proportional to the square roots of natural numbers.

(b) What is a diffraction grating? Discuss the phenomenon of diffraction due to plane diffraction grating.

I Semester Theory Examination – 2019 – 20 (Unit-III)

Section – A

f. *Two independent sources could not produce interference, why?*

g. *What is dispersive power of plane transmission grating?*

Section – B

d. *A plane transmission grating has 16,000 lines to an inch over a length of 5 inches. Find in the wavelength region of 6000 Å, in the second order (i) the resolving power of grating and (ii) the small wavelength difference that can be resolved.*

Section – C

6. *Attempt any one part of the following:*

(a) *Describe and explain the formation of Newton's rings in reflected monochromatic light. Deduce the necessary expression for bright and dark rings.*

(b) *Discuss the phenomenon of Fraunhofer diffraction at a single slit. Show that the intensity of the first subsidiary maximum is about 4.5% of the principal maximum.*

B. Tech : Engg. Physics

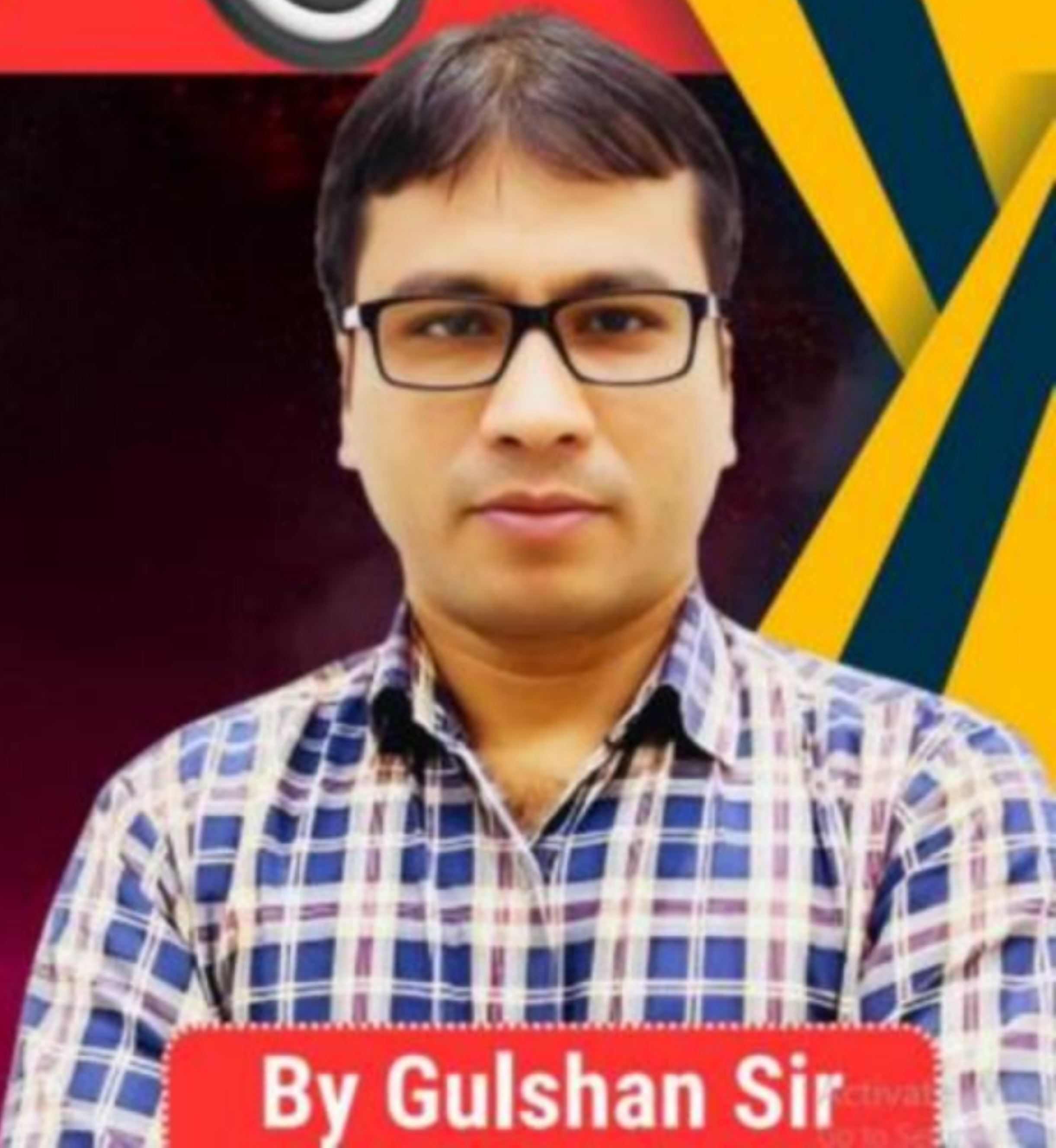
Unit : Wave Optics

(Interference)

Lecture -1

Today's Target

- Introduction to Wave optics
- DPP
- PYQs



By Gulshan Sir

Interference of light

➤ It is the phenomena of redistribution of intensity of light on account of superposition of light waves coming from the two Coherent sources of light (i.e. same frequency and constant phase difference)

Types of Interference

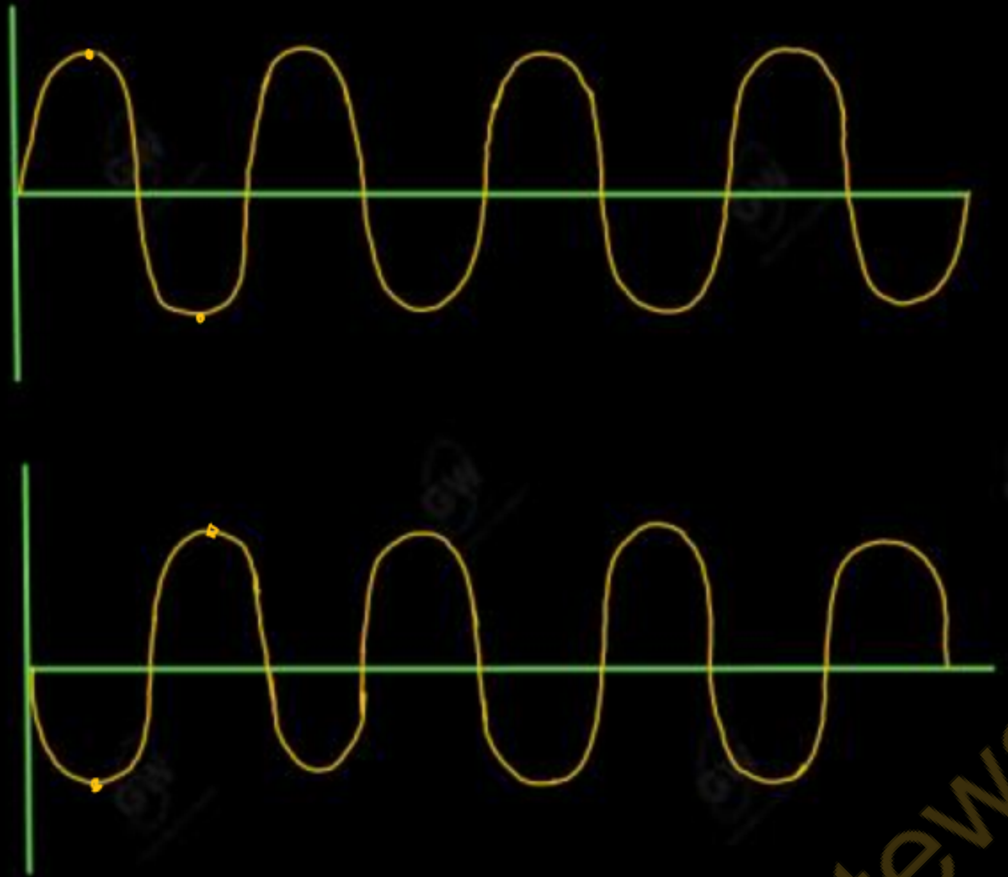
(i) Constructive interference (Bright or Maxima)

Crest + Crest
Trough + Trough → constructive

At those points of the medium where the two interfering waves reach in phase, the resultant displacement and hence the resultant intensity become Maximum. These points are called Maxima and this interference is called Constructive interference.

(ii) Destructive interference (Dark or Minima)

At those points of the medium where the two interfering waves reach in opposite phase, the resultant displacement and hence the resultant intensity become Minimum. These points are called Minima and this interference is called Destructive interference



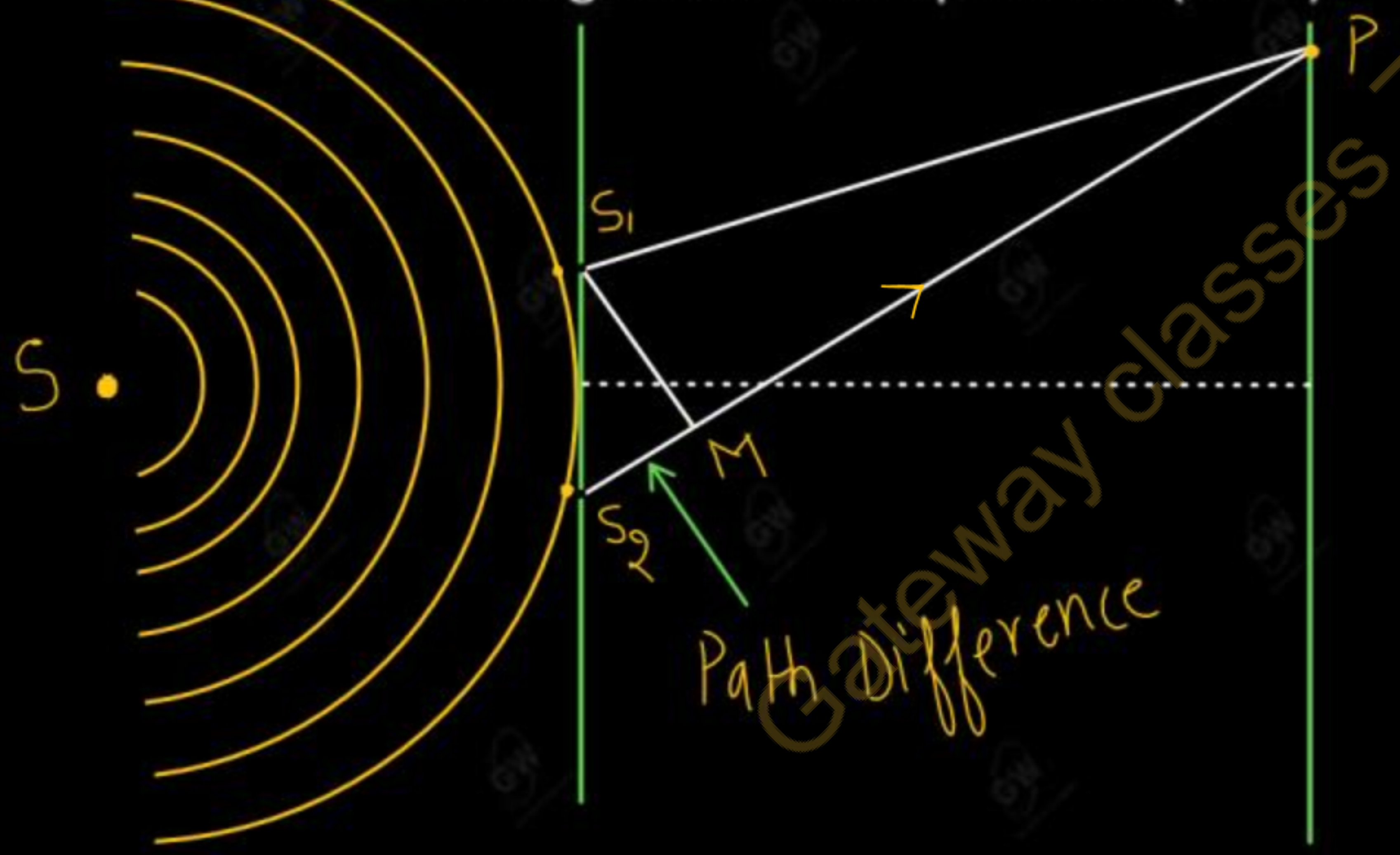
Coherent Sources

V. imp

- The sources of light emitting waves of same frequency having zero or constant phase difference are called coherent sources.
- The sources of light emitting waves with a random phase difference are called incoherent sources.

Note : For interference Phenomenon, the sources must be Coherent.

Example : Young Double Slit Experiment (YDSE)



$$\text{Path Difference} = \frac{\lambda}{2\pi}\,\text{Phase Difference}$$

$$\boxed{\Delta x = \frac{\lambda}{2\pi}\phi}$$

Two independent sources can not produce interference. Why ?

V.imp

OR

Two independent sources of light can not be coherent

- Two independent sources of light can not be coherent because the two independent beams of light do not have constant phase difference. Light is emitted from millions of excited atoms or molecules whose vibrations are independent of each other.
- Hence, two independent sources of light can not produce interference.

Types of Interference on the basis of source formation

Based on the formation of two Coherent sources, interference are of two types

(i) Division of wave front

Coherent sources are obtained by dividing the wave front, originating from a common source

- Young's Double Slit Experiment (YDSE)
- The Fresnel's Double mirror method
- Llyod's mirror method

(ii) Division of Amplitude

In this method, the amplitude of incident beam is divided in to two or more parts either by partial reflection or refraction.

- The interference in thin film
- The interference in Wedge shaped thin film
- Newton's ring

Resultant intensity due to superposition of two interfering waves

Let a_1 and a_2 are amplitude of interfering waves and Ø is the phase difference at a point under consideration, then resultant intensity at a point in the region of superposition

$$y_1 = a_1 \sin\omega t$$

$$y_2 = a_2 \sin(\omega t + \phi)$$

Apply Principle of Superposition

$$\boxed{y = A\sin(\omega t + \phi)}$$

$$\boxed{A^2 = a_1^2 + a_2^2 + 2a_1 a_2 \cos\phi}$$

$$\boxed{I = KA^2}$$

$$I_1 = Ka_1^2$$

$$I_2 = Ka_2^2$$

$$KA^2 = Ka_1^2 + Ka_2^2 + 2Ka_1a_2\cos\phi$$

$$\boxed{I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi}$$

Intensity $\propto$ (Amplitude)^2

$$I \propto A^2$$

Condition for Constructive interference OR Condition for Maxima

$$I = I_1 + I_2 + 2 I_1 I_2 \cos\phi$$

Intensity will be maximum, when

$$\cos\phi = 1$$

$$\phi = 2n\pi, \quad n = 0, 1, 2, 3 \ldots$$

(i) Phase Difference

$$\boxed{\phi = 2n\pi}$$

(ii) Path Difference

$$\boxed{\Delta x = 2n\left(\frac{\lambda}{2}\right) \quad n = 0, 1, 2, 3 \ldots}$$

Condition for Destructive interference OR Condition for Minima

$$I = I_1 + I_2 + 2 I_1 I_2 \cos\phi$$

Intensity will be minimum, when

$$\cos\phi = -1$$

$$\phi = (2n+1)\pi, \quad n = 0, 1, 2, 3 \ldots$$

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

(i) Phase Difference

$$\boxed{\phi = (2n+1)\pi \text{ OR } \phi = (2n-1)\pi}$$

(ii) Path Difference

$$\boxed{\Delta x = (2n+1)\frac{\lambda}{2} \quad n = 0, 1, 2, 3 \ldots}$$

$$\boxed{\Delta x = (2n-1)\frac{\lambda}{2} \quad n = 1, 2, 3 \ldots}$$

Condition for sustained interference V.imp

- Two sources of light should emit light continuously
- The light waves should be of same wavelength
- The light waves should be of same amplitude
- The light waves should be of same frequency
- The two waves must be in same phase or bear a constant phase difference.
- For constructive interference

$$I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2}$$

- For destructive interference

$$I_{min} = 0$$

Engineering Physics (By Gulshan Sir)

DPP-1

UNIT : Wave Optics

Q.1 Write the main condition for sustained interference.

Q.2 What do you understand by Coherent sources ?

Q.3 Why two independent light sources can not produce interference pattern ?

Q.4 The light rays from two independent bulbs do not show interference. Give reason

B. Tech : Engg. Physics

Unit : Wave Optics

(Interference)

Lecture - 2

Today's Target

- Interference in a Thin Film
- DPP
- PYQs

By Gulshan Sir

Interference in a thin film

CASE - 1 : Interference in a thin film by Reflected light

CASE - 2 : Interference in thin film by Transmitted light

Interference in a thin film by Reflected light

Consider a thin transparent film of thickness t and refractive index μ

➢ Let a light ray SA is incident on the upper surface of the film.

(i) At point A : The light ray SA is partially reflected along AR_1 and partially refracted along AB

(ii) At point B : The light ray AB is partially reflected along BC

(iii) At point C : The light ray BC is partially refracted along CR_2

➢ Since the light rays AR_1 and CR_2 are derived from the incident ray SA , so they act as coherent light rays and produce interference pattern.

Optical path Difference (Δ)

Δ = Path ABC in thin Film − Path AN in Air

$$\Delta = \mu(AB + BC) - AN \quad \text{———} \quad (1)$$

In Right-Angle triangle ABM

$$\cos\gamma = \frac{BM}{AB}$$

$$AB = \frac{BM}{\cos\gamma}$$

$$\boxed{AB = \frac{t}{\cos\gamma}}$$

Also

$$\tan\gamma = \frac{AM}{BM}$$

$$AM = BM\tan\gamma$$

$$\boxed{AM = t\tan\gamma}$$

In Right Angle triangle BCM

$\cos r = \frac{BM}{BC}$

$BC = \frac{BM}{\cos r}$

$$\boxed{BC = \frac{t}{\cos r}}$$

Also

$\tan r = \frac{MC}{BM}$

$MC = BM \tan r$

$$\boxed{MC = t \tan r}$$

In Right Angle triangle ACN

$\sin i = \frac{AN}{AC}$

$AN = AC \sin i$

$AN = (AM + MC) \sin i$

$AN = (t \tan r + t \tan r) \sin i$

$AN = 2t \tan r \sin i$

$AN = 2t \times \frac{\sin r}{\cos r} \times \frac{\sin i}{\sin r} \times \sin r$

By Snell's law

$$\frac{\sin i}{\sin r} = \mu$$

$$AN = 2t \times \frac{\sin r}{\cos r} \times \mu \times \sin r$$

$$\boxed{AN = \frac{2\mu t}{\cos r} \times \sin^2 r}$$

Put AB, BC and AN in eqn (1)

$$\Delta = \mu(AB + BC) - AN$$

$$\Delta = \mu\left(\frac{t}{\cos r} + \frac{t}{\cos r}\right) - \frac{2\mu t}{\cos r}\sin^2 r$$

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

$$\Delta = \frac{2\mu t}{\cos r}(1 - \sin^2 r)$$

$$\Delta = \frac{2\mu t}{\cancel{\cos r}} \times \cos^{\cancel{2}} r \qquad \left\{\because \sin^2\theta + \cos^2\theta = 1\right\}$$

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

According to Stoke's law, when light reflected from the surface of denser Medium, an additional phase change of π or path difference of $\frac{\lambda}{2}$ is produced

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

Actual path difference

Condition For constructive interference (or Maxima/ Bright)

We know that

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

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

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

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

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

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

(2)

Thin film will appear Bright

Condition For Destructive interference

(or Minima | Dark)

We know that

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

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

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

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

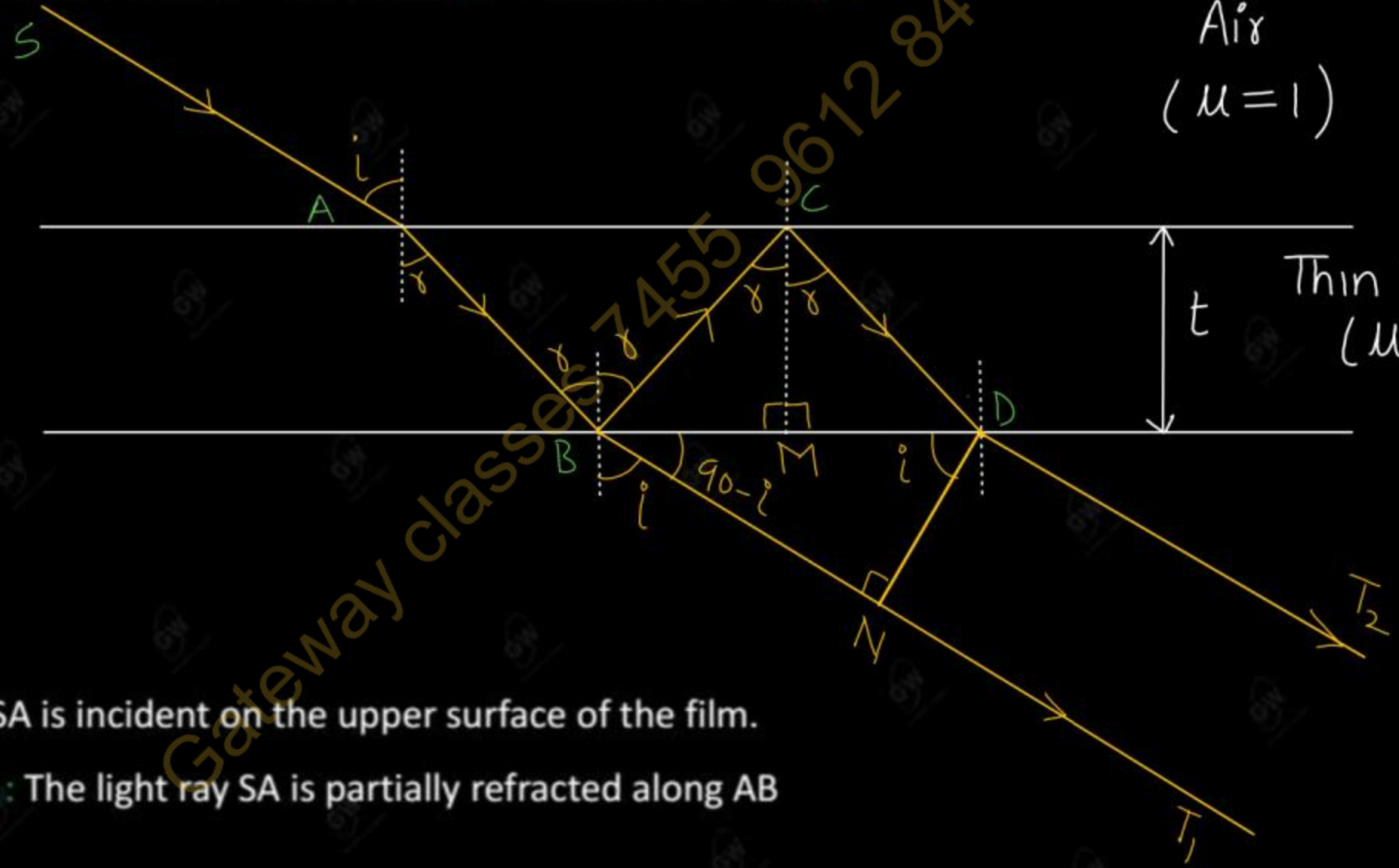
$$\boxed{2\mu t\cos r = n\lambda}$$

(3)

Thin film will appear Dark

Interference in a thin film by Transmitted light

Consider a thin transparent film of thickness t and refractive index μ .



- Let a light ray SA is incident on the upper surface of the film.

  (i) At point A : The light ray SA is partially refracted along AB

(ii) At point B : The light ray AB is partially reflected along BC and partially refracted along BT_1

(iii) At point C : The light ray BC is partially reflected along CD

(iv) At point D : The light ray CD is partially refracted along DT_2

➢ Since, the transmitted ray BT_1 and DT_2 are derived from the same incident ray SA, so they act as coherent light rays and produced interference pattern.

Optical path difference (Δ)

Δ = Path BCD in film − Path BN in Air

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

In Right angle-triangle BCM

$$\cos\gamma = \frac{CM}{BC}$$

$$BC = \frac{CM}{\cos\gamma}$$

$$\boxed{BC = \frac{t}{\cos\gamma}}$$

Also

$$\tan\gamma = \frac{BM}{CM}$$

$$BM = CM\tan\gamma$$

$$\boxed{BM = t\tan\gamma}$$

In triangle CDM

$$\cos\gamma = \frac{CM}{CD}$$

$$CD = \frac{CM}{\cos\gamma}$$

$$\boxed{CD = \frac{t}{\cos\gamma}}$$

Also

$$\tan\gamma = \frac{MD}{CM}$$

$$MD = CM\tan\gamma$$

$$\boxed{MD = t\tan\gamma}$$

In triangle BDN

$$\sin i = \frac{BN}{BD}$$

$$BN = BD\sin i$$

$$BN = (BM + MD)\sin i$$

$$BN = (t\tan\gamma + t\tan\gamma)\sin i$$

$$BN = 2t\tan\gamma\sin i$$

$$BN = 2t \times \frac{\sin\gamma}{\cos\gamma} \times \sin i$$

$$BN = 2t \times \frac{\sin\gamma}{\cos\gamma} \times \frac{\sin i}{\sin\gamma} \times \sin\gamma$$

By Snell's law

$$\frac{\sin i}{\sin\gamma} = \mu$$

$$BN = 2t \times \frac{\sin\gamma}{\cos\gamma} \times \mu \times \sin\gamma$$

$$\boxed{BN = \frac{2\mu t}{\cos\gamma} \times \sin^2\gamma}$$

Put BC, CD and BN in (1)

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

$$\Delta = \mu\left(\frac{t}{\cos\gamma} + \frac{t}{\cos\gamma}\right) - \frac{2\mu t}{\cos\gamma}\sin^2\gamma$$

$$\Delta = \frac{2\mu t}{\cos\gamma} - \frac{2\mu t}{\cos\gamma} \times \sin^2\gamma$$

$$\Delta = \frac{2\mu t}{\cos\gamma}(1 - \sin^2\gamma)$$

$$\Delta = \frac{2\mu t}{\cancel{\cos\gamma}} \times \cos^{\cancel{2}}\gamma$$

$$\boxed{\Delta = 2\mu t \cos\gamma}$$ Actual path Difference

Condition For constructive interference (or Maxima | Bright)

We know that

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

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

$$\boxed{2\mu t\cos r = n\lambda} \quad \text{——— (2)}$$

Thin film will appear Bright

Condition Destructive interference (or minima | Dark)

We know that

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

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

(3)

Conclusion

Interference in Thin Film due to Reflected light

- Condition for Maxima

$$2\mu t \cos r = (2n \pm 1)\frac{\lambda}{2} \quad \text{—— } 2$$

- Condition for Minima

$$2\mu t \cos r = n\lambda \quad \text{—— } 3$$

Interference in Thin Film due to Transmitted light

- Condition for Maxima

$$2\mu t \cos r = n\lambda \quad \text{—— } 2$$

- Condition for Minima

$$2\mu t \cos r = (2n \pm 1)\frac{\lambda}{2} \quad \text{—— } 3$$

From equation 2 and 3 in both the cases it is clear that the film, which appears dark in reflected light will appear bright in transmitted light and vice versa. Hence reflected and transmitted system are complementary in thin film.

Q.1 Calculate the thickness of thin film (soap bubble) that will result in constructive interference in reflected light. The film is illuminated with light of wavelength 5000 Å and refractive index of film is 1.45.

Given

$\lambda = 5000\ \text{Å} = 5000 \times 10^{-10}\ m$

$\mu = 1.45$

For constructive interference in Reflected light

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

For least thickness

$r = 0$

$n = 1$

$2\mu t \cos 0 = \frac{\lambda}{2}$

$t = \frac{\lambda}{4\mu}$

$t = \frac{5000 \times 10^{-10}}{4 \times 1.45}$

$\boxed{t = 8.62 \times 10^{-8}}$ ✓

$1\text{Å} = 10^{-10}\ m$

$1\text{Å} = 10^{-8}\ cm$

Q.2 Light of wavelength 5893 Å is reflected at nearly normal incidence from a soap film of refractive index 1.42 What is the least thickness of the film that will appear (i) Bright (ii) Dark ?

Given

$\lambda = 5893\,\mathring{A} = 5893 \times 10^{-10}\,m$

$\mu = 1.42$

(i) condition for Bright

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

For normal incidence $(r = 0)$

$\cos r = 1$

For least thickness

$n = 1$

$2\mu t \times 1 = \frac{\lambda}{2}$

$t = \frac{\lambda}{4\mu}$

$t = \frac{5893 \times 10^{-10}}{4 \times 1.42}$

$\boxed{t = 1037.5\,\mathring{A}}$

condition for Dark

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

$2\mu t \times 1 = \lambda$

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

$t = \frac{5893 \times 10^{-10}}{2 \times 1.42}$

$\boxed{t = 2075\,\mathring{A}}$

Q.3 A soap film of refractive index 1.43 is illuminated by white light incident at an angle of 30°. The reflected light is examined by a spectroscope in which dark band corresponding to the wavelengths 6×10^{-7} m is observed. Calculate the thickness of the film.

Given

$\mu = 1.43$

$i = 30°$

$\lambda = 6 \times 10^{-7}$ m

By Snell's law

$$\mu = \frac{\sin i}{\sin r}$$

$$\sin r = \frac{\sin i}{\mu}$$

$$\sin r = \frac{\sin 30}{1.43}$$

$$\sin r = 0.3496$$

$$\cos^2 r = 1 - \sin^2 r$$

$$\cos r = \sqrt{1 - \sin^2 r}$$

$$\cos r = \sqrt{1 - (0.3496)^2}$$

$$\cos r = 0.94$$

Condition for Dark band

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

$$t = \frac{n\lambda}{2\mu \cos r} = \frac{1 \times 6 \times 10^{-7}\text{ m}}{2 \times 1.43 \times 0.94}$$

$$\boxed{t = 2.23 \times 10^{-7}\text{ m}}$$

DPP-2

UNIT : Wave Optics

Q.1 Describe the phenomenon of interference in thin film (uniform thickness)due to reflected light and write down the conditions for constructive and destructive interference.

Q.2 Discuss the phenomenon of interference of light due to parallel thin films and find the condition of maxima and minima. Show that the interference patterns of reflected and transmitted source of light are complementary.

Q.3 Calculate the thickness of a soap bubble thin film that will result in constructive interference in reflected light. The film is illuminated with light of wavelength 5000 Å and the refractive index of the film is 1.45.

Q.4 A parallel beam of sodium light of 5880 Å is incident on a thin glass plate of refractive index 1.5. Such that the angle of refraction in the plate is 60°. Calculate the smallest thickness of the plate, which will make it appear dark by reflection.

Q.5 White light is incident on a soap film at an angle $\sin^{-1}\left(\frac{4}{5}\right)$ and the reflected light is observed with a spectroscope. It is found that two consecutive dark bands correspond to wavelengths 6.1×10^{-5}cm and 6.0×10^{-5}cm. If the refractive index of the film is $\frac{4}{3}$, calculate the thickness.

B. Tech : Engg. Physics

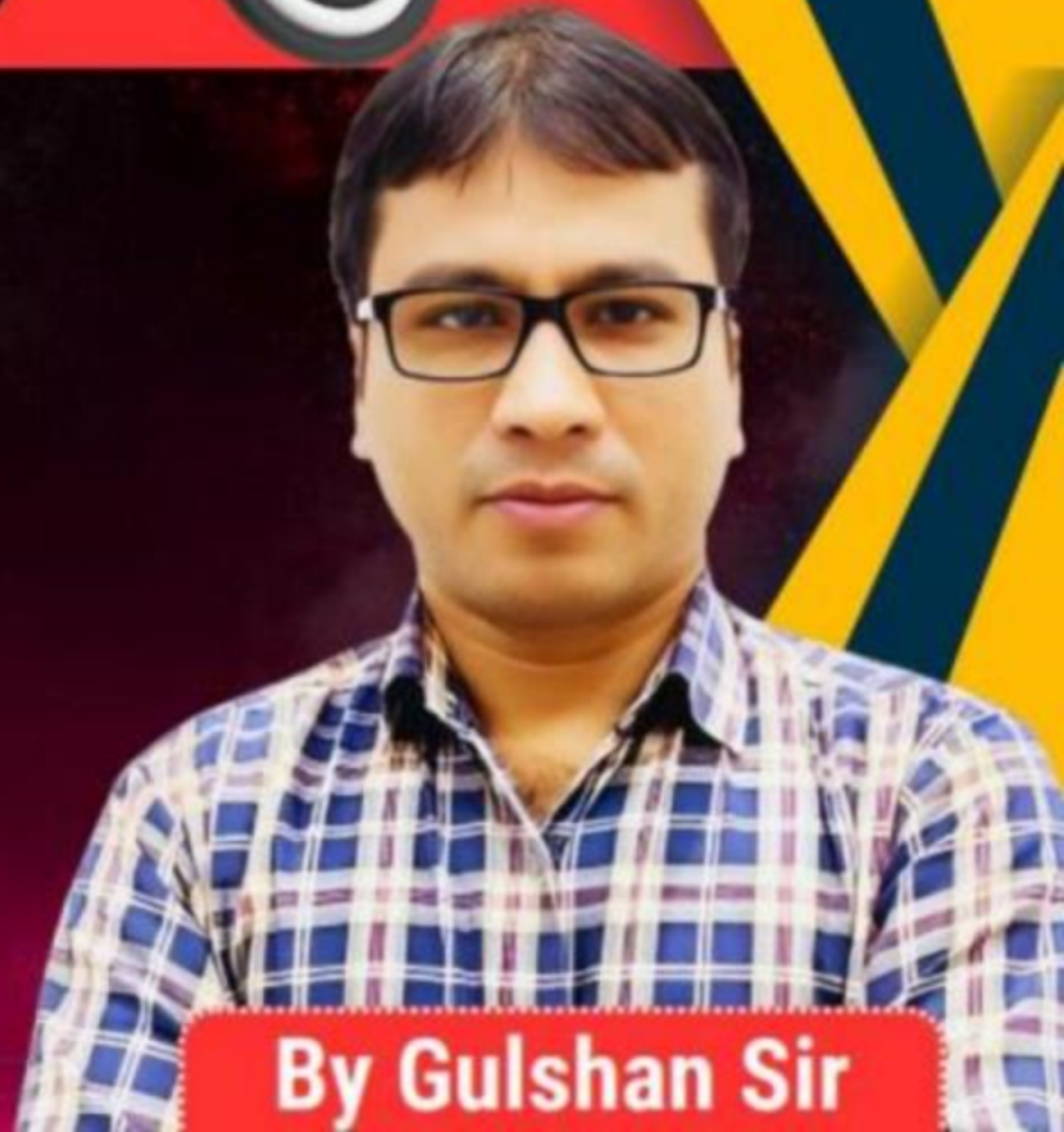
Unit : Wave Optics

(Interference)

Lecture -3

Today's Target

- Interference in a Wedge Shaped thin Film
- DPP
- PYQs



By Gulshan Sir

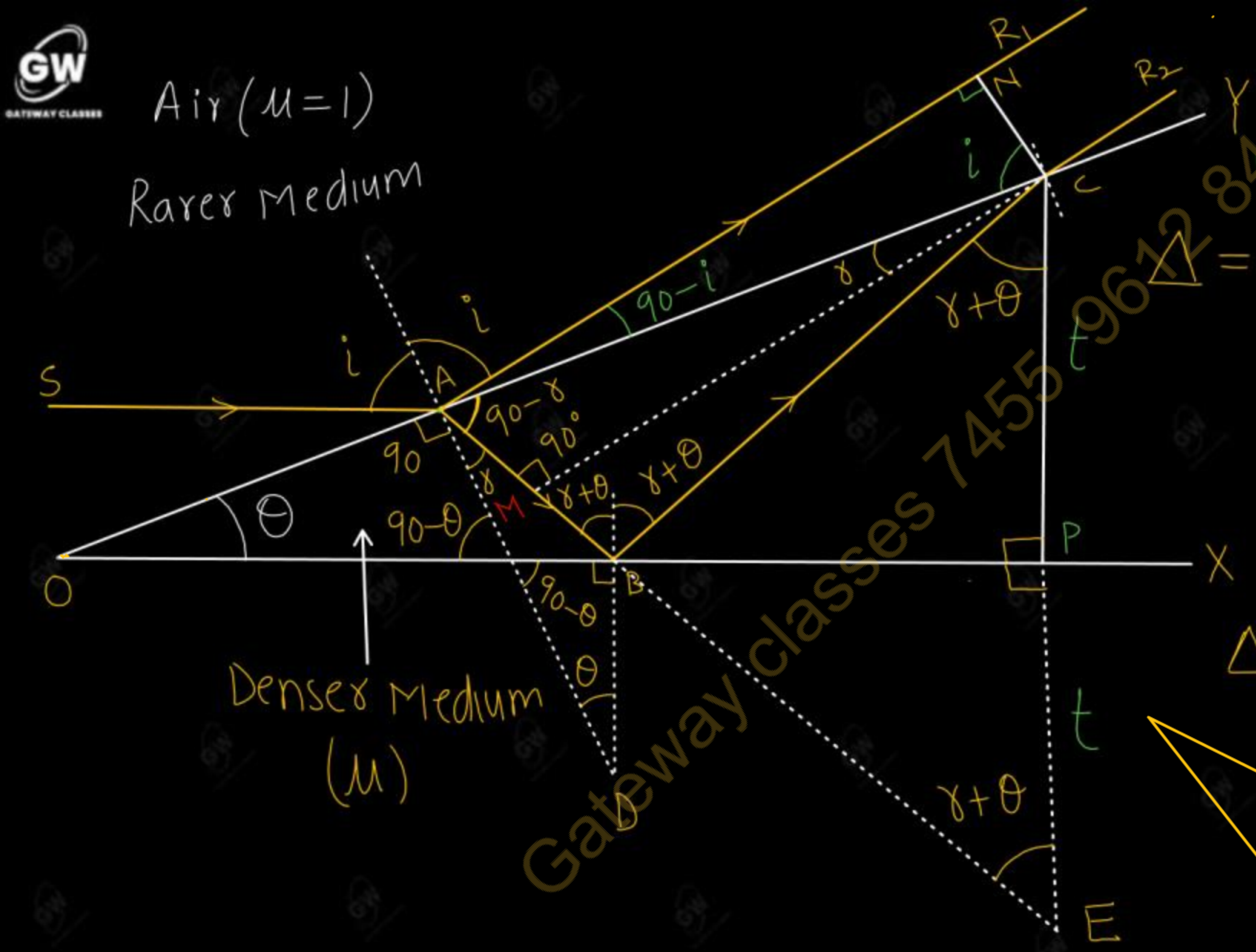
Wedge-Shaped thin film

Note θ is very-very small

A wedge-shaped thin film is one whose plane surfaces (OY and OX) are slightly inclined to each other at an angle θ and encloses a film of transparent material of refractive index μ. The thickness of the film increases from one end to other end.

Interference in a Wedge-Shaped thin film by Reflected light

- Consider a thin transparent Wedge-Shaped film of varying thickness and refractive index μ
- Let a light ray SA is incident on the upper surface OY
  - (i) At point A : The light ray SA is partially reflected along AR_1 and partially refracted along AB
  - (ii) At point B : The light ray AB is partially reflected along BC
  - (iii) At point C : The light ray BC is partially refracted along CR_2
- Since the reflected rays AR_1 and CR_2 are derived from the incident ray SA , they act as coherent light rays and produce interference pattern.

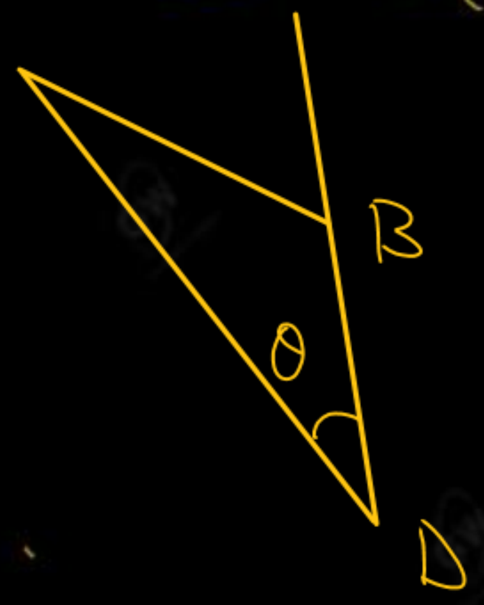


Optical path Difference

Δ = Path ABC in thin Film − Path AN in Air

$$\Delta = \mu(AB + BC) - AN$$

$$\Delta = \mu(AM + MB + BC) - AN \quad \text{——— (1)}$$



In ΔACN

$$\sin i = \frac{AN}{AC}$$

In ΔACM

$$\sin r = \frac{AM}{AC}$$

$$\frac{\sin i}{\sin r} = \frac{AN}{\cancel{AC}} \times \frac{\cancel{AC}}{AM}$$

$$\frac{\sin i}{\sin r} = \frac{AN}{AM}$$

By Snell's law

$$\mu = \frac{\sin i}{\sin r}$$

$$\mu = \frac{AN}{AM}$$

$$AN = \mu(AM)$$

Put AN in (1)

$$\Delta = \mu(AM + MB + BC) - \mu AM$$

$$\Delta = \mu(\cancel{AM} + MB + BC - \cancel{AM})$$

$$\Delta = \mu(MB + BC) \quad \text{—— (2)}$$

Draw, $CP \perp OX$ and produced CP and AB to meet at E

$\because \Delta BPC \cong BPE$

$\therefore BC = BE$

$\therefore CP = PE = t$

Put BC in (2)

$\Delta = \mu(MB + BE)$

$\Delta = \mu ME$ —— (3)

In $\triangle MCE$

$\cos(r+\theta) = \frac{ME}{CE}$

$ME = CE\cos(r+\theta)$

$ME = 2t\cos(r+\theta)$

Put ME in (3)

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

By Stoke's law

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

Actual path Difference

Condition for Maxima

We know that

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

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

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

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

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

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

Thin film will appear Bright

Condition for Minima

We know that

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

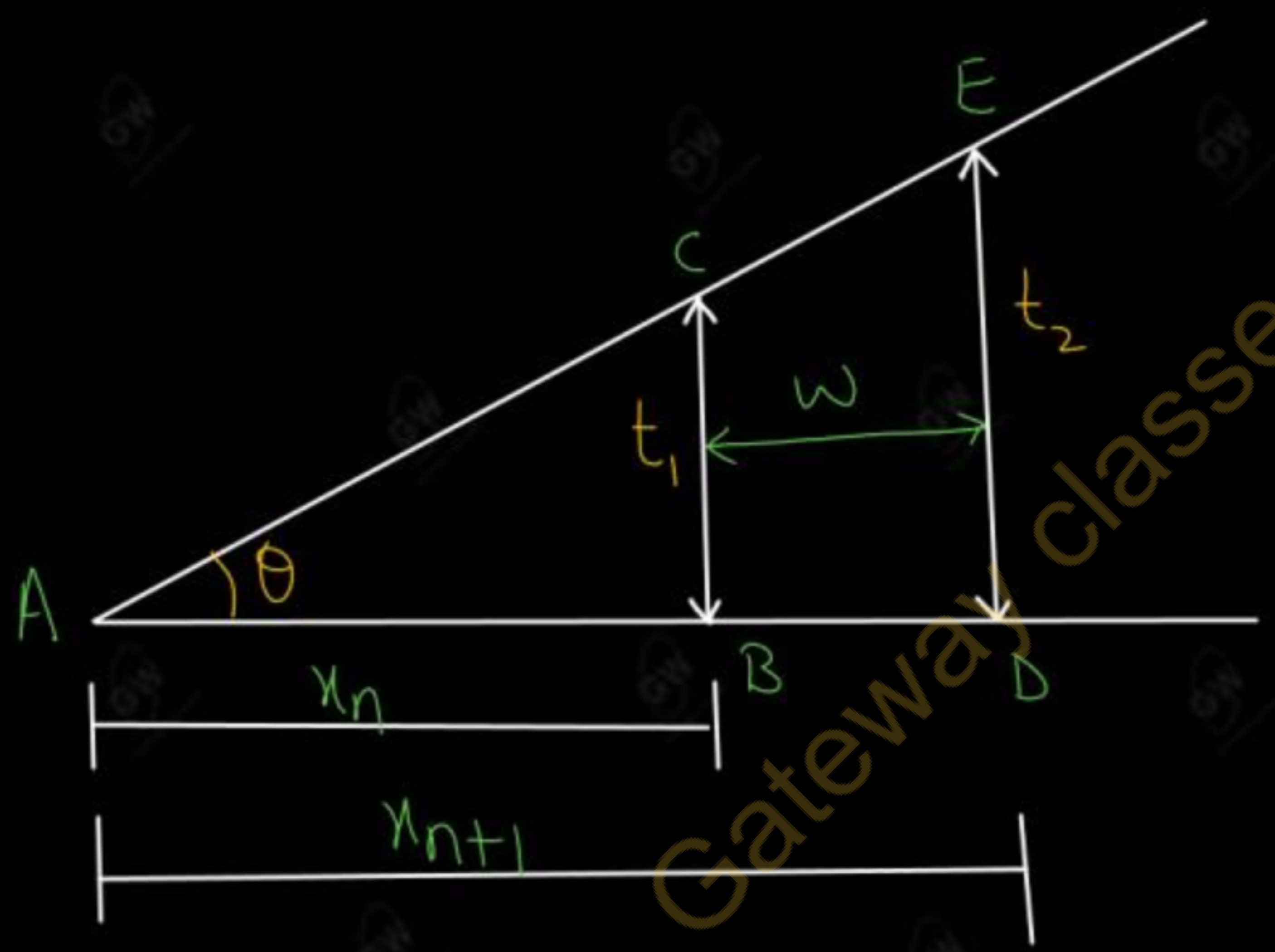
$$2\mu t\cos(r+\theta) - \frac{\lambda}{2} = (2n-1)\frac{\lambda}{2}$$

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

Thin Film will appear dark

Fringe-width

- Consider a thin transparent Wedge-Shaped film of varying thickness and refractive index μ
- Let x_n be the distance of n^{th} bright fringe from the edge of the film
- Let x_{n+1} be the distance of $(n+1)^{th}$ bright fringe from the edge of the film



In ΔABC

$$\tan\theta = \frac{t_1}{x_n}$$

$$t_1 = x_n \tan\theta$$

For Bright Fringe

$$2\mu t_1 \cos(r+\theta) = (2n-1)\frac{\lambda}{2}$$

Put t_1 in above eqn

$$2\mu x_n \tan\theta \cos(r+\theta) = (2n-1)\frac{\lambda}{2} \quad \text{——— } ①$$

In ΔADE

$$\tan\theta = \frac{t_2}{x_{n+1}}$$

$$t_2 = x_{n+1}\tan\theta$$

For Bright Fringe

$$2\mu t_2 \cos(r+\theta) = (2n-1)\frac{\lambda}{2}$$

Put t_2 in above eq^n

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

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

$$2\mu x_{n+1} \tan\theta \cos(r+\theta) = (2n+1)\frac{\lambda}{2} \quad \text{——— } ②$$

Subtract ① From ②

$$2\mu x_{n+1} \tan\theta \cos(r+\theta) - 2\mu x_n \tan\theta \cos(r+\theta)$$

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

$$2\mu \tan\theta \cos(r+\theta)\{x_{n+1} - x_n\} = \frac{\lambda}{2}(\cancel{2n}+1-\cancel{2n}+1)$$

$$2\mu \tan\theta \cos(r+\theta)\{x_{n+1} - x_n\} = \lambda$$

$$x_{n+1} - x_n = \frac{\lambda}{2\mu \tan\theta \cos(r+\theta)}$$

$$\boxed{w = \frac{\lambda}{2\mu \tan\theta \cos(r+\theta)}}$$

For normal incidence

$$i = r = 0$$

$$w = \frac{\lambda}{2\mu \tan\theta \cos\theta} = \frac{\lambda}{2\mu \times \frac{\sin\theta}{\cancel{\cos\theta}} \cancel{\cos\theta}}$$

$$\boxed{w = \frac{\lambda}{2\mu \sin\theta}}$$

Since θ is very-very small

$$\sin\theta \simeq \theta$$

$$\tan\theta \simeq \theta$$

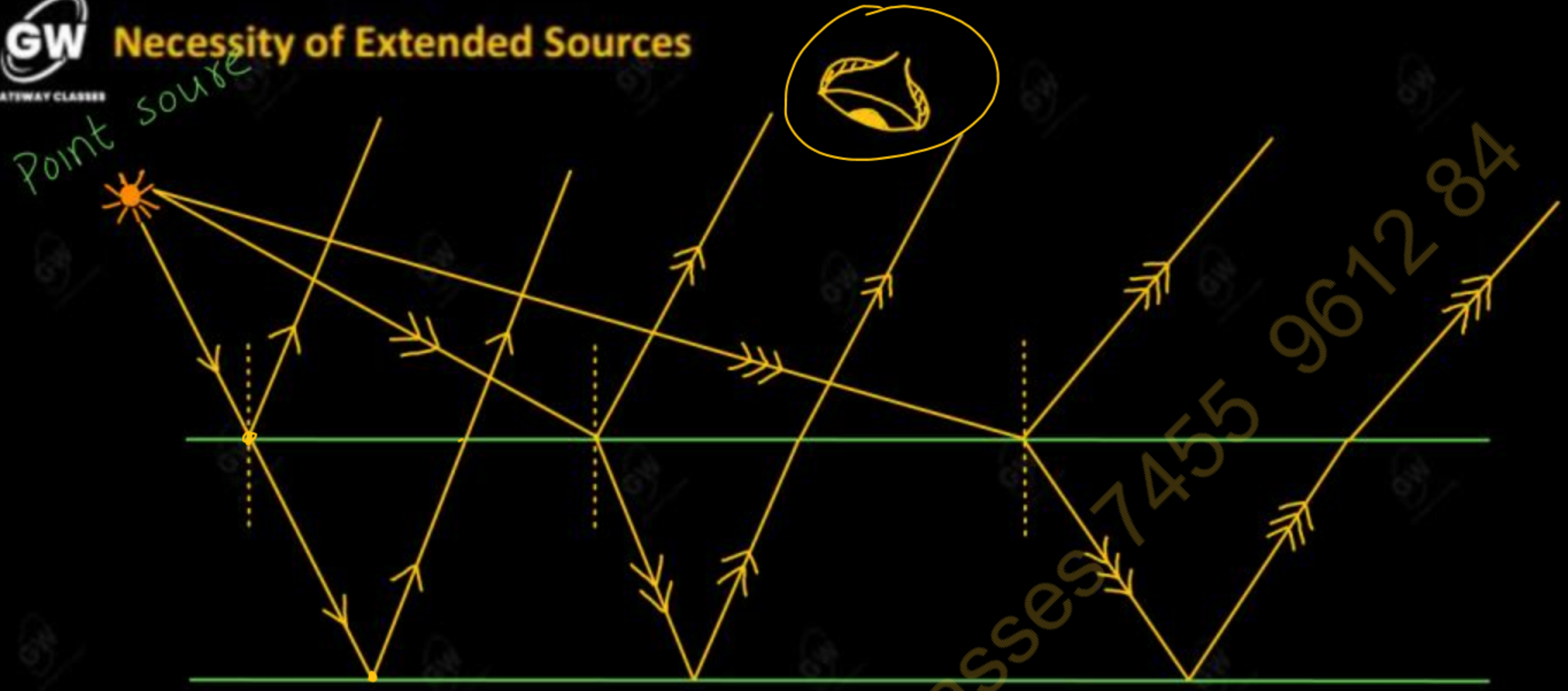
$$\boxed{w = \frac{\lambda}{2\mu\theta}}$$

For Air Film

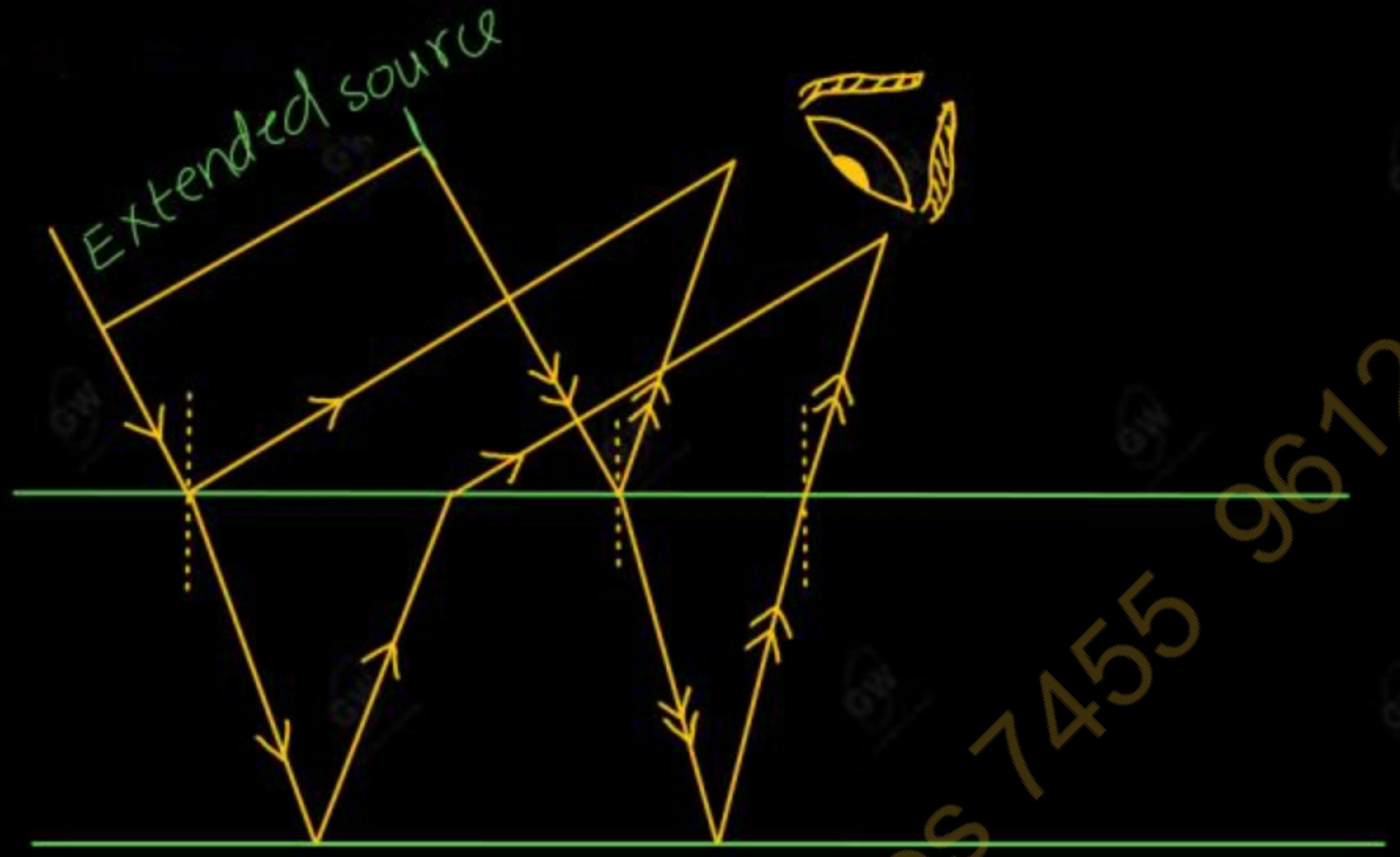
$\mu = 1$

$$\boxed{w = \frac{\lambda}{2\theta}}$$

Necessity of Extended Sources



- If the light is incident on thin film from a point source then for different incident rays, different pairs of interfering rays are obtained along different directions. All these pairs can not be seen by the eye simultaneously. Hence, only a limited portion of the film is visible



- On the other hand, if we use an extended source instead of point source then the different pairs of interfering reflected rays will reach the eye from a large portion of the film (may be from the whole film)
- Hence to see the interference effects over the entire film simultaneously, an extended source of light is necessary

Q.1 Light of wavelength 6000 Å falls normally on a thin wedge-shaped film of refractive index 1.4 forming fringes that are 2.0 mm apart. Find the angle of wedge in seconds.

Given

$\lambda = 6000\,\text{Å} = 6000 \times 10^{-10}\, m$

$\mu = 1.4$

$w = 2\, mm = 2 \times 10^{-3}\, m$

For normal incidence

$$\boxed{w = \frac{\lambda}{2\mu\theta}}$$

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

$1^\circ = 60$ min

1 min $= 60$ sec

$$\theta = \frac{6000 \times 10^{-10}}{2 \times 2 \times 10^{-3} \times 1.4} \times \frac{180}{\pi}$$

$$\theta = 0.0061^\circ = 0.0061 \times 60 \times 60$$

$$\boxed{\theta = 21.96 \text{ second}}$$

Q.2 Two plane glass surfaces in contact along one edge are separated at the opposite edge by a thin wire. if 20 interference fringes are observed between these edges in sodium light of $\lambda = 5890$ Å of normal Incidence, find the diameter of the wire.

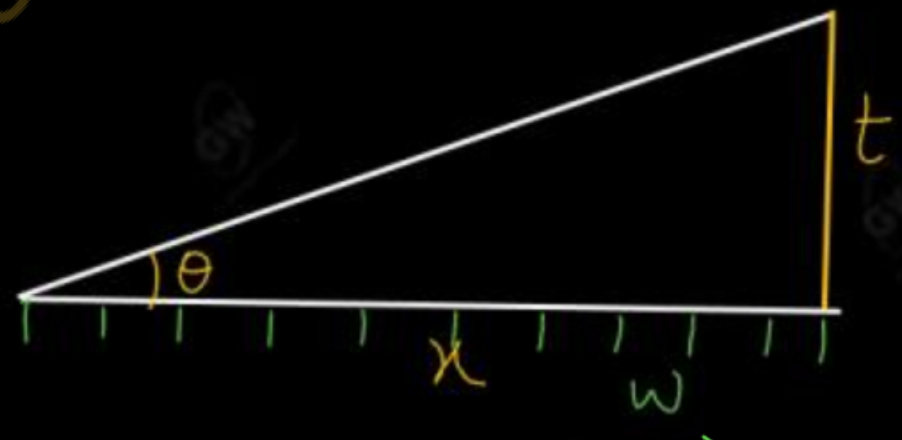
Given

$n = 20$

$\lambda = 5890 \text{Å} = 5890 \times 10^{-10} \, m$

Let t be the thickness or diameter of wire

$\tan\theta = \frac{t}{x}$



$x = nw$

$\theta = \frac{t}{x}$

For normal incidence

$w = \frac{\lambda}{2\theta}$

$w = \frac{\lambda \times x}{2 \times t}$

But

$x = nw$

$$w = \frac{\lambda \times nw}{2t}$$

$$t = \frac{\lambda \times n\cancel{w}}{2\cancel{w}}$$

$$t = \frac{\lambda n}{2} = \frac{5890 \times 10^{-10} \times 20}{2}$$

$$t = 5.89 \times 10^{-6}\, m$$

$$\boxed{t = 5.89 \times 10^{-4}\, cm}$$

Engineering Physics (By Gulshan Sir)

DPP-3

UNIT : Wave Optics

Q.1 Obtain an expression for the fringe width in a wedge – shaped thin film and explain nature of fringe pattern.

Q.2 What do you mean by a wedge- shaped film? Discuss the interference due to it and obtain the expression for the fringe width.

Q.3 Two plane rectangular piece of glass in contact at one edge and separated by a hair at opposite edge so that a wedge is formed. When light of wavelength 6000 Å falls normally on the wedge, 9 interference fringes are observed. What is the thickness of hair?

B. Tech : Engg. Physics

GATEWAY CLASSES

Unit : Wave Optics

(Interference)

Lecture - 4

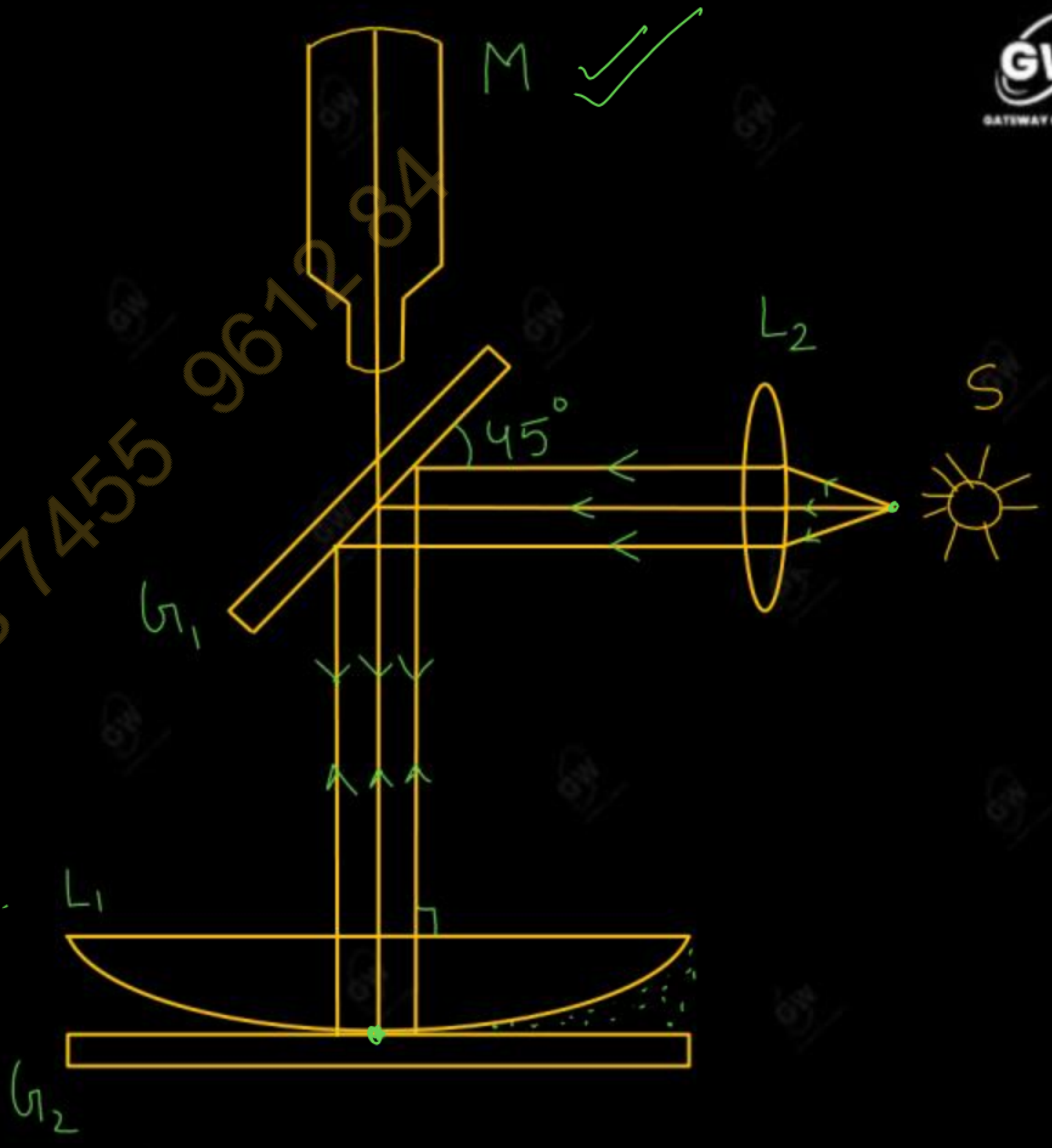
Today's Target

- Newton's Rings
- Applications of Newton's Rings
- DPP
- PYQs

By Gulshan Sir

Experimental Arrangement

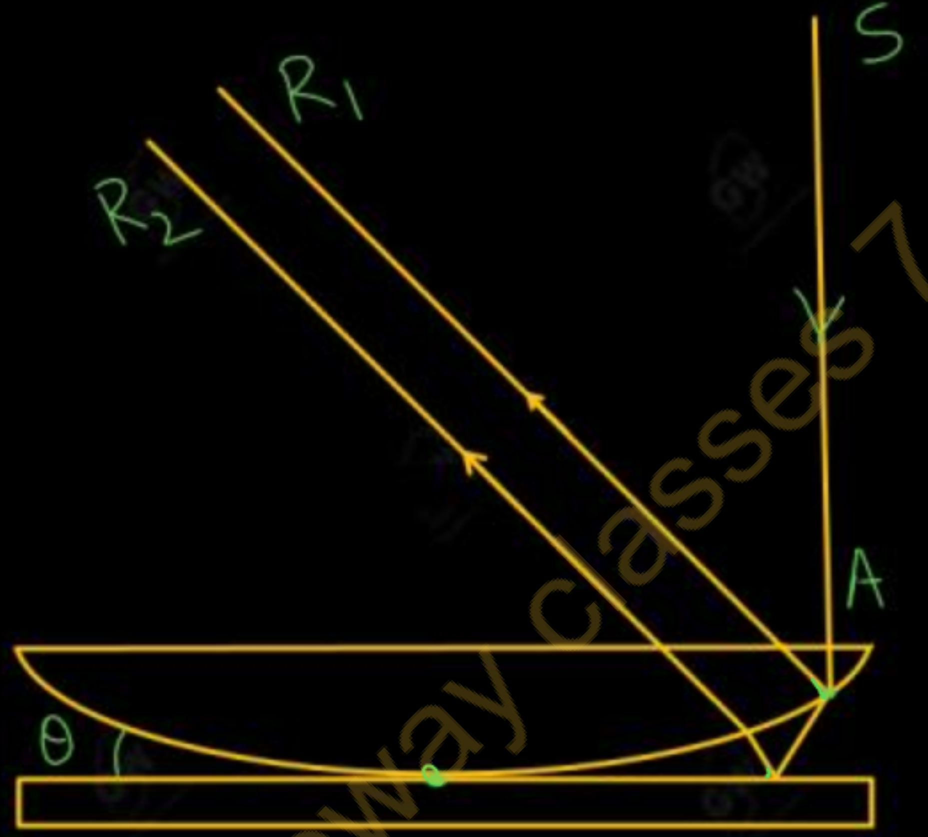
- The experimental arrangement to obtain Newton's Rings is shown in figure
- Light from a monochromatic source (Sodium light) S is converted in to parallel beam by a Lens L_2 Which falls on a glass plate G_1 oriented at an angle of 45^o with the vertical.
- The light reflected by a plate G_1 turns through 90^o and is incident normally on the wedge-shaped film formed between the Plano - convex Lens L_1 and the glass plate G_2.
- A microscope M placed above the Plano - convex Lens L_1 is used to see the concentric dark and bright Newton's rings



Newton's Rings

GW
GATEWAY CLASSES

- When a Plano–Convex lens of large radius of curvature is placed on a plane glass plate, a thin film of air is enclosed between the lower surface (convex surface) of the lens and upper surface of the glass plate.
- The thickness of air film is zero at the point of contact and it gradually increases as we move away from the point of contact.



- If a Monochromatic light is allowed to fall on this air film then alternate Bright and Dark concentric Rings with their Centre Dark are formed. These rings are known as Newton's Rings.

➤ Newton's rings are formed due to the interference between the waves reflected from the top surface (R_1) and bottom surface (R_2) of wedge – shaped air film between the Plano-Convex lens and plane glass plate.

Inference theory in Newton's Rings

Path Difference

The path difference between R_1 and R_2 is given as

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

Since, θ is very – very small ($\theta \approx 0$)

$$\Delta = 2\,\mu t\, cos\, r \pm \frac{\lambda}{2}$$

For normal incidence ($r = 0$)

$$\boxed{\Delta = 2\,\mu t \pm \frac{\lambda}{2}}$$

For air film (μ = 1)

$$\boxed{\Delta = 2\,t \pm \frac{\lambda}{2}}$$

Condition for constructive interference

(Maxima or Bright Rings)

We know that

$$\Delta = 2\,n\left(\frac{\lambda}{2}\right)$$

$$2\mu t \pm \frac{\lambda}{2} = 2\,n\,\frac{\lambda}{2}$$

$$\boxed{2\mu t = (2\,n \pm 1)\,\frac{\lambda}{2}}$$

For air film (μ=1)

$$2t = (2\,n \pm 1)\,\frac{\lambda}{2}$$

Condition for destructive interference

(Minima or Dark Rings)

We know that

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

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

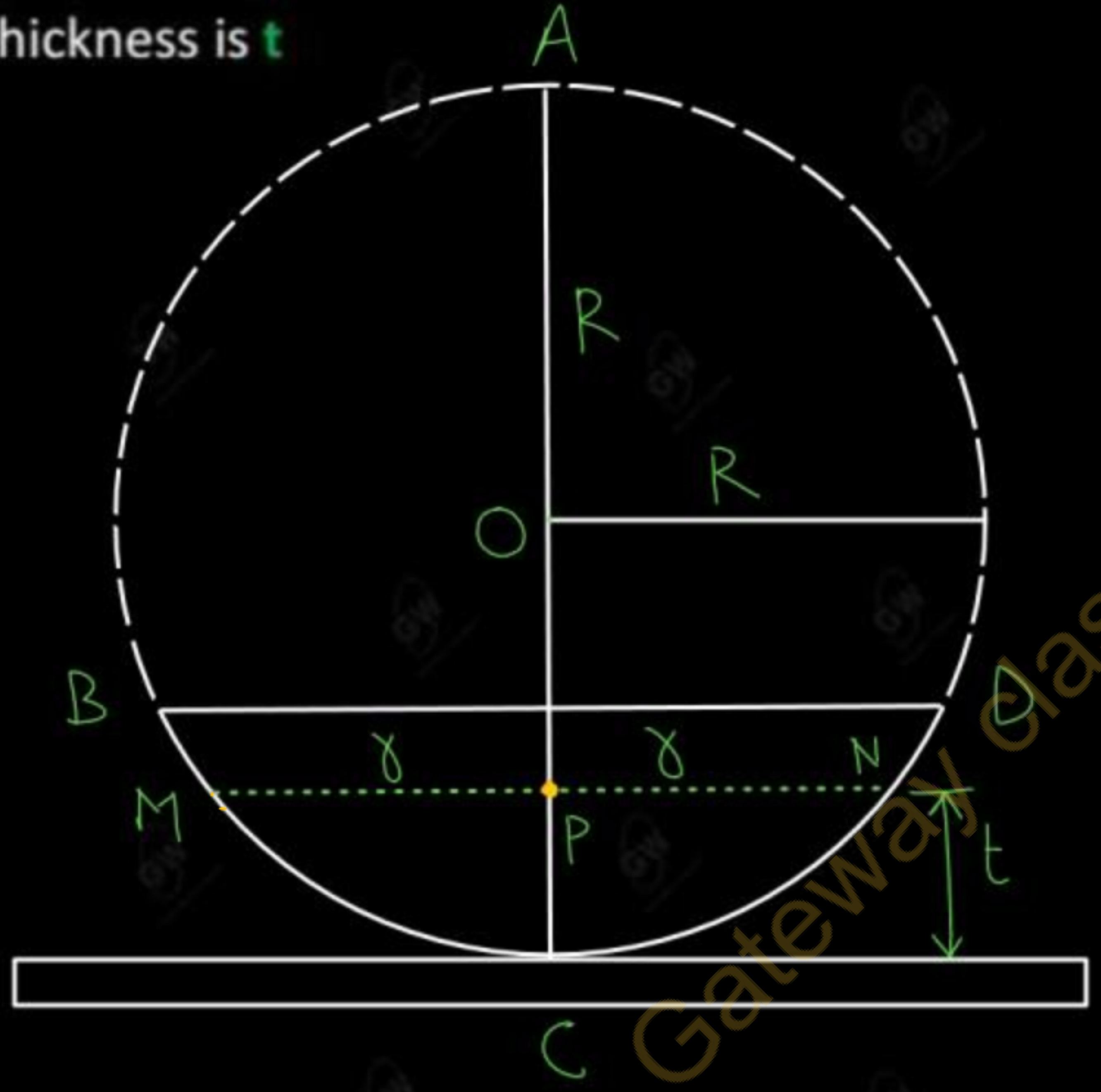
$$\boxed{2\mu t = n\lambda}$$

For air film (μ=1)

$$2t = n\lambda$$

Expression for diameter of Bright and Dark Newton's Rings.

- Let R be the radius of curvature of the Plano-convex lens and r be the radius of a Newton's ring where film thickness is t



By the property of circle

$$MP \times PN = AP \times PC$$

$$r \times r = (2R - t)\,t$$

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

$$t = \frac{r^2}{2R - t}$$

Since, $t <<< 2R$

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

OR

$$\boxed{t = \frac{D^2}{8R}}$$ V.imp

Where D is diameter of Newton's Ring

Diameter of Bright Rings

Put value of t in $2\mu t = (2n-1)\frac{\lambda}{2}$

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

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

For n^{th} ring

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

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

$$\boxed{D_n^2 = \frac{2(2n-1)\lambda R}{\mu}}$$ v.imp

For Air Film ($\mu = 1$)

$$\boxed{D_n^2 = 2(2n-1)\lambda R}$$

$$D_n = \sqrt{2(2n-1)\lambda R}$$

$$D_n = \sqrt{2(2n-1)\lambda R}$$

$$D_n = \sqrt{2\lambda R} \times \sqrt{2n-1}$$

Put $\sqrt{2\lambda R} = K$

$$D_n = K\sqrt{2n-1}$$

$$D_n \propto \sqrt{2n-1}$$

Thus, Diameter of Bright rings is directly proportion to the square root of odd natural numbers

Diameter of Dark rings

Put the value of t in $2\mu t = n\lambda$

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

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

For n^{th} ring

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

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

$$\boxed{D_n^2 = \frac{4n\lambda R}{\mu}}$$ v.imp

For air Film

$$\boxed{D_n^2 = 4n\lambda R}$$

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

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

Let $\sqrt{4\lambda R} = K$

$$D_n = K\sqrt{n}$$

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

Thus, Diameter of Dark rings is directly proportional to the square root of natural numbers

Centre of Newton's Rings is Dark. Give reason

The wedge – shaped air film is formed between the curved surface of Plano-convex lens and plane glass plate, therefore path difference between interfering rays in reflected light will be

$$\Delta = 2\,\mu\, t\cos\,(r+\theta)+\frac{\lambda}{2}$$

At the point of contact (t = 0)

$$\Delta = \frac{\lambda}{2}$$

Which is the condition for minimum intensity, hence the Centre of Newton's ring is dark

Fringes in Newton's Ring experiment are circular. Give reason

Fringes in Newton's Ring experiment are circular because the wedge-shaped air film is symmetrical about the point of contact of the lens with the plane glass plate and locus of all the points of equal thickness are concentric circles with respect to the point of contact.

(i) Determination of Wavelength of Monochromatic light (or sodium light) using Newton's Ring.

Let $D_n = Diameter\ of\ n^{th}\ Dark\ Ring$

$D_{n+p} = Diameter\ of\ (n+p)^{th}\ Dark\ Ring$

We know that

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

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

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

Subtract (1) from (2)

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

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

$$\boxed{\lambda = \frac{D_{n+p}^2 - D_n^2}{4\,pR}}$$

Same result will be obtained for bright ring

(ii) Determination of refractive index of a liquid using Newton's Ring.

The transparent liquid whose refractive index is to be determined is introduced between lens and glass plate.

The diameter of n^{th} dark ring is given by

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

$Diameter\ of\ (n+p)^{th}\ dark\ ring$ is given by

$$D_{n+p}^2 = \frac{4(n+p)\lambda R}{\mu} \quad \text{—— } (2)$$

Subtract (1) from (2)

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

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

$$D_{n+p}^2 - D_n^2 = \frac{4p\lambda R}{\mu} \quad \text{—— } (3)$$

For air ($\mu = 1$)

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

Divide (4) by (3)

$$\boxed{\mu = \frac{[D_{n+p}^2 - D_n^2]_{air}}{[D_{n+p}^2 - D_n^2]_{liquid}}}$$

Thickness of film

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

OR

$$t = \frac{D^2}{8R}$$

Diameter of Bright Ring

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

For Air Film ($\mu = 1$)

$$D_n^2 = 2(2n-1)\lambda R$$

Diameter of Dark ring

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

For Air Film

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

Wavelength (λ)

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

Refractive index

$$\mu = \frac{\left[D_{n+p}^2 - D_n^2\right]_{Air}}{\left[D_{n+p} - D_n^2\right]_{liquid}}$$

Q.1 If in a Newton's ring experiment, the air in the interspace is replaced by a liquid of refractive index 1.33. In what proportion would the diameter of the rings changed.

Given

$\mu_{air} = 1$

$\mu_{liquid} = 1.33$

Diameter of ring

$$D \propto \frac{1}{\sqrt{\mu}}$$

$$D_{air} = \frac{K}{\sqrt{\mu_{air}}} \quad \text{—— } (1)$$

$$D_{liquid} = \frac{K}{\sqrt{\mu_{liquid}}} \quad \text{—— } (2)$$

Divide (2) by (1)

$$\frac{D_{liquid}}{D_{air}} = \frac{\cancel{K}}{\sqrt{\mu_{liquid}}} \times \frac{\sqrt{\mu_{air}}}{\cancel{K}}$$

$$\frac{D_{liquid}}{D_{air}} = \sqrt{\frac{\mu_{air}}{\mu_{liquid}}}$$

$$\frac{D_{liquid}}{D_{air}} = \sqrt{\frac{1}{1.33}}$$

$$= 0.867$$

$$\boxed{D_{liquid} = 0.867\, D_{air}}$$

Q.2 A light source of wavelength 6000 Å is used along with Plano – convex lens with radius of curvature equal to 100 cm in a Newton's ring arrangement. Find out the diameter of the 15th dark ring.

Given

$\lambda = 6000 \text{ Å}$

$R = 100 \text{ cm}$

$n = 15$

$\mu = 1$

We know that

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

$$D_{15}^2 = 4 \times 15 \times 6000 \times 10^{-8} \times 100$$

$$D_{15}^2 = 36 \times 10^{6} \times 10^{-8} = 0.36$$

$$\boxed{D_{15} = 0.6 \text{ cm}}$$

$1 \text{ Å} = 10^{-10} \text{ m}$

$1 \text{ Å} = 10^{-8} \text{ cm}$

Q. 3 Newton's rings are observed normally in reflected light of wavelength 6000 Å. The diameter of 10th dark ring is 0.50 cm. Find the radius of curvature of the lens and the thickness of the air film.

Given

$\lambda = 6000\,\text{Å}$

$n = 10$

$D_{10} = 0.50\,cm$

$R = ?$

$t = ?$

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

$$D_{15}^2 = 4 \times 10 \times 6000 \times 10^{-8} \times R$$

$$(0.50)^2 = 24 \times 10^{4} \times 10^{-8} R$$

$$R = \frac{0.50 \times 0.50}{24 \times 10^{-4}} = \frac{2500}{24}$$

$$\boxed{R = 104.16\,cm}$$

$$t = \frac{D_{15}^2}{8R}$$

$$t = \frac{(0.50)^2 \times 24}{8 \times 2500}$$

$$\boxed{t = 3 \times 10^{-4}\,cm}$$

Q. 4 In Newton's rings experiment the diameter of 4^{th} and 12^{th} dark ring are 0.400 cm and 0.700 cm respectively. Deduce the diameter of 20^{th} dark ring

Given

$D_4 = 0.4\,cm$

$D_{12} = 0.7\,cm$

Let D_n = Diameter of n^{th} ring

D_{n+p} = Diameter of $(n+p)^{th}$ ring

We know that

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

$$D_{12}^2 - D_4^2 = 4 \times 8 \times \lambda R \quad \text{——} \quad (1)$$

Also

$$D_{20}^2 - D_4^2 = 4 \times 16 \times \lambda R \quad \text{——} \quad (2)$$

Divide eq^n (2) by (1)

$$\frac{D_{20}^2 - D_4^2}{D_{12}^2 - D_4^2} = \frac{4 \times 16 \times \cancel{\lambda R}}{4 \times 8 \times \cancel{\lambda R}}$$

$$\frac{D_{20}^2 - D_4^2}{D_{12}^2 - D_4^2} = 2$$

$$D_{20}^2 - D_4^2 = 2D_{12}^2 - 2D_4^2$$

$$D_{20}^2 = 2D_{12}^2 - D_4^2$$

$$D_{20}^2 = 2(0.7)^2 - (0.4)^2$$

$$D_{20}^2 = 0.98 - 0.16$$

$$\boxed{D_{20} = 0.906\,cm}$$

Q. 5 Newton's rings are observed by keeping a spherical surface of 100 cm radius on a plane glass plate. If the diameter of 15^{th} bright ring is 0.590 cm and diameter of 5^{th} ring 0.336 cm. What is the wavelength of light used ?

Given

$R = 100\,cm$

$D_{15} = 0.590\,cm$

$D_5 = 0.336\,cm$

We know that

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

$$\lambda = \frac{D_{15}^2 - D_5^2}{4 \times 10 \times 100}$$

$$\lambda = \frac{(0.590)^2 - (0.336)^2}{4 \times 10 \times 100}$$

$$\boxed{\lambda = 5880\,\mathring{A}}$$

Q. 6 Newton's rings are formed in reflected light of wavelength 6000 Å with a liquid between the plane and curved surface. If the diameter of 6^{th} bright ring is 3.1 mm and the radius of curvature of the curved surface is 100 cm, calcutate the refractive index of the liquid.

Given

$\lambda = 6000\,Å$

$D_6 = 3.1\,mm$

$= 0.31\,cm$

$R = 100\,cm$

$n = 6$

Diameter of Bright ring

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

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

$$\mu = \frac{2 \times 11 \times 6000 \times 10^{-8} \times 100}{(0.31)^2}$$

$$\boxed{\mu = 1.373}$$

DPP-4

UNIT : Wave Optics

Q. 1 Why the center of Newton's ring in reflected system is dark?

Q.2 Describe and explain the formation of Newton's rings in reflected monochromatic light. Deduce the necessary expression for bright and dark rings.

Q.3 Discuss the formation of Newton's rings. Show that the diameters of the bright rings are proportional to the square root of odd natural numbers.

Q. 4 Describe the formation of Newton's rings in monochromatic light. Show that in reflected light, the diameters of dark rings are proportional to the square roots of natural numbers.

Q.5 Describe how Newton's ring experiment can be used to determine the wavelength of light

Q.6 Describe how Newton's ring experiment can be used to determine the refractive index of a liquid.

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Thank You